

# Job Information Networks, Neighborhood Effects, and Inequality

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## 1. Introduction

Considerable interest has emerged recently in the economic literature about social interactions and the ways in which social norms and structures condition individual behavior. The treatment of labor-market transactions as very different from trading in goods reflects the importance of idiosyncrasies due to social effects.

One prominent example of where such idiosyncrasies play a prominent role is job-market search. Search theory formally models frictions associated with job-seekers' access to information about availability of jobs of different types and about the conditions of employment (George Stigler 1961, 1962; Christopher Pissarides 2001). Until relatively recently, the job-search literature has focused on individuals making decisions on a one-to-one basis. Everyday experience

indicates, however, that access to information is heavily influenced by social structure and that individuals use connections with others, such as friends and social and professional acquaintances, to build and maintain information networks. Albert Rees (1966) first drew attention to differences among workers in their use of the variety of available informational outlets. In this context, *formal* sources of information include state and private employment agencies, newspaper advertisements, union hiring halls, and school and college placement services. *Informal* sources include referrals from employees and other employers, direct inquiries by job seekers, and indirect ones through social connections. Since then a burgeoning literature in economics has developed about the details of social interactions that affect the job-search process. This literature complements the more extensive sociological analysis of networks. One of the objectives of this article is to explore the roles social interactions and social norms play in the context of this new literature. There is an important richness that the term “networks” connotes in sociology which to a considerable extent has entered economics as well. A second objective is to explain its salience within both theoretical and empirical economics research.

<sup>1</sup> Ioannides and Loury: Department of Economics, Tufts University. This is an outgrowth of an invited paper presented at the American Economic Association Meetings, New York, January 5, 1999. We are grateful to two referees and to the editor, John McMillan, and to Anna Hardman for generous comments and suggestions. We also thank Chris Pissarides for his insightful discussion in New York and Giulio Zanella for useful suggestions. Ioannides acknowledges support from the National Science Foundation and the John D. and Catherine T. MacArthur Foundation. We thank Pamela Jia for expert assistance.

Section 2 of this paper attempts to organize what we have learned from the empirical literature about how individuals go about collecting information for the purpose of finding jobs and how the outcomes are influenced by their social connections. The conventional wisdom that can be garnered from much of the empirical literature on job information networks and neighborhood effects is organized into a number of broad categories of seven stylized facts. Section 3 starts by reviewing the sociology literature on job information networks. It then turns, in subsections 3.2 to 3.5, to models of exogenous job information networks, ones in which individuals obtain job-related information through a given social structure and, in subsection 3.6, to the consequences for job information networks of the recent literature on evolutionary models of information transmission. Section 4 reviews models of endogenous information networks that result from individuals' uncoordinated action, starting in subsection 4.1 with the recent literature on strategic network formation. We then examine, in subsection 4.2, endogenous job information networks. Section 5 sketches the outline of a model that integrates job information networks and the dynamics of human-capital formation and thus provides an overarching theme for the purpose of examining earned income inequality. Section 6 summarizes suggestions for future research and section 7 concludes.

## 2. Stylized Facts about Job Information Networks and Neighborhood Effects

The first generation of empirical work on job information networks established several stylized facts about such networks. The *first* stylized fact is that there is widespread use of friends, relatives, and acquaintances to search for jobs and this has increased over time. About 15 percent of unemployed workers interviewed in the 1970 and 1971 monthly *Current Population Surveys* used

friends and relatives to search for jobs in the preceding four weeks (Thomas Bradshaw 1973). The 1991 and 1992 CPS figures were higher at 23 percent (Steven Bortnick and Michelle Ports 1992; and Ports 1993). Unemployed and employed workers were equally likely to use friends and relatives during periods of job search, according to David Blau (1992) and Blau and Philip Robins (1990). Our own computations using PSID data for 1993,<sup>2</sup> reported in appendix table 1, show that 15.5 percent of the unemployed and 8.5 percent of the employed check with friends and relatives. This is in a sense surprising because economists tend to think of the U.S. economy as being increasingly penetrated by markets, and yet at the same time reliance on friends suggests persistence of personalized exchange.

