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Job Search, Social Interactions and Labor Market Performance of Low-Skilled Immigrants

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Abstract

In the last two decades, economists have recognized that immigrants make extensive use of their immigrant networks when deciding to migrate and during their stay in the host country. A way in which immigrants utilize their networks is to find information on potential employers during their job search. It thus seems natural to question what the consequences of using the immigrants' networks as a job search strategy are, and whether the size of the network matters. In this paper we develop an on-the-job search model in which immigrants may look for a job using formal and informal channels (i.e. their networks). In order to account for differences in the quality of job offers, we assume that the distributions of wage offers of the network and the formal channels are different. Moreover, the probability of receiving a wage offer through the informal channels depends in a non-linear fashion on the network size, both while employed and while unemployed. Our model predicts that under certain conditions, an immigrant looking for a job through a large network may hurt his/her labor market outcomes. The model also predicts that an increase in the network size could lead to clustering into the network jobs if some restrictions hold.

Resumen

En las últimas dos décadas, los economistas han reconocido que los inmigrantes hacen un amplio uso de las redes de migrantes al tomar su decisión de migración y durante su estancia en el país receptor. Una forma en que los migrantes utilizan sus redes es para encontrar información de empleadores potenciales durante su búsqueda de trabajo. Es natural, entonces, preguntarnos cuáles son las consecuencias del uso de las redes de migrantes como estrategia de búsqueda de trabajo y si el tamaño de la red importa. En este artículo, se desarrolla un modelo de búsqueda de trabajo en el que los migrantes pueden buscar un empleo utilizando métodos de búsqueda formales o informales (por ejemplo, la red de migrantes). Para tomar en cuenta las diferencias en la calidad de las ofertas de trabajo, se asume que la distribución de las ofertas salariales por parte de la red y los canales formales de búsqueda son diferentes. Además, la probabilidad de recibir una oferta de trabajo por el canal informal depende en forma no-lineal en el tamaño de la red, tanto cuando se está empleado como cuando se está desempleado. El modelo predice que bajo ciertas condiciones, un migrante buscando empleo por medio de una red muy grande puede perjudicar sus logros en el mercado laboral. El modelo también predice que un aumento del tamaño de la red puede conducir a conglomeración en trabajos de la red si se sostienen ciertas restricciones.

1 Introduction

In the last three decades, the United States has received a very large influx of immigrants from developing countries. The literature on the consequences of this massive immigration has focused mostly on the effects on the economic performance of natives, and, in particular, on the labor market performance of natives. However, economists have paid much less attention to the labor market performance of immigrants themselves. A more systematic study of immigrants' choices and economic performance in the United States seems necessary, especially if we consider that poverty is more pervasive among immigrant groups than in the population at large. From a policy standpoint, if immigrants' dependence on welfare is an issue with which taxpayers are concerned, then a close examination of immigrants' work opportunities and work behavior would certainly be required.

Sociologists, and more recently economists, have recognized that immigrants make extensive use of their immigrant networks when deciding to migrate and during their stay in the host country. These networks help the newcomers to familiarize themselves with the new environment by providing them with the much needed economic and moral support upon arrival to the host country. Another way in which immigrants utilize their networks is to find information on potential employers during their job search. It thus seems natural to question what the consequences of using the immigrants' networks as a job search strategy are, and whether the size of the network matters. The goal of this paper is to develop a theoretical job search model that would help us answer such questions. In this paper, we develop an on-the-job search model in which individuals simultaneously search for jobs using their network and formal methods. We allow for the size of the network to have a direct impact on the probability of hearing about a job offer both while unemployed and while on the job. Moreover, we will assume that the offers received from each search method are drawn from different wage distributions. In this way, we are recognizing that the different search methods may offer jobs of different quality.

Recent empirical literature has provided evidence on the effect of social networks on a

wide range of an individual's labor market outcomes[1] including: the probability of finding a job or remaining unemployed,[2] hours worked (Weinberg *et al.*, 2004), wages,[3] occupational choice (Bentolila *et al.*, 2004; Patel and Vella, 2007), location choices,[4] and assimilation in the host country (Damm and Rosholm, 2006). However, the empirical evidence on the effect of networks on employment and wages is rather mixed. We can find evidence of positive network effects in Bayer et al. (2008), and Hellerstein et al. (2008) who find positive neighborhood effects on the probability of being employed in the same census block or establishment, respectively. Goel and Lang (2009) find that people who find a job through the network receive higher wages, but that the wage differential decreases when people use their strong ties. Patel and Vella (2007) find that immigrants tend to cluster in the same occupations as their compatriots, and that there is a positive effect of this clustering in their hourly wages. On a study of the Danish spatial dispersal of refugees, Damm (2009) finds than increases in the network size improve the chances of finding employment and earnings. In a study of Mexican immigrants in the United States, Munshi (2003) also finds that an exogenously larger network increases the probability of employment and induce a higher wage in a non-agricultural job.

Evidence on negative network effects is provided by Delattre and Sabatier (2007); they estimate a switching-regression model to control for selection of the network as a search method and find a negative effect on the network on wages in France. However, they also present evidence that highly educated people are the ones that choose searching through the network, as opposed to the United States. Battu et al. (2005) find that although networks are a popular method for gaining employment, it is not very effective for the least assimilated

[1] For a survey of the literature refer to Ioannides and Loury (2004).

[2] Refer to Battu et al. (2005); Bayer et al. (2008); Beaman (2009); Bentolila et al. (2004); Damm (2009); Hellerstein et al. (2009); Marmaros and Sacerdote (2002); Munshi (2003); Topa (2001); Wahba and Zenou (2005); and Zenou (2008), among others.

