Job Search and Contact Networks

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Abstract

Many workers hear about or obtain their jobs through friends and relatives rather than through formal sources. Both the individual's reservation and expected wages are correlated with the structure and size of his personal contacts set under alternative formulations of the strength-of-weak-ties hypothesis. Furthemore an individual incentive of strategic job network formation and job information transmission arises and is justifiable both at the individual and the aggregate level. This paper attempts to overview some of the relevant results relating the contact network composition of job seekers to their labor market outcome and to review in detail two corresponding formal models.

1 Introduction

The importance of social networks in job finding has been documented already a while ago by sociologists and economists altogether. Early and influential studies dating back to the 60's and 70's found for instance that the majority of new hires in a sample of both blue and white collar workers reported that they had not been looking particularly for a new job but learned about a favorable opportunity from some network tie, e.g. Rees (1966), Granovetter (1974). In this sense, it seems that job seeking and job finding are intimately related to ongoing social relationships. In this paper I distinguish two directions in the literature discussing the job search in a social network context and summarize the current state of research therein, discussing in depth one relevant formal model within each of these trends.

To begin with, it has been asserted under two alternative theories that the most useful contacts for finding a job were not the family links, the strong ties, but instead the more distant connections, the weak ties: Granovetter (1973, 1974), Lin (1982). The "strength-of-weak-ties" hypothesis has been tested in a number of empirical studies, however a final conclusion on its complete significance has not been reached. Corcoran et al (1980), Bridges and Villemez (1986) or Marsden and Hurlbert (1988) found no correlation between tie strength and wages after controlling for worker characteristics and concluded that the use of contacts altogether is unimportant in labor market success. A relevant formal model which tests the empirical implications of the strength-of-weak-ties alternative formulations and draws positive conclusions of their effect on reservation and expected wages of job seekers is discussed in Montgomery (1992). This study will be in detailed reviewed herein.

If the research on the implications of the strength-of-weak-ties assumption on the network composition has at least some number of controversies, the literature on the strategic formation of the job contact networks and the communication process underlying it is almost inexistent. Except for the seminal paper by Boorman (1975) that embeds the empirical findings of Granovetter (1973) in a more formal model of communication flow, the only study that relates geometry of networks to efficiency of job information transmission is the very recent paper of Calvo-Armengol (2002). He analyzes the individual incentives to form contacts and studies the strategic network formation specifying the process by which information about jobs is obtained and transmitted. This paper is using very recently developed network formation methods and tools introduced in the papers by Jackson and Wolinsky (1996) respectively Bala and Goyal (2000). I will discuss the study by Calvo-Armengol (2002) in one the following sections of this paper.

2 Implications of the strength-of-weak-ties theory

2.1 Background

There are two alternative formulations of the strength-of-weak-ties hypothesis suggesting that job seekers benefit from weak ties for two distinct reasons. One approach has been developed by Granovetter (1973, 1974) and assumes that the offer probabilities differ. Namely weak ties relay useful information about potential jobs more frequently than strong ties since weak ties are more prone to move in circles different from one's own and hence tend to have better access to non-redundant information. The other formulation belongs to Lin (1982) and suggests that weak-tie job offers are drawn from a different distribution so that both the mean and/or the variance can differ. One implication of this latter theory is that given a lower and an upper bound on the offer distribution, weak ties may provide a better distribution of opportunities for individuals with low initial socioeconomic background, while strong ties are better for individuals with high initial background.

Empirical studies investigating the implications of the strength-of-weak-ties assumptions focused on the effect of an increase in the proportion of weak ties on the reservation wage holding the network size constant. Two such studies, Bridges & Villemez (1986) and Marsden & Hurlbert (1988), found no significant relation between wages and tie strength after controlling for human capital variables. Montgomery (1992) constructs a formal model based on the "friction" job search framework developed by Mortensen (1986) in order to investigate the effect on expected wages of the strength-of-weak-ties theory under both formulations and to argue that the empirical studies above centered on ties *actually used* to find a job while they should have focused on the *network structure* per se, stream advocated by Campbell et al (1986).