The *second* stylized fact about job information networks is that the use of friends and relatives to search for jobs often varies by location and by demographic characteristics. The 1971 *Current Population Surveys*,<sup>3</sup> analyzed by Bradshaw (1973), showed that unemployed women were less likely to have checked with friends or relatives to find jobs in the preceding four weeks (12.5 percent) than were men (17.4 percent). The same rough difference prevailed in 1992: 20.0 percent for women and 26.6 percent for men (Ports 1993). See also J. E. Rosenbaum et al. (1999) and Sandra

<sup>2</sup> This is the same data set as used by Corcoran, Datcher, and Duncan (1980). The job-search categories are those employed by the Current Population Survey (Peter Kuhn and Mikal Skuterud 2000). Unlike the European data (see Michelle Pellizzari 2004a), they are not mutually exclusive. Unfortunately, in 1993, relevant questions were not asked of all respondents in the PSID, but of only those actively engaged in job search, who were either unemployed, (5.8 percent of the sample), or on-the-job searchers (8.1 percent of the sample).

<sup>3</sup> Calculations based on data from surveys of individuals are likely to understate the importance of referrals, because they consider only one side of the job market. In fact, the numbers discussed above are affected by adverse selection, as employers are likely to receive referrals from current employees.

Smith (2000).<sup>4</sup> More educated job-seekers were also less likely to use friends and relatives. From appendix table 1, 20.8 percent of the unemployed job-searchers who check with friends and relatives have more than twelve years of schooling, and 23.3 percent had at most eight years. The respective percentages for those searching on the job are 44.8 and 11.6 percent. Clearly, these particular patterns are unlikely to be two sides of the same phenomenon. Indeed, different forces may be affecting workers with more schooling.

Differences in using informal contacts by age, race, and ethnicity show conflicting patterns. According to Ports (1993), about 18 percent of 16–19 year-old job-seekers and 22 percent of 20–24 year-olds checked with friends or relatives, compared to about 26.5 percent of 45–55 year-olds and 55–64 year-olds in 1992. On the other hand, others (Mary Corcoran, Linda Datcher, and Greg Duncan 1980; Peter Marsden and Karen Campbell 1990, and Marsden and Jeanne Hurlbert 1988) reported that use of informal contacts declines with age and/or work experience. Harry Holzer (1987a) found only small racial gaps for younger workers. In his data, roughly 69 percent of white job-seekers ages 16 to 23 used friends and relatives to look for jobs in the previous year (1982) compared to 67 percent of black male job-seekers.<sup>5</sup> More generally, across all age groups, there were small racial differences in

searching through friends or relatives (23.9 for whites and 21.5 for blacks in 1992; Ports 1993). Hispanics, however, used such methods more extensively at 32.8 percent.

Methods of job search also vary by location. James Elliott (1999) looks at workers with no more than twelve years of schooling and finds that those in high-poverty neighborhoods were substantially more likely (88 percent) to use informal job-search methods than those from low-poverty neighborhoods (74 percent). More generally, our own counts with the PSID data show that use of informal contacts increases with the size of the largest city in the county where the household resides. While 40 percent of the respondents live in SMSAs with a largest city of at least 100,000 inhabitants, 65 percent of unemployed job-searchers and 45 percent of employed job-searchers who used friends and relatives resided in such areas (appendix table 2).

The *third* stylized fact about job information networks is that job search through friends and relatives is generally productive. Both employed and unemployed workers who used friends to search for jobs received more offers per contact and accepted more offers per contact than did workers who used other sources of information about job openings (Blau and Robins 1990). This could explain first why about half of all workers heard about their current job through a friend or relative (Corcoran et al. 1980). Summarizing the results of 24 studies, Truman Bewley (1999) estimated that 30 to 60 percent of jobs were found through friends or relatives.