[3] Some examples of this literature are: Beaman (2009); Bentolila et al. (2004); Delattre and Sabatier (2007); Goel and Lang (2009); Loury (2006) Patel and Vella (2007); Pellizzari (2004); Zenou (2008), among others.

[4] See for example Aslund (2005); Bartel (1989); Bauer, Epstein and Gang (2005, 2006); Damm (2009); Jaeger (2000, 2008); Scott et al. (2005); and Zavodny (1999) among others.

immigrants in the UK. They also find that these immigrants perform relatively poorly in terms of the type of job they find. Finally, Bentolila et al. (2004) find that networks reduce unemployment duration by 1 to 3 months, but jobs obtained through this channel come with a wage penalty. They attribute this wage discount to the fact that the use of networks may induce individuals to accept jobs in which they do not a productive advantage, so that networks lead to job mismatches.

There is also evidence on heterogeneous network effects. Pellizzari (2004) finds that positive and negative wage effects are equally frequent in European data. He attributes his findings to the firms' recruitment investments: firms that investment heavily in hiring will penalize people using informal channels (i.e. the network), whereas firms that do not invest in hiring will provide a wage premium to those using their networks. Zenou (2008) presents evidence that there is an advantage of using weak ties relative to strong ties; he finds that people using weak ties get a wage premium. Wahba and Zenou (2005) present a model in which the effect of the network is increasing and concave in the network size, so in theory the effect turns negative for relatively large networks. Their empirical evidence confirms their model's implications. Using data from resettled refugees in the United States, Beaman (2009) finds that the size of the concurrent cohort deteriorates the labor market outcomes of recent immigrants, whereas the size of the pre-established cohorts raises the wages of new arrivals. Loury (2006) also finds heterogenous effects from the type of contacts; in her case, contacts in previous generations generate wage premiums, whereas contemporaneous contacts have no effects. Hence, so far the literature has presented three different sources of heterogeneity: firms' investment on hiring, the network size, and the type of contacts.

The theoretical literature also offers a wide range of explanations on the source and sign of the network's effects on labor market outcomes. In a seminal paper, Montgomery (1991) concludes that networks have the ability to transmit information about the productivity of their members, and thus can potentially increase the wages of its members. He developed a model in which firms do not have perfect information on the productivity of their workers.

Given this adverse selection, firms recur to the referrals of high-productivity workers as a recruitment strategy to find more high-productivity employees. As a result, he finds that workers who are well connected (that is, connected to a high-productivity worker) earn more than workers who did not have a reference. In another project, he also finds (Montgomery, 1992) that the reservation wage is an increasing function of the network size and composition.[5]

Mortensen and Vishwanath (1994) develop an on-the-job search model in which individuals are allowed to simultaneously search through formal and informal methods. According to these authors, the distribution of wages in the network (i.e. the informal channel) first-order stochastically dominates the distribution of wage offers from formal channels (i.e. direct application to employers). This stochastic dominance is a result of on-the-job search: employed individuals move to higher paying jobs. Mortensen and Vishnawath implicitly assume that the offers generated from the network channel are drawn from the distribution of wages of the employed members of the network. In consequence, individuals who have a higher probability of obtaining job information through the network earn more than those individuals getting their information through the formal channels. In contrast to this model Koning et al. (1997) do not make any *a priori* assumptions on the stochastic dominance of the network's wage offer distribution over the formal channel's offer distribution. In this more general setting, they conclude that an individuals reservation wage, the transition rate into employment, and the job-to-job mobility rate increase as the proportion of job offers from the network increases if the network's wage offer distribution is stochastically dominated by the formal channel's wage offer distribution.

Another strand of the literature has focused on the information transmission within the

[5]The composition of the network refers to the share of members who are weak ties, as opposed to strong ties. In this paper, Montgomery develops a search model and tries to test Granovetter's (1973) and Lin's (1982) "strength-of-weak-ties" hypotheses. Granovetter (1973) established that weak ties (i.e. acquaintances) relay more job information than strong ties (i.e. relatives and close friends). Lin (1982) argues that the wage offer distribution of weak ties is superior to that of strong ties, given that the weak ties' job information is much more varied. Montgomery models these two hypotheses and concludes that both would contribute to higher reservation wages, but that they are not sufficient conditions for the weak ties to lead to higher expected wages.

network. Calvo-Armengol and Jackson (2004) develop a model in which the employed members receive information about jobs. If the job offer is not as good as their current job, then they pass this information on to unemployed members of the network. In their model, this information transmission leads to a positive correlation between the employment status of the individuals who are connected with the network. Calvó-Armengol and Zenou (2005) extend this model to derive a matching function with depends on the network size in a non-monotonic fashion. In particular, as the network size increases, its unemployed members hear about job offers more often; however, they also need to compete with more people for a particular job. Hence, in this setup an increase in the size of a dense network gives rise to congestion effects, which may eventually lead to a deterioration of the job prospects of the network's members. Calvó-Armengol and Zenou (2005) thus establish that networks may have heterogenous effects, where the source of heterogeneity is the network size. As it was mentioned above, Pellizzari (2004) also presents a theoretical model in which the source of heterogeneity is introduced from the firm-side and refers to the investment in recruitment technologies. Finally, Bentolila et al. (2004) present an equilibrium search model in which networks may lead to job mismatches, and thus conclude that the network can have adverse effects on wages.