2.2 Model specifications

Montgomery's model starts with two simplifications of the job search model in Mortensen (1986). He first excludes on-the-job-search, hence only unemployed workers are searching and next he does not allow for job separations of any kind, thus quits, layoffs or retirement are all prohibited. The infinite horizon assumption implies further stationarity: the reservation wage is constant within time. The present value of future earnings on a job paying wage w is $w/(1-\beta)$, where $\beta < 1$ is the worker's discount factor. The worker receives a random number of offers each period. The highest offer received has a distribution $H(w)$ with probability density $h(w)$. Let w_R the worker's reservation wage and V worker's value of search, i.e. the present value of future earnings given that the worker remains unemployed at the end of the period. Given this notation, the worker's expected future earnings viewed from before any offers are received are:

$$\int_0^{w_R} Vh(w)dw + \int_{w_R}^{\infty} \frac{w}{1-\beta} h(w)dw \tag{1}$$

Considering now the expected future earnings from the perspective of the end of the preceding period, i.e. after all offers were rejected, the value of search is defined as:

$$V = \beta \left(\int_0^{w_R} Vh(w)dw + \int_{w_R}^{\infty} \frac{w}{1-\beta} h(w)dw \right) \tag{2}$$

At the same time $V = w_R/(1-\beta)$ since the worker is indifferent between accepting the job at w_R or continuing to search. By substitution into (2) and noting that $\int_0^{w_R} Vh(w)dw = V - \int_{w_R}^{\infty} Vh(w)dw$ we obtain immediately the unique level of the reservation wage:

$$w_R = \frac{\beta}{1-\beta} \int_{w_R}^{\infty} (w - w_R)h(w)dw \tag{3}$$

Montgomery further assumes that the worker receives job information through three channels: strong ties, weak ties and formal search. A worker has ϖN weak ties and $(1-\varpi)N$ strong ties, where N is the network size and ϖ represents the proportion of weak ties. p_W and p_S are the probabilities of offer receivals through a weak, respectively a strong tie. Weak-tie and strong-tie wage offers are drawn from distributions $F_W(w)$, respectively $F_S(w)$ with probability densities $f_W(w)$, $f_S(w)$. The worker receives formal offers from a distribution $F_F(w)$ with density $f_F(w)$ by applying directly to M firms during each period. Assume that wage offers drawns are independent. Then one can write

$$H(w) = [\Phi_F(w)]^M [\Phi_W(w)]^{\varpi N} [\Phi_S(w)]^{(1-\varpi)N} \tag{4}$$

where $\Phi_i(w) \equiv 1 - p_i[1 - F_i(w)]$, for $i \in \{F, W, S\}$

2.3 Network composition and wages

2.3.1 Effect on the reservation wage

Montgomery discusses next some comparative statics effects on the reservation wage.

Proposition 1 *Reservation wage is increasing in network size.*

Start from (3) and integrate by parts:

$$w_R^H = \frac{\beta}{1-\beta} \int_{w_R^H}^{\infty} 1 - H(w)dw \tag{5}$$

where w_R^H is the reservation wage corresponding to $H(w)$. Consider an alternative offer distribution $\widetilde{H}(w)$, where $\forall x$,

$$\int_x^{\infty} 1 - H(w)dw > \int_x^{\infty} 1 - \widetilde{H}(w)dw \tag{6}$$

It is now easy to prove by contradiction using (6) that $w_R^H > w_R^{\widetilde{H}}$, where $w_R^{\widetilde{H}}$ is the reservation wage corresponding to offer distribution $\widetilde{H}(w)$. Now suppose that $H(w)$ and $\widetilde{H}(w)$ are considered given network size N_H, respectively $N_{\widetilde{H}}$, where $N_H > N_{\widetilde{H}}$, then from eq. (4) we have

$$H(w) - \widetilde{H}(w) = \widetilde{H}(w)[[\Phi_W(w)]^{\varpi(N_H - N_{\widetilde{H}})}[\Phi_S(w)]^{(1-\varpi)(N_H - N_{\widetilde{H}})} - 1] \qquad (7)$$

Because the RHS in (7) is negative for all w we have that inequality (6) holds, hence w_R^H increases with N.