Using friends and family may be productive, not only in finding jobs, but also in improving the quality of the match between firms and workers. Those who found jobs through personal contacts were generally less likely to quit (Datcher 1983, and Theresa Devine and Nicholas Kiefer 1991) and had longer tenure on their jobs (Curtis Simon and John Warner 1992). On the other hand, however, the estimated effects of job contacts on wages vary considerably across

<sup>4</sup> The gender differences may, however, vary according to the type of contact. Marmaros and Sacerdote (2002) report results on the effects of peer and social network on job search using a sample of Dartmouth College seniors. Individuals who were randomly assigned as roommates when freshmen were asked how they use social networking in their job search later on when they reached their senior year. Women were less likely to get fraternity/sorority help, equally likely to get help from relatives, and more likely to use help from professors.

<sup>5</sup> As in the case of gender difference, racial disparity in using informal sources may depend on the type of contact. Marmaros and Sacerdote (2002) report that whites were more likely to report that fraternity/sorority members, relatives, and professors were influential in helping them find a full-time job or career. Racial differences are especially large for the last two categories.

studies. Using their Dartmouth College data, David Marmaros (2001) and Marmaros and Bruce Sacerdote (2002) found large positive correlations between getting help from fraternity/sorority contacts and obtaining prestigious, high-paying jobs. Rosenbaum et al. (1991) reported that workers with contacts enjoyed a wage advantage that increased with age. In contrast, other work has found that an initial wage advantage declined over time (Corcoran et al. 1980; Doug Staiger 1990; Simon and Warner 1992) or found no general initial or persistent earnings effects (William Bridges and Wayne Willemez 1986; Holzer 1987b; Marsden and Hulbert 1988). Adding to the spectrum of results, Louri (2003) and Elliott (1999) showed that at least some types of job contacts were correlated with lower wages.

The *fourth* stylized fact about job information networks is that part of the variation in the productivity of job search by demographic group simply reflects differences in usage. As indicated above, women were less likely to use friends and relatives during job search. This could explain why, according to Corcoran et al. (1980), 52 percent of white men and 47 percent of all women who were household heads or wives ages 45 and under found out about their current job from a friend or relative (see also Smith 2000). Hispanic men report more frequent use of friends and relatives for job search than non-Hispanic whites, and are also significantly more likely to have found out about their most recent job through personal contacts (Smith 2000). Looking at differences as neighborhood income varies, Elliott (1999) showed that less-well educated workers in high-poverty neighborhoods were more likely to use informal contacts and that these contacts were also the main avenue by which these individuals found work. About 73 percent of jobs in neighborhoods with poverty rates of 40 percent or more were found through informal means, compared to 52 percent of jobs in neighborhoods with poverty rates less than 20 percent.

The *fifth* stylized fact is that many differences in productivity of job search by age, gender, race, and ethnic group cannot be completely accounted for by differences in usage. Consider employment effects first. According to Bortnick and Ports (1992), men who were unemployed in a given month in 1991 and who used informal contacts in that month were slightly more likely than their female counterparts to have found jobs (24 compared to 21 percent). The differences between blacks and whites who used informal contacts were more substantial: 15 percent of blacks who were unemployed in a given month in 1991 and who used informal contacts in that month found jobs, compared to 24 percent of whites. According to Sanders Korenman and Susan Turner (1996) (see also Rosenbaum et al. 1999), employed young black inner-city men were less likely to have found their jobs through friends and relatives, even though other analysts report few racial differences in the incidence of use of friends and relatives by job seekers. More specifically, Holzer (1987a) showed that, in 1981, 25 percent of previously unemployed African-Americans ages 16–23, compared to 32 percent for similar whites, obtained jobs through friends and relatives. Most of this discrepancy was due to differences in the likelihood of receiving offers from jobs heard about through friends and relatives. In fact, almost one-fifth of the total difference in probability of gaining employment between black and white youth resulted from racial differences in this probability (see also Smith 2000).