In the light of this lack of consensus, we think that further research on the effects of networks on labor market outcomes is necessary. In particular, it seems important to establish the sources of heterogeneity of the estimated effects. In our model we allow for both on-the-job search and the direct impact of network size on the arrival rate of wage offers. Previous theoretical literature[6] on the topic has usually assumed that immigrants can only search for a job while unemployed (Beaman, 2009; Calvó-Armengol and Zenou, 2005; Montgomery, 1992Montgomery (1992); Patel and Vella, 2007). If we believe that the search and matching process produces some wage growth during the life cycle of a worker, then limiting the immigrants (at least theoretically) to unemployment search would rather

[6]For a comprehensive review of the literature on social interactions in economic models of migration see Radu (2008).

restrict their pursuit of better economic opportunities. Our model relaxes this assumption and generalizes some results by considering on-the-job search. Allowing the immigrants to search while on the job will lead to important testable implications about starting wages and wage growth.

Another restrictive assumption in the previous work is that the wage offers generated by the different job search methods are drawn from the same wage distribution (Bentolila, Michelacci, and Suárez, 2004; Calvó-Armengol and Jackson, 2004; Calvó-Armengol and Zenou, 2005; Patel and Vella, 2007). This amounts to assume that a network job would offer exactly the same expected wage than an offer obtained through direct application to an employer. Relaxing this assumption will allow us to explain why immigrants in very large networks might exhibit a different behavior than immigrants in smaller networks. Mortensen and Vishwanath (1994), and Koning et al. (1997) consider both on-the-job search, but they do not allow for the arrival rate of wage offers to depend on the network size. Our model will relax this assumption by allowing the arrival rate of wage offers to be a concave function of the network size.

In our model, the source of heterogeneity of the effects of the network comes from the introduction of on-the-job search. If individuals are able to expand their networks and gain more knowledge on the workings of the host country's labor market once they have obtained a job, then they may hear more often about job opportunities than when they were unemployed. Theoretically, this would entail a higher arrival rate of wage offers while employed than while unemployed. As a consequence, the reservation wage decreases with the network size, given that immigrants know that there are good odds for future job mobility. However if the opposite is true and the cost of search while employed is prohibitively high, then our model's implications are consistent with the rest of the literature in the sense that a larger network induces an increase in the reservation wages, and thus in the expected wage conditional on employment.

Our model also predicts that immigrants will cluster in network jobs. More specifically,

the proportion of job-to-job transitions due to the network increases as the network grows larger. However, the proportion of transitions from unemployment to employment increases with the network size if the following conditions hold: (1) the reservation wages decrease with the network size; and (2) the distribution of wage offers from the formal channels is superior than the distribution of offers from the network in the hazard rate order sense. The latter result is consistent with the findings in Patel and Vella (2007).

The rest of the paper is organized as follows. In Section 2 we develop an on-the-job search model for low-skilled immigrants. Section 3 presents some comparative statics on labor market outcomes. Finally, Section 4 presents the conclusions of our work, and some avenues for future research.

2 The Model

This section develops an on-the-job search model[7] in which individuals use two job search methods simultaneously: their network and other formal channels. Our contribution to the literature is that we allow for differences in the distribution of wage offers of the two search methods *and* the arrival rate of job offers from the network depends on the network size. Previous work had only allowed for differences in the distributions of wage offers (Mortensen and Vishwanath, 1994; and Koning, van den Berg and Ridder, 1997) or for the dependence of the arrival rate on the network size (Beaman, 2009; Calvó-Armengol and Zenou, 2005), but not both. The exception in the literature is Calvó-Armengol and Jackson's (2004) model of information transmission in networks, which does allow for both dependence on the network size and on-the-job search. In their model all individuals receive information on job availability at the same rate. However, if the offer is not convenient for an employed individual, she may pass the job information on to an unemployed acquaintance in her network. This implies that unemployed individuals search for jobs using formal and informal channels (that is, their job offer arrival rate while unemployed is larger than the

[7] Mortensen (1987), and Rogerson et al. (2005) present a survey of the literature on job search.

offer arrival rate while employed), but employed individuals search only through the formal channels. Our model relaxes this assumption by allowing unemployed *and* employed workers to search using formal and informal methods.

Assume we have a utility maximizing individual who is searching for a job. As it is characteristic of search models, individuals do not posses perfect information about the available vacancies in their labor market. They thus use the available search methods, which we will classify in the following two categories: (1) the informal methods, which include obtaining information from the individual's network (i.e. relatives, friends, and acquaintances); and (2) formal methods, such as contacting or visiting employers directly, posting advertisements, and so on. Hence in our model we will assume that the immigrants can search using both formal and informal methods at the same time. Let n index the informal methods, and f the formal methods. If the individual uses the network, she will receive a wage offer at rate $\lambda_n^e(N)$ if she is employed, and $\lambda_n^u(N)$ if she is unemployed, where N is the network size. For simplicity, assume that

$$\begin{aligned} \lambda_n^e(N) &= \theta_n^e \lambda(N), \text{ and } \lambda_n^u(N) = \theta_n^u \lambda(N), \\ \text{with } \lambda(0) &= 0, \lambda' > 0, \text{ and } \lambda'' < 0 \end{aligned} \tag{1}$$

Hence, we will assume that the effect of the network is positive, but concave. When the individual uses the formal search methods, the arrival rates are going to be given by λ_f^e, and λ_f^u, for the employed and unemployed, respectively. For simplicity, we are going to assume that $\lambda_f^e = \lambda_f^u$, but we will continue denoting these arrival rates with different subscripts to keep the interpretation of the equations clearer.