Proposition 2 *Reservation wage is increasing in the proportion of weak ties if weak ties relay offers with a higher probability than strong ties or if the weak-tie distribution first or second order stochastically dominates the strong-tie distribution.*

Let $\widetilde{H}(w)$ be the highest offer distribution when worker has wN weak ties and $(1-w)N$ strong ties and $H(w)$ the same distribution when worker replaces one strong tie with a weak tie. From eq (4)

$$H(w) - \widetilde{H}(w) = [\Phi_W(w) - \Phi_S(w)]\frac{\widetilde{H}(w)}{\Phi_S(w)} \qquad (8)$$

Because $\widetilde{H}(w)/\Phi_S(w) > 0 \Rightarrow H(w) - \widetilde{H}(w) < 0$, hence w_R increases in ϖ if

$$\Phi_W(w) - \Phi_S(w) = p_S[1 - F_S(w)] - p_W[1 - F_W(w)] < 0$$

This main condition can be decomposed for an easier interpretation in subconditions. The reservation wage increases in the proportion of weak ties if

i) $p_W > p_S$, given $F_W(w) = F_S(w)$, $\forall\ w$, i.e. weak ties relay job offers with higher probability than strong ties (Granovetter)

ii) $F_W(w) < F_S(w)$, $\forall w$, given $p_W = p_S$, i.e. the weak-tie offer distribution is superior to the strong-tie distribution (Lin)

iii) $p_W > p_S$, $\int_0^\infty w f_W dw = \int_0^\infty w f_S dw$ and $\exists\ \widetilde{w}$ s.t. $sign\{F_W - F_S\} = sign\{\widetilde{w} - w\}$ where $sign(.)$ is the sign function. That is, the offer distributions have the same mean, but the weak-tie distribution is more dispersed than the strong-tie (Lin). In a more technical language, the weak-tie distribution second-order stochastically dominates the strong-tie distribution which is the same as saying that the weak-tie is a mean preserving spread of the strong-tie distribution e.g. Rothschild and Stiglitz (1970), Mortensen (1986).

2.3.2 Effect on expected wages

It has been so far assumed by empiricists that the strength-of-weak-ties hypothesis implies that workers obtaining jobs through weak ties should receive higher wages after controlling for human capital characteristics. In Montgomery's model this is equivalent to testing whether $E\{w|W\} > E\{w|S\}$. Firstly, from equation (4), the density function can be written as

$$h(w) = H'(w) = g_F(w) + g_W(w) + g_S(w) \qquad (9)$$

where $g_F(w) \equiv M p_F f_F(w)[\Phi_F(w)]^{M-1}[\Phi_W(w)]^{\varpi N}[\Phi_S(w)]^{(1-\varpi)N}$

$$g_W(w) \equiv \varpi N p_W f_W(w)[\Phi_F(w)]^M[\Phi_W(w)]^{\varpi N-1}[\Phi_S(w)]^{(1-\varpi)N}$$

$$g_S(w) \equiv (1-\varpi)Np_S f_S(w)[\Phi_F(w)]^M[\Phi_W(w)]^{\varpi N}[\Phi_S(w)]^{(1-\varpi)N-1}$$

The worker becomes employed in a given period with probability $\int_{w_R}^{\infty} h(w)dw$. Conditional upon employment, his expected wage can then be written

$$E\{w\} = \left(\int_{w_R}^{\infty} wh(w)dw\right) / \left(\int_{w_R}^{\infty} h(w)dw\right)$$

The worker accepts a job through channel $i \in \{F, W, S\}$ with probability $\int_{w_R}^{\infty} g_i(w)dw$. Again conditional on employment,this probability can be written $\Pr(i) = \left(\int_{w_R}^{\infty} g_i(w)dw\right) / \left(\int_{w_R}^{\infty} h(w)dw\right)$. The worker's expected wage will be then

$$E\{w|i\} = \left(\int_{w_R}^{\infty} wg_i(w)dw\right) / \left(\int_{w_R}^{\infty} g_i(w)dw\right)$$