In addition to variation in the relationship between informal contacts and employment across groups, there are many demographic differences in the effects on wages of job search through contacts. Korenman and Turner (1996) reported that, among young workers in inner-city Boston, whites who found jobs through contacts received much larger wage gains, 19 percent higher, than blacks with similar characteristics. Smith

(2000) showed that gender wage differences were small for those using formal job-search methods. In contrast, she found larger wage differences between Hispanics and whites who used personal contacts to find jobs compared to those who used more formal means. Korenman and Turner (1996) replicated the results on Hispanics for a nationally representative sample of urban youth. Elliott (1999) reported that for less-educated workers, the use of informal contacts results in significantly lower wages.

The *sixth* stylized fact is new and needs to be treated as tentative. The internet is being used increasingly for the purpose of job search, at least according to anecdotal evidence. This area is little explored because data are only just starting to become available. According to Kuhn and Skuterud (2000), who use data from a special supplement to the December 1998 *Current Population Survey*, which asked respondents about computer and internet use, 13 percent of unemployed Americans and 7 percent of employed Americans looked for a new job via the internet. However, there appears to be a “digital divide” for the unemployed: only 7 percent of unemployed Hispanic job-seekers looked for jobs online in December 1998, compared with 9 percent of blacks and more than 16 percent of whites. For those employed, the respective figures are 4, 6, and 7 percent. The gender divide is not nearly as stark. Unemployed women used the internet for job search at the same rate as men. Among employed women, 6.7 percent looked for jobs on the internet in December as opposed to 7.6 percent of employed men. However, comparison of the trends in use of traditional methods of job search (*ibid*, table 8, p. 10) suggests that use of public employment agencies has declined from 1994 to 1999, although it is overrepresented among internet job-seekers in December 1998 (*op. cit.*, table 7, p. 9). While we will not pursue this angle further in this paper, we underscore that models of job search will need to accommodate this

new technology. We argue in section 6 that this is an important issue for future research.

The *seventh* stylized fact is also new but arguably more robust than the sixth. There appear to be important differences across countries in the use of personal contacts by both firms and workers. Pellizzari (2004a) explores the empirical evidence for the countries of the European Union as of 2003 (with the exception of Sweden)<sup>6</sup> using the European Community Household Panel and compares with the United States using the National Longitudinal Survey of Youth (NLSY). Pellizzari finds large cross-country and cross-industry variation in the wage differentials between jobs found through formal and informal methods. Across countries and industries, premiums and penalties are equally frequent. Pellizzari attributes these differences to different recruitment strategies by firms. However, such differences could be attributable to both different institutional and social practices which may compound the impact of differences in industrial compositions of economies.

Taken together, these stylized facts imply that the role of information networks in the job search process is not straightforward. Neither is it always clear a priori why some groups rely more on informal methods than others, nor why the pattern of employment and earnings payoffs to networks varies across groups. Moreover, recent research indicates that these stylized facts do not exhaust the range of effects of job-search networks. For example, what effects do contacts have on wage and employment inequality, the duration of unemployment, and labor-market withdrawal?

More generally, a common problem underlies much of the literature on job contact use and the correlation of job contacts with labor-market outcomes. It often (though not always) fails to be well-grounded

<sup>6</sup> The exception of Sweden is unfortunate because including it might have provided an important benchmark: all job openings are centrally registered in Sweden.



in economic or other theory about how networks form or under what circumstances networks are likely to have their largest effects. In filling this vacuum, much of the more recent detailed research into job networks (discussed below) points to four important considerations—employer, relational, contact, and worker heterogeneity. Employer characteristics determine the context in which job search methods operate. For some employers, desired applicant characteristics may be easily discernible, while for other employers recommendations from trusted sources may provide better information. Contact and relational heterogeneity respectively denote variations in the resource endowments of one's associates and the social relationships that allow individuals to claim access to resources possessed by their associates. Worker heterogeneity refers to differences in worker productivity or other characteristics. It interacts with all three of the other areas in determining access to contacts and employers.