Wage offers are an *i.i.d.* draw from a cumulative distribution function $F_n(w_n)$, where w_n is the wage of a "network job". Each wage offer from the formal channel is an *i.i.d.* draw from a distribution function $F_f(w_f)$, where w_f is the wage of a "formal-channel job". Assume that the support of the distribution functions is upperly bounded by $\bar{w} < \infty$. So

$\bar{w}$ is the minimum wage such that $F_j(\bar{w}) = 1$ for $j = n, f$. Mortensen and Vishwanath (1994) assume that the distribution of network's wage offers stochastically dominates the distribution of the formal channel's offers, given that the network's offers are drawn from the network's wage distribution. We will generalize their model and relax this implicit assumption. Our argument to do so is that employed individuals in the network may pass on information on jobs which have the same or lower quality than their own, so that the distribution of wages of the network is not necessarily the same as the distribution of wage offers from the network. Hence, the distribution of offers from the network need not stochastically dominate the distribution of offers from formal channels.

In the case of low-skilled immigrants, it is probably the case that the formal channel's distribution of wage offers is superior to the immigrant's network wage offer distribution. In particular, we will assume that $F_f(w_f)$ is larger than $F_n(w_n)$ in the hazard rate order sense, which formally means that:

$$\frac{dF_n(w)}{\bar{F}_n(w)} \geq \frac{dF_f(w)}{\bar{F}_f(w)} \quad \text{for all } w \geq 0.$$

The intuition behind this condition in the context of an unemployed immigrant would be as follows. Assuming that the arrival rates are the same within and outside the network, and given a wage offer w^o in the common support of $F_f(w)$ and $F_n(w)$, the probability that an immigrant will find a job in the network in an infinitesimal interval to the right of w^o is higher than the probability of finding a job outside the network. The hazard rate order is stronger than, and in fact implies, first-order stochastic dominance. Figure 1 depicts the probability density functions of the wage offers.

In each labor status the individual's income is equal to:

$$y = \begin{cases} w_n & \text{if employed in a network job} \\ w_f & \text{if employed in an formal-channel job} \\ z & \text{when unemployed} \end{cases}$$

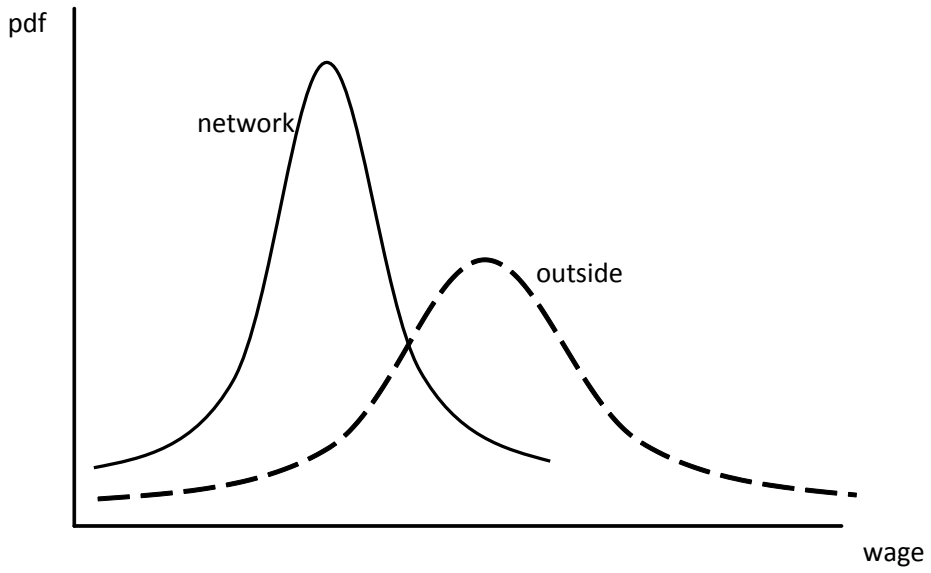

Figure 1: Network and outside wage-offer distributions

where $z = b - c$, b denotes the gross income from unemployment (i.e. unemployment benefits, utility from leisure and home production), and c are the search costs assumed constant across job search methods in this model; so, z is the income in unemployment net of search costs. Finally, jobs end at an exogenous rate q, independently of the job source.

The individual's objective is to maximize his lifetime wealth by choosing the optimal reservation wage and the optimal strategy for changing jobs. Let dt be the length of a period. When unemployed, the immigrant receives income z, and a wage offer during the period. At the end of the period she can be in either of the three following states: (i) in a network-job, (ii) in an outside-job, and (iii) still unemployed. The probabilities that each of these states happen are given by: $\lambda_n^u(N)\Pr\{w \geq w_n^r\}$, $\lambda_f^u \Pr\{w \geq w_f^r\}$, and $\left(1 - \lambda_n^u(N)\Pr\{w \geq w_n^r\} - \lambda_f^u \Pr\{w \geq w_f^r\}\right)$, respectively, where w_j^r is the reservation wage of the j^{th} channel, $j = n, f$. If the immigrant finds a new j-job he will receive an expected payoff equal to $\mathbf{E}\left[V_j^e(w) \,|w \geq w_j^r\right]$, $j = n, f$, but if he stays unemployed he will receive V^u,

the indirect expected utility of unemployment. Thus V^u is given by:

$$\begin{aligned} V^u &= \frac{1}{1+rdt}\left[zdt + \lambda_n^u(N)\,dt\Pr\left\{w \geq w_n^r\right\}\mathbf{E}\left[V_n^e(w)\,|w \geq w_n^r\right]\right. \\ &\quad +\lambda_f^u dt\Pr\left\{w \geq w_f^r\right\}\mathbf{E}\left[V_f^e(w)\,|w \geq w_f^r\right] \\ &\quad \left.+\left(1-\lambda_n^u(N)\Pr\left\{w \geq w_n^r\right\}-\lambda_f^u\Pr\left\{w \geq w_f^r\right\}\right)dtV^u\right] \end{aligned}$$