In order to treat analytically the problem, assume further that the expected wage functions can be written as

$$E\{w|W\} = \left(\int_{w_R}^{\infty} wx(w)\xi(w)dw\right) / \left(\int_{w_R}^{\infty} x(w)\xi(w)dw\right) \tag{10}$$

$$E\{w|S\} = \left(\int_{w_R}^{\infty} w\xi(w)dw\right) / \left(\int_{w_R}^{\infty} \xi(w)dw\right) \tag{11}$$

where $\xi(w) \geq 0, \forall w$ and $x(w)$ is continuous and monotonous. Define $\widehat{w}$ s.t. $x(\widehat{w}) \int_{w_R}^{\infty} \xi(w)dw = \int_{w_R}^{\infty} x(w)\xi(w)dw$. Given the conditions above on $\xi(w)$ and $x(w)$, $\exists\, \widehat{w} \in (w_R, \infty)$ and moreover $\widehat{w}$ is unique. Then if we multiply both the numerator and the denominator of eq. (11) by $x(\widehat{w})$ and we substract this from eq. (10) we get that $E\{w|W\} > E\{w|S\}$ iff

$$\int_{w_R}^{\infty} w[x(w) - x(\widehat{w})]\xi(w)dw > 0 \tag{12}$$

Given the conditions on $x(w)$ and $\xi(w)$, (12) translates in

$$\int_{w_R}^{\infty} w[x(w) - x(\widehat{w})]\xi(w)dw > \widehat{w} \int_{w_R}^{\infty} [x(w) - x(\widehat{w})]\xi(w) \text{ if } dx(w)/dw > 0$$

$$\int_{w_R}^{\infty} w[x(w) - x(\widehat{w})]\xi(w)dw < \widehat{w} \int_{w_R}^{\infty} [x(w) - x(\widehat{w})]\xi(w) \text{ if } dx(w)/dw < 0$$

Proposition 3 *Granovetter's formulation implies that the use of a weak tie will be negatively related to average expected wages.*

Under the assumption i) of identical distributions but different probabilities seen in previous subsection (Granovetter), the expected wages are given by eq. (10) and (11), where $x(w) = \Phi_S(w)/\Phi_W(w)$ and $\xi(w) = f_S(w)[\Phi_F(w)]^M[\Phi_W(w)]^{\varpi N}[\Phi_S(w)]^{(1-\varpi)N-1}$. Because then

$$dx(w)/dw = f[w](p_S - p_W)/[\Phi_W(w)]^2 < 0 \tag{13}$$

we have $E\{w|S\} > E\{w|W\}$, claimed in the proposition above.

Proposition 4 *In some cases under Lin's formulation (normal, lognormal offer distribution) the use of a weak tie increases expected wage.*

Under assumptions ii) and iii) of equal probabilities but different distributions (Lin) expected wages are given again by (10) and (11), but

$$x(w) = \frac{f_W(w)}{\Phi_W(w)} \frac{\Phi_S(w)}{f_S(w)} = \frac{\partial \ln(\Phi_W(w))/\partial w}{\partial \ln(\Phi_S(w))/\partial w}$$

(while $\xi(w)$ same as in the previous case). This case has not been analytically solved, nonetheless numerical simulations assuming a lognormal offer distribution (assumption arising frequently in the job search literature e.g. Burdett (1981), Heckman and Honore (1990)) generate $E\{w|W\} > E\{w|S\}$, claimed above.

3 Strategic formation and job information flow in contact networks

3.1 Overview

To this very moment there are few models that formally analyze the role of personal contacts in labor market processes although their importance has been widely acknowledged empirically. In particular the literature on job contact network formation has been inexistent up to very recently since the general literature on network formation is very fresh itself: Jackson and Wolinsky (1996) and Bala and Goyal (2000). Apart from the early contribution of Boorman (1975), the study of network formation in labor markets has been void before Calvo-Armengol (2002).

The author first shows that the information inflow to any agent is dependent on the network structure of his direct and indirect contacts by inferring implications at the individual but also the aggregate level. Henceforth direct connections are beneficial because an increase in their number broadens the available information channels and thus improve employment prospects. Indirect connections are detrimental because they compete with each other for the same information and face an information sharing constraint on each other. Two networks with the same total number of links but different geometry may thus induce different unemployment rates.