Without the appropriate theoretical grounding that pinpoints the role of these four considerations, it is difficult, for example, to interpret demographic variation in contacts use. Does lower contact use by women constitute a problem of access to the best job opportunities, or does it reflect differences in the ease of observing the types of skills with which many women enter the labor market? Does higher contact use by Hispanics than blacks signal high-quality contacts and, therefore, greater returns to informal compared to formal methods for Hispanics? On the other hand, does it imply an absence of job information alternatives for Hispanics who are forced to rely on informal sources as, in some cases, the only means of finding jobs? Interpreting differences in effects of contacts on labor-market outcomes generates similar ambiguity. Is the larger positive correlation between wages and using contacts for whites compared to blacks reported by some analysts spurious?

That is, do white workers earn more with or without using contacts due to higher levels of unobserved productivity? Does the correlation arise simply because contacts are more likely to pass on job information to such workers? Alternatively, do whites gain more from contacts than blacks because their contacts have access to more information about better-quality jobs? As the remainder of this article indicates, all four of these elements—employer, relational, contact, and worker heterogeneity—are critical to understanding this myriad of commonly observed findings as well as to extending the role of job networks to account for other labor-market outcomes.

### 3. *Job Information Networks*

One of the objectives of this essay is to actually identify and explore mutual influences and patterns of interplay between the literatures on social networks in economics and sociology, with particular emphasis on social networks that have consequences for the job market. In sociology, the concept of a network and use of network models is standard (Ronald Burt 1980). Usage of the term networks is perhaps as ubiquitous as that of markets in economics and is used in a comparably broad range of contexts. In economics, one the other hand, network refers to “personalized exchange among many agents” (Samuel Kortum 2003). The central importance of networks to sociology has forced it to define economic networks more precisely as: 1) particular patterns in economic exchanges; 2) indications of “primordial” relationships among agents, and 3) “structures of mutual orientation” (Ezra Zuckerman 2003). The third definition encompasses the previous two as special cases: it allows for social ties that differ in terms of “type, valence and strength of connection” (ibid). Networks in sociology are not just an important descriptive device but also a tool to explore direction of causality and the role of unobserved heterogeneity.

In contrast to the extensive treatment of networks by sociologists, economists' formal as well as qualitative understanding of the role of networks is much less developed. There has also been influence in the other direction, however, from economics to sociology. In at least one instance, articulation of patterns in interpersonal interactions relevant to economic outcomes by economists has influenced sociological methodology. This is the case with the concept of social capital, which is particularly relevant in our context. Social capital was originally defined by Glenn Loury (1977) as the set of resources resulting from family relationships and community social organization that affect the cognitive and social development of the young. It has found much fertile ground in sociology. James Coleman (1990), who helped popularize the concept, treats social capital as a form of social organization created when the structure of relations among persons facilitates action making possible the achievement of certain ends that in its absence would not be possible (*ibid.*, p. 300). The term social capital is now used quite commonly to refer to the web of connections individuals use in daily life and is therefore important to mention here.<sup>7</sup> Some economists use the terms social capital and social networks almost interchangeably, which for reasons of clarity we do not adopt in the remainder of this essay.

Another instance of interplay between economics and sociology is found in the most recent economics literature on job information networks and reflects the influence of the empirical findings of Mark Granovetter (1974:1995). Granovetter's

empirical findings in support of the role of weak contacts are widely cited in both the economics and sociology literature. The second edition (1995) of this book contains a review of the evidence since the 1974 study. Granovetter argues that the voluminous evidence that has accumulated since 1974 continues to support his book's original thesis that social networks are very important in helping people to find jobs and employers to find prospective employees. In particular, local contacts, "weak ties," help women "in women's occupations" locate jobs, and that "networking is crucial for expanding women's opportunities in male-dominated occupations" (*ibid.*, p. 170). He concludes that in spite of "an outpouring of research," we still know little about the complex network processes by which "inequities are produced and reproduced."

This paper is focused on job information networks as patterns of exchange of job-related information. We look at these patterns either as given ("primordial"), or as the outcome of deliberate decisions by individuals to help us untangle the complex and seemingly contradictory findings about use of job information networks in the labor-market context and their effects on employment and wages. The paper shows how network considerations imply different outcomes than the simple one-to-one search models that typify most economic analyses of job acquisition.