Given that $\Pr\left\{w \geq w_j^r\right\}\mathbf{E}\left[V_j^e(w)\,|w \geq w_j^r\right] = \int_{w_j^r}^{\bar{w}_j} V_j^e(w)\,dF_j(w)$, $j = n, f$, we can rewrite the expression above as:

$$\begin{aligned} V^u &= \frac{dt}{1+rdt}\left[z + \lambda_n^u(N)\int_{w_n^r}^{\bar{w}}\left[V_n^e(w) - V^u\right]dF_n(w)\right. \\ &\quad \left.+\lambda_f^u\int_{w_f^r}^{\bar{w}}\left[V_f^e(w) - V^u\right]dF_f(w) + V^u\right] \end{aligned} \tag{2}$$

Analogously, when employed in a j-job, the immigrant receives w_j with $j = n,\ f$, and hears about other job opportunities. Hence, at the end of the period he can be in either of the next mutually exclusive states: (i) laid off, (ii) in a new network-job, (iii) in a new outside-job, and (iv) in the same job. These states happen with probability q, $\lambda_n^e(N)\Pr\{w \geq w_n\}$, $\lambda_f^e\Pr\{w \geq w_f\}$, and $\left(1-q-\lambda_n^e(N)\Pr\{w \geq w_n\}-\lambda_f^e\Pr\{w \geq w_f\}\right)$, respectively. The corresponding payoffs for each state are given by: V^u, $\mathbf{E}\left[V_n^e(w)\,|w \geq w_j\right]$, $\mathbf{E}\left[V_f^e(w)\,|w \geq w_j\right]$, and $V_j^e(w_j)$, respectively. Then we have that the expected indirect utility of being employed in a j-job is given by:

$$\begin{aligned} V_j^e(w_j) &= \frac{1}{1+rdt}\left[w_j dt + qdtV^u + \lambda_n^e(N)\,dt\Pr\{w \geq w_j\}\mathbf{E}\left[V_n^e(w)\,|w \geq w_j\right]\right. \\ &\quad +\lambda_f^e dt\Pr\{w \geq w_j\}\mathbf{E}\left[V_f^e(w)\,|w \geq w_j\right] \\ &\quad \left.+\left(1-q-\lambda_n^e(N)\Pr\{w \geq w_n\}-\lambda_f^e\Pr\{w \geq w_f\}\right)dtV_j^e(w_j)\right] \end{aligned}$$

for $j = n, o$. We can rewrite the expression above as:

$$V_j^e(w_j) = \frac{dt}{1+rdt}\left[w_j + q\left[V^u - V_j^e(w_j)\right] + \lambda_n^e(N)\int_{w_j}^{\bar{w}}\left[V_n^e(w) - V_j^e(w_j)\right]dF_n(w)\right. \quad (3)$$
$$\left. +\lambda_f^e\int_{w_j}^{\bar{w}}\left[V_f^e(w) - V_j^e(w_j)\right]dF_f(w) + V_j^e(w_j)\right]$$

Finally, as $dt \longrightarrow 0$ and simplifying, we have that (2) and (3) simplify to:

$$rV^u = z + \lambda_n^u(N)\int_{w_n^r}^{\bar{w}}\left[V_n^e(w) - V^u\right]dF_n(w) + \lambda_f^u\int_{w_f^r}^{\bar{w}}\left[V_f^e(w) - V^u\right]dF_f(w) \quad (4)$$

$$rV_j^e(w_j) = w_j + q\left[V^u - V_j^e(w_j)\right] + \lambda_n^e(N)\int_{w_j}^{\bar{w}}\left[V_n^e(w) - V_j^e(w_j)\right]dF_n(w) \quad (5)$$
$$+\lambda_f^e\int_{w_j}^{\bar{w}}\left[V_f^e(w) - V_j^e(w_j)\right]dF_f(w), \text{ for } j = n, f.$$

These are the Bellman equations for our search problem. From equation (4) we know that the flow value of unemployment is given by the addition of the net income from unemployment, the expected value of the net gain from a network job, and the expected value of the net gain from a formal-channel job. The last two terms in this equation represent the value of unemployment search. Similarly, the last two term in equation (5) are the value of on-the-job search, which is the expected net gain from taking a higher paying job.

The maximization problem of the individual is to find the optimal strategy to transit from unemployment to employment, and from job to job in order to maximize lifetime wealth. In the latter case, we know that individuals will move to a new job if the new wage offer is higher than the current wage. The transitions from unemployment to employment are governed by the reservation wage. The reservation wage is defined as the wage that leaves the immigrant indifferent between working and continuing unemployed. Hence in our context,

the reservation wage solves for:

$$V_n^e\left(w_n^r\right) = V^u \tag{6}$$

$$V_f^e\left(w_f^r\right) = V^u \tag{7}$$

Hence, we have that at the reservation wage $V_n^e\left(w_n^r\right) = V_f^e\left(w_f^r\right)$. Evaluating (5) in w_j^r,and simplifying we have that:

$$\begin{aligned} rV_j^e\left(w_j^r\right) &= w_j^r + \lambda_n^e(N)\int_{w_j^r}^{\bar{w}}\left[V_n^e(w) - V_j^e\left(w_j^r\right)\right]dF_n(w) \\ &\quad + \lambda_f^e\int_{w_j^r}^{\bar{w}}\left[V_f^e(w) - V_j^e\left(w_j^r\right)\right]dF_f(w) \end{aligned} \tag{8}$$

Under certain conditions we can assume that $w_n^r = w_f^r = w^r$;[8] substituting this equality into (4), and using (8), (6), and (7), we get:

$$\begin{aligned} w^r &= z + \left[\lambda_n^u(N) - \lambda_n^e(N)\right]\int_{w^r}^{\bar{w}}\left[V_n^e(w) - V^u\right]dF_n(w) \\ &\quad + \left[\lambda_f^u - \lambda_f^e\right]\int_{w^r}^{\bar{w}}\left[V_f^e(w) - V^u\right]dF_f(w) \end{aligned} \tag{9}$$

Differentiating (5) with respect to w_j, we get:[9]

$$V_j^{e\prime}(w_j) = \frac{1}{r + q + \lambda_n^e(N)\bar{F}_n(w_j) + \lambda_f^e\bar{F}_f(w_j)} \tag{10}$$

where $\bar{F}_j(w) = 1 - F_j(w)$, $j = n, o$. Finally, integrating by parts (9) and substituting (10)

[8] See these conditions in the Appendix A.