Second, starting from the assumption that contacts are costly to form and to maintain, Calvo-Armengol investigates the endogenous formation of contact networks. He discusses pairwise-equilibrium networks defined as the Nash equilibria of some non-cooperative network formation game. The study finds that inefficiencies of two kinds might arise at equilibrium; individual incentives to form links may be excessive to the socially desirable outcome and it might also happen that a direct contact between two asymmetric players in a network has a positive total value but generates a negative return to one player.

3.2 Job transmission

Consider $N = \{1, ..., n\}$, $n \geq 2$, a finite set of players in a network. The network consists of symmetric binary ties and is modeled as a non-directed graph following Boorman (1975). The binary ties represent personal contacts and constitute for the purpose of this model direct communication channels. Let g^N denote the set of all subsets of N of size 2. Denote

$G \equiv \{g | g \in g^N\}$ the set of all possible graphs of N. If $g \in G$, then a link between 2 players i and j is $ij \in g$. Then $g \pm ij$ represents the network obtained by adding/deleting a link. Further $N_i(g) = \{j \in N \backslash \{i\} | ij \in g\}$ is the set of direct contacts of i and $n_i(g) = |N_i(g)|$.Then $n(g) = \sum_{i \in N} n_i(g)/2$ is the total number of ties in g.

The paper assumes that initially all workers are employed and subsequently they lose their job with an identical breakdown probability $b \in (0,1)$. Each worker is then informed about a new job opportunity with identical arrival probability $a \in (0,1)$. When the worker is unemployed he will fill a vacancy that he heard about; otherwise he refers this to his unemployed direct contacts, which receive this information with the same probability. Calvo-Armengol simplifies thus the Montgomery (1992) model of weak and strong ties, since there is no priority ranking over direct contacts. Given the notation above, an employed worker has an extra job slot for his unemployed direct contacts with probability $\alpha = a(1-b)$, while an unemployed worker needs his personal contacts to find a job with probability $\beta = b(1-a)$.

Let $g \in G$. We want to compute the probability $P_i(g)$ that $i \in N$ gets a job through contacts. Assume that some direct contact $j \in N_i(g)$ of player i hears of a vacant job but he is employed. Then he transmits this to j with probability

$$\sum_{k=0}^{n_j(g)-1} \binom{n_j(g)-1}{k} \frac{(1-b)^{n_j(g)-1-k} b^k}{k+1} = \frac{1-(1-b)^{n_j(g)}}{b n_j(g)} \tag{14}$$

But then the probability that i does not actually find a job through j

$$q(n_j(g)) = 1 - \frac{\alpha[1-(1-b)^{n_j(g)}]}{b n_j(g)} \tag{15}$$

So finally:

$$P_i(g) = 1 - \prod_{j \in N_i(g)} q(n_j(g)) \tag{16}$$

Proposition 5 *Probability $P_i(g)$ for player i to find a job through contacts increases with respect to the set $N_i(g)$, but decreases in the number of indirect ties $n_j(g)$.*

In order to prove this proposition we simply need to look at the behavior of function $q(.)$. Calvo-Armengol ingeniously shows (refer to the appendix of his paper to follow all the steps of this proof since it would take too much space to follow it here) that $q(.)$ increases on $[1, \infty)$ and in the limits, $q(1) = 1 - \alpha$ while $\lim_{x \to \infty} q(x) = 1$, which proves the claim. It is to be noted that the monotonicity is with respect to the set $N_i(g)$ (hence for the inclusion ordering on sets) and not to the number of connections $n_i(g)$ since we need to keep track of the structure of i's indirect connections when evaluating the contributions to $P_i(g)$ of the players in $N_i(g)$.