### 3.1 *The Sociology Literature on Job Information Networks*

The sociological literature includes a rich array of analysis of three of the categories of job network effects—employer, contact, and relational heterogeneity. Much of the initial research to explain the operation of job networks focused on relational heterogeneity. Granovetter (1974:1995) argued that a key characteristic determining the effect of job networks on finding employment is the strength of *social ties*. Roughly speaking, strong links join close friends and weak links join acquaintances. Strong links

<sup>7</sup> The notion of social capital has been used extensively to account for a wide variety of outcomes (Partha Dasgupta and Ismail Serageldin 2000; Robert Putnam 2000; Edward Glaeser et al. 2000). The two key elements of social capital include the resource endowments of one's associates and the "social relationship itself that allows individuals to claim access to resources possessed by their associates" (Alejandro Portes 1998; Glaeser et al. 2000; Putnam 2000). Additional evidence of the popularity of the concept is given by Markus Möbius (2001), who uses the terms social capital and social networks interchangeably.

tend to traverse a society “slowly.” If you start with an arbitrary person and develop the network of links to her close friends, and then to the close friends of her close friends and continue in this manner, then the overall size of the group grows slowly. The close friends of my friends are likely to be my close friends too. Societies of closely knit relations are likely to develop a large number of closely knit groups. If, on the other hand, we track my acquaintances and their acquaintances in turn, it is less likely that the acquaintances of my acquaintances are also my own acquaintances. As sociological research has measured (Stanley Milgram 1967) and random graph theory has demonstrated (E. M. Palmer 1985; Mark Newman 2003) any two individuals in the United States can be connected by as few as six weak links. So, the overall size of the group of interconnected individuals will grow faster with weak ties. Sheridan Dodd, Roby Muhamad, and Duncan Watts (2003) show, based on a recent global internet-based social search experiment, that successful social search is conducted primarily through intermediate-to-weak strength ties, relies disproportionately on professional relationships, and reaches its destination in a median five-to-seven steps, depending on the actual distance between source and target.

Granovetter’s original work and the 1995 edition of the 1974 study have been read very widely. Within sociology the notion of tie strength has been incorporated into more general analyses of job networks and social capital. Yet, Granovetter’s work has been much less influential in promoting modelling of job information networks within economics. This is not so surprising: economists are typically more likely to be interested in *why* a network forms, whereas sociologists take the existence of networks as *given* and study their effects. In the first subsection below, we explore our understanding of job information networks from the interplay between the sociology and economics literatures. Then we turn to the eco-

nomics literature on exogenous job information networks and on neighborhood effects that have consequences for job markets.

The notion of weak versus strong ties is, of course, one of the most important concepts that have motivated the literature on the effects of social contacts on job outcomes. Burt (1992) argues that, while tie strength is correlated with information benefits, the true causal agent in social networks is the *structural hole*. Burt defines a structural hole as the “gap,” the separation, between nonredundant contacts. Regardless of tie strength, individuals located at structural holes provide a bridge for information to flow between groups that would otherwise not have access to each other. For example, suppose group A consists of individuals who often contact each other and would be considered to have strong ties in the Granovetter framework. The same is true for the members of group B. Group A is linked to group B only through the individual at a structural hole in group A. This link allows information to flow between otherwise inaccessible groups. Note, however, that the relationship between the group A individual at a structural hole and his nonredundant contact in group B may be strong or weak. The key factor is not the strength of the tie but that the individual occupying the structural hole bridges the gap between groups A and B. The structural holes argument<sup>8</sup> implies that: 1) a network with more nonredundant contacts can provide more information than the same size network with redundant contacts; and, 2) a network with a given number of nonredundant contacts provides more information if, in turn, those contacts “reach separate and therefore more diverse social worlds” (ibid, p. 21 ).