[9] This derivative is obtained using Leibnitz's rule:

$$\int_{a(\theta)}^{b(\theta)} f(x,\theta)\,dx = f\left(b(\theta),\theta\right)\frac{d}{d\theta}b(\theta) - f\left(a(\theta),\theta\right)\frac{d}{d\theta}a(\theta) + \int_{a(\theta)}^{b(\theta)}\frac{\partial}{\partial\theta}f(x,\theta)\,dx$$

.

we get the following expression:[10]

$$\begin{aligned} w^r &= z + \left[\lambda_n^u(N) - \lambda_n^e(N)\right] \int_{w^r}^{\bar{w}} \frac{\bar{F}_n(w)\,dw}{r + q + \lambda_n^e(N)\,\bar{F}_n(w) + \lambda_f^e \bar{F}_f(w)} \\ &\quad + \left(\lambda_f^u - \lambda_f^e\right) \int_{w^r}^{\bar{w}} \frac{\bar{F}_f(w)\,dw}{r + q + \lambda_n^e(N)\,\bar{F}_n(w) + \lambda_f^e \bar{F}_f(w)} \end{aligned} \tag{11}$$

Recall that we are assuming that $\lambda_f^u = \lambda_f^e$, so, in our case, the reservation wage further simplifies to:

$$w^r = z + \left[\lambda_n^u(N) - \lambda_n^e(N)\right] \int_{w^r}^{\bar{w}} \frac{\bar{F}_n(w)\,dw}{r + q + \lambda_n^e(N)\,\bar{F}_n(w) + \lambda_f^e \bar{F}_f(w)} \tag{12}$$

So the reservation wage is equal to the net income from unemployment plus the net value of unemployment search relative to on-the-job search. Thus we have that if $\lambda_n^u(N) = \lambda_n^e(N)$, the individual's reservation wage will just be equal to z, the net income when unemployed. However, if $\lambda_n^u(N) < \lambda_n^e(N)$, then $w^r < z$; that is, the immigrant will be enticed to accept bad jobs when unemployed, because once employed he has good prospects of finding higher paying jobs. Finally, if $\lambda_n^u(N) > \lambda_n^e(N)$, then $w^r > z$. In this case, the immigrant's value of search while unemployed increases relative to the value of on-the-job search. This result is similar to the case in which there is no on-the-job search.

3 Implications of the Model: Comparative Statics

One of our objectives in this paper was to establish another source for the heterogeneity in the effect of the network. The following claim establishes that the effect of the network's size

[10] $\int_a^b u dv = uv|_a^b - \int_a^b v du$. Let $u = \left[V_j^e(w) - V^u\right]$, and $dv = dF_j(w)$. Then $du = V_j^{e\prime}(w)\,dw$, and $v = -\left[1 - F_j(w_j)\right]$. Thus we have that:

$$\begin{aligned} \int_{w^r}^{\bar{w}} \left[V_j^e(w) - V^u\right] dF_j(w) &= -\left[V_j^e(w) - V^u\right]\left[1 - F_j(w)\right]|_{w_r}^{\bar{w}} + \int_{w_r}^{\bar{w}} \left[1 - F_j(w)\right] V_j^{e\prime}(w)\,dw \\ &= \int_{w_r}^{\bar{w}} \left[1 - F_j(w)\right] V_j^{e\prime}(w)\,dw. \end{aligned}$$

on the reservation wages, and hence in the expectation of the observed wages, is ambiguous. The network effect will depend on whether unemployment search is relatively more valuable than on-the-job search or not.

Claim 1 *The effect of the network size on the reservation wage is ambiguous. We have the following three cases:* (1) *if there is no on-the-job search, as it has been assumed in part of the literature or* $\lambda_n^e(N) < \lambda_n^u(N)$*, then* $\frac{\partial w^r}{\partial N} > 0$; (2) *if* $\lambda_n^e(N) > \lambda_n^u(N)$, *then* $\frac{\partial w^r}{\partial N} < 0$.; *and finally,* (3) *if* $\lambda_n^e(N) = \lambda_n^u(N)$, *then* $\frac{\partial w^r}{\partial N} = 0$.