Proposition 6 *Direct links generate positive marginal returns while indirect links generate negative externality on one-link-away contacts.*

A comparative statics approach is further taken in order to analyze the marginal returns from one link. Denote $k \in N_i(g) \cup N_j(g)$ the direct contacts of players i and j. Let $ij \notin g$. Then from Proposition 5, $P_i(g + ij) > P_i(g)$, thus individual direct links generate positive marginal returns. Now let $k \in N_i(g)$, $k \notin N_j(g)$. Then, again through Proposition 5, $P_k(g + ij) < P_k(g)$. In other words individual indirect links generate a negative externality on one-link-away contacts.

Proposition 7 *The aggregate unemployment rate is negatively correlated with the aggregate probability of finding a job through contacts.*

As a next step the author departs from the individual level and establishes a relationship between the aggregate unemployment level and the social structure. The unemployment rate can be defined as

$$u(g) = \beta \left[1 - \sum_{i \in N} P_i(g)/n \right] \tag{17}$$

The vector $(P_1(g), ..., P_n(g))$ determines the way job information flows through personal contacts. Networks that mediate information fluently are such that the aggregate probability $\sum_{i \in N} P_i(g)$ of finding a job through contacts is high. Then by (17) these networks result in a low unemployment rate, negatively related to this aggregate probability.

3.3 Equilibrium networks

3.3.1 Pairwise-equilibrium characterization

As a second line of reasoning in the paper, the focus is on individual incentives and strategic behavior in network formation. First, given a network $g \in G$, the expected payoff $Y_i(g)$ of an initially employed player $i \in N$ is given by $Y_i(g) = (1-b) + b[a + (1-a)P_i(g)] - cn_i(g)$, where $1-b$ is the prob. that i keeps the job and $a + (1-a)P_i(g)$ is the prob. that i is fired and reemployed. Using expressions (15) and (16), we can further write

$$Y_i(g) = 1 - \beta \prod_{j \in N_i(g)} q(n_j(g)) - cn_i(g) \tag{18}$$

A noncooperative game of network formation is considered. Agents announce all the links they wish to be involved in: let $s_{i,j} = 1$ if i wants to create a direct link with j and $s_{i,j} = 0$ otherwise, $\forall i, j \in N$. A strategy of i is $s_i = (s_{i,1}, ..., s_{i,n})$. Let $S_i = \{0, 1\}^{n-1}$ the set of possible strategies of i. Then a link ij is created iff $s_{ij}s_{ji} = 1$.

As a Nash equilibrium of the network formation game is to weak to characterize networks created endogenously (when nobody announces any link we would be in a Nash equilibrium), Calvo-Armengol follows Goyal and Joshi (2002) in defining a so-called "pairwise-equilibrium".

A network $g \in G$ is a pairwise-equilibrium if and only if both:

(a) there is a Nash equilibrium strategy profile that supports g, so $\exists s* = (s_1^*, .., s_n^*)$ so that $\forall i \in N$ and $\forall s_i \in S_i$, $Y_i(g(s_i^*, s_{-i}^*)) \geq Y_i(g(s_i, s_{-i}^*))$;

(b) $\forall ij \notin g$, $Y_i(g + ij) > Y_i(g)$ implies $Y_j(g + ij) > Y_j(g)$

Suppose further that all players are initially employed and isolated. Then $\alpha\beta - c$ is the individual payoff from joining a pair. The benefits of forming a first link exceed its costs whenever $c \leq \alpha\beta$. Considering thus $c \leq \alpha\beta$ we have:

Proposition 8 *A network $g \in G$, $g \neq \emptyset$ is a pairwise-equilibrium network if and only if both:*

$$c \leq \beta min\{P_i(g) - P_i(g - ij), P_j(g - ij)\}, \forall ij \in g \tag{19}$$

$$c < \beta[P_i(g + ij) - P_i(g)] \Rightarrow c > \beta[P_j(g + ij) - P_j(g)\}, \forall ij \notin g \tag{20}$$

In order to understand this, one can note that

$$Y_i(g+ij) - Y_i(g) = \beta[P_i(g) - P_i(g+ij)] + c \quad (21)$$

$$Y_i(g-ij) - Y_i(g) = \beta[P_i(g) - P_i(g-ij)] - c \quad (22)$$

From (21), (22), the b) part of the definition of a pairwise-equilibrium above and from the result that if $Y_i(g) \geq Y_i(g-ij)\ \forall j \in N_i(g)$ then $Y_i(g) \geq Y_i(g-ij_1-..-ij_l)\ \forall j_1,..,j_l \in N_i(g)$ (Lemma 1 in Calvo-Armengol, proved in the appendix of the same paper), we obtain exactly the expressions (19) and (20).