Proof. Let $\Phi\left(w^r, N, \lambda_f^u, \lambda_f^e, r, q\right)$ be given by:

$$\Phi\left(w^r, N, \lambda_f^u, \lambda_f^e, r, q\right) = w^r - z - \left[\lambda_n^u(N) - \lambda_n^e(N)\right] \int_{w^r}^{\bar{w}} \frac{\bar{F}_n(w)}{\Delta(w)} dw = 0$$

where $\Delta(w) = r + q + \lambda_n^e(N)\bar{F}_n(w) + \lambda_f^e \bar{F}_f(w)$. Then using the implicit function theorem we have that $\frac{\partial w^r}{\partial N} = -\frac{\Phi_N}{\Phi_{w^r}}$. Thus differentiating $\Phi(\cdot)$ with respect to w^r, and assuming that $\lambda_n^u(N) < \lambda_n^e(N)$, we get:

$$\Phi_{w^r} = 1 - \left[\lambda_n^e(N) - \lambda_n^u(N)\right] \frac{\bar{F}_n(w^r)}{\Delta(w^r)} > 0$$

Differentiating $\Phi(\cdot)$ with respect to N we get:

$$\begin{aligned}
\Phi_N &= \left(\lambda_n^{e\prime} - \lambda_n^{u\prime}\right) \int_{w^r}^{\bar{w}} \frac{\bar{F}_n(w)}{\Delta(w)} dw - \lambda_n^{e\prime}\left(\lambda_n^e - \lambda_n^u\right) \int_{w^r}^{\bar{w}} \frac{\bar{F}_n(w)^2}{\Delta(w)^2} dw \\
&= \int_{w^r}^{\bar{w}} \frac{\lambda'\left(\theta_n^e - \theta_n^u\right)\bar{F}_n(w)\Delta(w) - \lambda'\left(\theta_n^e - \theta_n^u\right)\lambda_n^e \bar{F}_n(w)^2}{\Delta(w)^2} dw \\
&= \int_{w^r}^{\bar{w}} \frac{\lambda'\left(\theta_n^e - \theta_n^u\right)\bar{F}_n(w)\left(r + q + \lambda_f^e \bar{F}_f(w)\right)}{\Delta(w)^2} dw > 0
\end{aligned}$$

where $\lambda' = \frac{d\lambda(N)}{dN}$, and I have omitted the arguments of $\lambda_n^i(N)$,and $\lambda_n^{i\prime}(N)$, $i = e, u$, for simplicity. So we have that:

$$\frac{\partial w^r}{\partial N} = -\frac{\int_{w^r}^{\bar{w}} \frac{\lambda'(\theta_n^e - \theta_n^u)\bar{F}_n(w)\left(r+q+\lambda_o^e \bar{F}_o(w)\right)}{\Delta(w)^2}}{1 - \left[\lambda_n^e(N) - \lambda_n^u(N)\right]\frac{\bar{F}_n(w^r)}{\Delta(w^r)}}.$$

The sign of $\frac{\partial w^r}{\partial N}$ is ambiguous, $\frac{\partial w^r}{\partial N} \lesseqgtr 0$, and it will depend on whether $\lambda_n^e(N) \gtreqless \lambda_n^u(N)$. ■

Hence, the effect of the network size on the reservation wage is ultimately an empirical question. The results on the reservation wage are easily extended to the observed wage, given that the observed distribution of wages is truncated at the lower tail of the distribution by the reservation wage. Hence, a higher reservation wage implies that the mean of the observed wages is also higher.

Our next two results explore the relationship between the concentration on network jobs and the network size.

Claim 2 *The proportion of job-to-job transitions due to the network is an increasing function of the network size.*

Proof. Let α^e be the proportion of job-to-job transitions due to the network, which is given by:

$$\alpha^e = \frac{\lambda_n^e(N)\bar{F}_n(w)}{\lambda_n^e(N)\bar{F}_n(w) + \lambda_f^e \bar{F}_f(w)},$$

where w is the current wage. The numerator is the probability that an employed individual accepts a network offer, and the denominator is the probability that the individual will change jobs. Differentiating α^e with respect to N, we get:

$$\frac{\partial \alpha^e}{\partial N} = \frac{\lambda_n^{e\prime}\lambda_f^e \bar{F}_n(w)\bar{F}_f(w)}{\left[\lambda_n^e \bar{F}_n(w) + \lambda_f^e \bar{F}_f(w)\right]^2} > 0.$$

Hence as the network size increases more of the job-to-job transitions are going to be due to wage offers coming from the network. ■

Claim 3 *The proportion of unemployment to employment transitions is an increasing function of the network size if* $\frac{\partial w^r}{\partial N} < 0$ *and* $F_f(w_f)$ *is larger than* $F_n(w_n)$ *in the hazard rate order sense.*

Proof. Let α^u be the fraction of transitions from unemployment to employment due to the network, which is given by:

$$\alpha^u = \frac{\lambda_n^u(N)\,\bar{F}_n(w^r)}{\lambda_n^u(N)\,\bar{F}_n(w^r) + \lambda_f^u \bar{F}_f(w^r)},$$

where the numerator is the probability that an unemployed migrant finds a job through the network, and the denominator is the probability that he finds a job using either search method. Differentiating α^u with respect to N, we get:

$$\frac{\partial \alpha^u}{\partial N} = \frac{\lambda_f^u \lambda_n^{u\prime} \bar{F}_n(w^r)\,\bar{F}_f(w^r) + \lambda_f^u \lambda_n^u \frac{\partial w^r}{\partial N}\left[\bar{F}_n(w^r)\,dF_f(w^r) - \bar{F}_f(w^r)\,dF_n(w^r)\right]}{\left[\lambda_n^u \bar{F}_n(w) + \lambda_f^u \bar{F}_f(w)\right]^2}$$

In order to determine the sign of $\frac{\partial \alpha^u}{\partial N}$, we need to find the sign of the numerator in the expression above. Dividing the numerator by $\lambda_f^u \bar{F}_n(w^r)\,\bar{F}_f(w^r)$,we get the following expression:

$$\lambda_n^{u\prime} + \lambda_n^u \frac{\partial w^r}{\partial N}\left[\frac{dF_f(w^r)}{\bar{F}_f(w^r)} - \frac{dF_n(w^r)}{\bar{F}_n(w^r)}\right]$$

The expression above will be strictly positive if $F_f(w)$ is larger than $F_n(w)$ in the hazard rate order sense, and hence we will have that:

$$\frac{\partial \alpha^u}{\partial N} = \frac{\lambda_f^u \lambda_n^{u\prime} \bar{F}_n(w^r)\,\bar{F}_f(w^r) + \lambda_f^u \lambda_n^u \frac{\partial w^r}{\partial N}\left[\bar{F}_n(w^r)\,dF_f(w^r) - \bar{F}_f(w^r)\,dF_n(w^r)\right]}{\left[\lambda_n^u \bar{F}_n(w) + \lambda_f^u \bar{F}_f(w)\right]^2} > 0$$

Thus unemployed individuals will tend to concentrate on network jobs as the network size increases. ■

In the case of low-skilled immigrant, especially those who recently arrived, it seems sensible to assume that the job offer arrival rate when employed is higher than the offer arrival

rate when unemployed. The intuition behind this assumption is that when immigrants start working both their knowledge on the host country's labor market and their network expand, so that overall, they receive more valuable information per connection than an unemployed worker. Hence, in the case of low-skilled workers, our model reaches a result consistent with Patel and Vella (2007).

4 Conclusions

This paper developed an on-the-job search model in which individuals are allowed to search for a job using formal and informal methods simultaneously. The model allows for the network size to have a direct effect on the arrival rate of job offers both while employed and while unemployed. We also assume that the distribution of wage offers from the network is different than the distribution of offers from formal channels. We find that the effect of the network size on the reservation wages, and hence on observed wages, is ambiguous. The heterogeneity of the effect arises from the difference in the employment-offer arrival rate relative to the unemployment-offer arrival rate. Our model is consistent with previous literature in the sense that when there is no on-the-job search (Beaman, 2009; Calvó-Armengol and Zenou, 2005) or when the unemployment-offer arrival rate is higher than the employment-offer arrival rate (Calvó-Armengol and Jackson, 2004), the reservation wage increases when the network is larger. We also find that the proportion of job-to-job transitions due to the network is increasing on the network size. In contrast, the relationship between the network size and the proportion of unemployment-to-employment transitions requires some rather restrictive assumptions for it to be positive. We think that these assumptions are very likely to hold in the case of low-skilled immigrants, in which case our results would be consistent with Patel and Vella (2007).

Our contribution to the literature is threefold. First, our model allows for on-the-job search, *and* the offer arrival rates for both the employed *and* unemployed depend on the

network size. Previous literature had not considered these assumptions in a single job search model. Second, we allow for the distribution of wage offers from the network to be different to that of formal search methods. We assume that the distribution of offers from the formal channels is larger than the distribution of offers from the network in the hazard rate order sense. This assumption leads us to different conclusions than those in Mortensen and Vishwanath (1994). Third, we derive some implications of the network size on the proportion of job-to-job transitions and unemployment-to-employment transitions due to the network.

One of the drawbacks in our analysis is that we do not model the information transmission within the network. This is the reason why we need to assume that the offer arrival rates are a concave function of the network size. Future work would need to extend our model (or Calvó-Armengol and Jackson's model for that matter) in order to incorporate the transmission of information within the network. The model would need to assume that employed workers are allowed to transmit information on job availability to any (employed or unemployed) member of the network. Another issue that we leave for future research is to explore the case in which the reservation wages of the formal and informal channels are not the same. Finally, the empirical test of our model's implications is also part of our future research agenda.

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A Conditions for equality of the reservation wages

Following a similar procedure to the one described in the text, we can find the reservation wages. These are given by:

$$\begin{aligned} w_n^r &= w^r - \lambda_f^e \int_{w_n^r}^{w_f^r} \frac{\bar{F}_f(w)}{\Delta(w)} dw \\ w_f^r &= w^r + \lambda_n^e(N) \int_{w_n^r}^{w_f^r} \frac{\bar{F}_n(w)}{\Delta(w)} dw \end{aligned}$$

where the common component w^r is given by:

$$w^r = z + [\lambda_n^u(N) - \lambda_n^e(N)] \int_{w_n^r}^{\bar{w}} \frac{\bar{F}_n(w)}{\Delta(w)} dw$$

and $\Delta(w) = r + q + \lambda_n^e(N)\bar{F}_n(w) + \lambda_f^e \bar{F}_f(w)$. So we have that the difference between the reservation wages is given by:

$$
\begin{aligned}
w_f^r - w_n^r &= \lambda_n^e(N)\int_{w_n^r}^{w_f^r}\frac{\bar{F}_n(w)}{\Delta(w)}dw + \lambda_f^e\int_{w_n^r}^{w_f^r}\frac{\bar{F}_f(w)}{\Delta(w)}dw \\
&= \lambda_n^e(N)\int_{w_n^r}^{w_f^r}\left[V_n^e(w) - V_n^e(w_n^r)\right]dw \\
&\quad +\lambda_f^e\int_{w_n^r}^{w_f^r}\left[V_f^e(w) - V_f^e\left(w_f^r\right)\right]dw
\end{aligned}
$$

This equation has a very nice interpretation: the difference in the reservation wages is equal to the weighted sum of the expected gain from gaining employment through each of the search methods, where the weights are the wage-offer arrivals while employed. Thus, in order for the reservation wages to be equal,we would need the following condition to hold:

$$
\lambda_n^e(N)\int_{w_n^r}^{w_f^r}\left[V_n^e(w) - V_n^e(w_n^r)\right]dw = -\lambda_f^e\int_{w_n^r}^{w_f^r}\left[V_f^e(w) - V_f^e\left(w_f^r\right)\right]dw.
$$

Koning et al. (1997) simply assume that the reservation wages are equal, but they do not clarify which are the necessary conditions for this assumption to hold.

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