An important conclusion that this study draws on the pairwise equilibrium networks is that they can be characterized geometrically only in terms of the number of links adjacent to the nodes of the graph. Consequently a more in depth analysis of special classes of networks, such as the symmetric ones is performed by the author as further specific implications can be shown, but this analysis does not add to the general purpose of this paper being over-restrictive.

3.3.2 Equilibrium, efficiency and unemployment

A welfare measure can be defined taking into account that some networks in this model may achieve a widespread information at low cost, while others may be costly to maintain and/or transmit poorly the information. The welfare measure associated to $g \in G$ is defined as

$$W(g) = [1-u(g)]n - 2cn(g) \quad (23)$$

Using equations (17) and (18) we can further write $W(g) = \sum_{i \in N} Y_i(g)$, in other words the welfare measure is nothing else but the sum of the individual payoffs. Using an elaborate proof (in the appendix of his paper), Calvo-Armengol proves the following:

Proposition 9 *There exist $c_1 < c_2$ and $c_3 < c_4 < c_5$ s.t.*

a) g^N is the only pairwise-equilibrium network when $c \leq c_2$, while efficient networks have at least $n(g^N) - 1$ links when $c > c_1$;

b) separate pairs, g^{pairs}, are the only pairwise equilibrium networks when $c_3 < c < c_5$, while efficient networks have at least $n(g^{pairs}) + 1$ links when n is of the form $2m+1$ and $c_3 < c < c_4$.

This means that there are two potential sources of inefficiencies in pairwise-equilibrium networks: over-connection and under-connection. Firstly, translating condition a) of Proposition 9, i.e. for low per link costs c, the networks can be over-connected from an efficient point of view because of negative externalities exerted to direct contacts every time two players create a link to each other. Secondly, emerging in the setting of case b) of Proposition 9, i.e. for high per link costs c, the link ij may have a positive net value, $Y_i(g+ij)+Y_j(g+ij) > Y_i(g)+Y_j(g)$, but one of the players might get a negative return from it, $Y_i(g+ij) < Y_i(g)$. Hence in the absence of mutual consent the link is not formed although it is socially desirable. Then the network is under-connected.

Now, concerning ourselves with unemployment, the effect of adding a link results from the combination of the positive direct effect and the negative indirect effect (analyzed in the job transmission section). Formally, if $g \in G$ and $ij \notin g$ then

$$\frac{n}{\beta}[u(g+ij) - u(g)] = D_i + D_j + \sum_{k \in N_i(g) \cup N_j(g)} D_k \quad (24)$$

where

$$D_i = P_i(g + ij) - P_i(g) > 0, D_j = P_j(g + ij) - P_j(g) > 0$$

but

$$D_k = P_k(g + ij) - P_k(g) < 0$$

A sufficient (and necessary) condition for reduction in the overall unemployment is that welfare is improved with a link addition.

Proposition 10 *If* $W(g + ij) > W(g)$*, then* $u(g + ij) < u(g)$

We have from equation (23) that

$$W(g + ij) - W(g) = n[u(g) - u(g + ij)] - 2c \tag{25}$$

Proposition 10 solely identifies some situations where link addition reduces unemployment and consequently cannot be generalized.

4 Discussion

In this paper two main trends in the research relating social networks to labor market outcomes have been shortly overviewed. One is concerned with the implications of the strength-of-weak-ties assumption on job market outcomes such as reservation wages and expected average wages. The other trend centers on strategic network formation and efficiency outcomes under equilibrium job contact networks both at the individual level (individual payoffs) and at the aggregate level (unemployment). I have further reviewed in detail one relevant paper for each of these two research areas: Montgomery (1992) and Calvo-Armengol (2002).

Summing up the study by Montgomery, he concludes based on an economic model of job search that the use of a weak tie could be associated with lower expected wages even though weak links relay offers more frequently than strong ones and are on average superior as distribution to offers from other sources; nonetheless he does present an unambiguous relationship between reservation wages and network structure. That is, both formulations of the strength-of-weak-ties hypothesis imply that reservation wages rise with the proportion of weak ties and the size of the contact network. He thus argues that under any formulation of the strength-of-weak-ties hypothesis, the weak ties are beneficial. As a consequence of his research and in response to the empirical studies' no correlation findings between the use of a weak tie and effects on the wages, Montgomery suggests that network size ought to be the important dimension that empiricists should concentrate on.

Calvo-Armengol concludes in his paper on the one hand that direct contacts in a network are beneficial while indirect contacts are detrimental for the optimal information flow. On the other hand he emphasizes two potential inefficiencies in pairwise-equilibrium networks: i) the individual incentives to form contacts may be excessive compared to what is socially desirable and consequently the equilibrium networks are over-connected from an efficient point of view; ii) the distribution of the joint link gains to the players might be asymmetric and a link might not be formed in the absence of mutual consent although it is socially desirable, leading to efficiency-wise under-connected equilibrium networks. This second type of inefficiency can be eliminated by allowing for side payments between agents. The study also aggregates individual outcomes to an aggregate level and measures global unemployment level as function of the network pattern. One of the results obtained is that as long as the use of an extra tie is welfare enhancing, the aggregate unemployment level will be reduced.

References

Bala, V. and S. Goyal (2000) " A Noncooperative Model of Network Formation", Econometrica 68, 1181-1230

Boorman, S.A. (1975) "A Combinatorial Optimization Model for Transmission of Job Information Through Contact Networks", Bell Journal of Economics 6, 216-49

Bridges, W.P. and W.J. Villemez (1986) "Informal Hiring and Income in the Labour Market", American Sociological Review 51, 574-82

Burdett, K. (1981) "A Useful Restriction on the Offer Distribution in Job Search Models" in Studies in Labor Market Behavior: Sweden and the US 169-82, edited by Eliasson, Holmlund and Stafford, Stockholm, Sweden

Calvo-Armengol (2001) "Job Contact Networks", mimeo, Univ Carlos III Madrid

Campbell, K., P. Marsden, J. Hurlbert (1986) "Social Resources and Socioeconomic Status", Social Networks 8, 97-117

Corcoran, K.E., L. Datcher, G. Duncan (1980) "Information and Influence Networks in the Labor Market" in *Five Thousand American Families: Patterns of Economics Progress,* vol 7 1-37, edited by Duncan and Morgan, Ann Arbor, MI

Goyal, S. and S. Joshi (2002) "Unequal Connections", mimeo, Queen Mary College London

Granovetter, M. (1973) "The Strength of Weak Ties", American Journal of Sociology, 78, 1360-80

Granovetter, M. [1974](1995) Getting a Job: A Study of Contacts and Careers, 2^{nd} edition, Chicago University Press, Chicago

Heckman, J. and B.E. Honore (1990) "The Empirical Content of the Roy Model", Econometrica 58, 1121-49

Jackson, M. and A. Wolinsky (1996) "A Strategic Model of Social and Economic Networks", Journal of Economic Theory 71, 44-74

Lin, N. (1982) "Social Resources and Instrumental Action" in Social Structure and Network Analysis 131-45, edited by Marsden and Lin, Beverly Hills, CA

Marsden, P. and J.S. Hurlbert (1988) "Social Resources and Mobility Outcomes: A Replication and Extension", Social Forces 66, 1038-59

Montgomery, J.D. (1992), "Job Search and Network Composition: Implications of the Strength-of-Weak-Ties Hypothesis", American Sociological Review 57, 586-96

Mortensen, D.T. (1986) "Job Search and Labor Market Analysis" in Handbook of Labour Economics vol II 849-919, edited by Ashenfelter and Layard, Amsterdam, NL

Rees, A. (1966) "Information Networks in Labour Markets", American Economic Review 56, 559-66

Rothshild, M. and J. Stiglitz (1970) "Increasing Risk I: A Definition", Journal of Economic Theory 2, 225-43