<sup>8</sup> As an aside, to economists this argument is akin to an arbitrage-type argument and thus amenable, in principle, to analytical treatment. A very recent paper by Sanjeev Goyal and Fernando Vega-Redondo (2004) applies the strategic network formation approach to the concept of a structural hole. A noteworthy result here is, as we discuss further below, that if the cost for forming links is not very small, the unique equilibrium network is a star.



Burt (2001) also argues that the nonredundant information that structural holes possess is better communicated to, and acted upon, in networks with closure. He defines closure as “social capital” that is created by a network of strongly interconnected elements. With high levels of *closure*, everyone is cohesively connected to everyone else within the network. Information passed to a subgroup within the network quickly finds its way to the remainder of the network. When there is *closure*, referred workers may have higher job productivity because their reputation within the network is more contingent on their performance.

Why does closure, whereby agents are effectively interconnected in a cyclical fashion (Coleman 1990), and not just social connectedness play such a key role in sociological thinking? Here is a guess. Consider a social setting where people tend to imitate one another, as in the spread of a fashion. When everyone is directly connected with everyone else, different individuals starting fads are unlikely to have decisive influence on each other. Alternatively, consider individuals connected along a path—where each individual is connected to two others and there are two end agents—in which case everyone is at least indirectly connected with everyone else. Such an arrangement confers a modicum of influence to the two end agents, whose own actions are influenced by one other agent only. If those two end individuals were to be connected so that the topology of the social structure becomes a wheel, there is no longer any influence to be conferred by the topology of the social structure as such, and this is accomplished with the minimum total number of connections.

In spite of its popularity, the sociological concept of closure is to the best of our knowledge not very rigorously developed. An exception is Steffen Lippert and Giancarlo Spagnolo (2004), who provide rigorous support for the disciplining role of closure in sociology by means of a game-

theoretic model of networks of relational contracts. They examine networks of relations under different informational regimes, paying special attention to differences between circular and noncircular architectures. If agents cannot discipline themselves within a certain relation and are allowed to have relations with only two other agents (“neighbors”), a “circular pooling of asymmetries” made possible by a social network may end up sustaining all the relationships in equilibrium.

There are properties of social structures that have been attributed to closure that may instead be explained by symmetry in the network that represents social structure, rather than closure.<sup>9</sup> For example, this is the case when individuals who act similarly are more likely to be connected with one another than with others who act differently. Such patterns of correlation in the behavior of connected individuals resemble spatial waves and exhibit clustering. Clearly, this is an area where additional research would be very fruitful.

Other sociological research contends that the role of relational heterogeneity cannot be fully understood without taking into account the role of social setting or contact heterogeneity. Nan Lin’s (2001) “strength of position” proposition argues that individuals are more likely to associate with others in similar social and occupational positions; in other words, they sort. This proposition implies that social networks develop along dimensions such as race, ethnicity, religious affiliation, and education. The emphasis in Lin’s work is on the characteristics of the contacts themselves. Lin’s “social capital” proposition claims that contacts who possess, or have access to, more highly valued

<sup>9</sup> Ioannides (2001) shows that symmetry—technically speaking, all individuals’ being connected to the same number of other individuals—ensures that the maximal eigenvalue of the corresponding graph is equal to the number of neighbors. Therefore, if individuals are influenced by the average action among those they are connected with, then the respective dynamical system has an eigenvalue of 1 and an associated eigenvector that consists of 1’s, which ensures (relative) persistence.

resources improve outcomes for job-seekers more than other less well-placed contacts.

Lin, Vaughn, and Ensle (1981) and Lin, Ensle, and Vaughn (1981) report that the family background, education, and early occupational status of job-seekers all influence the occupational status of the contacts they can use. Furthermore, the occupational status of these contacts alters the prestige that job-seekers obtain. In related work, F. Carson Mencken and Idee Winfield (2000) emphasize that women who found their jobs through informal contacts and who used male contacts were less likely to work in female-dominated occupations. Echoing Mencken and Winfield, John Beggs and Hurlbert (1997) indicate that the gender of the informal contact tie affects occupational status. Women whose contacts are other women work in occupations with lower socioeconomic index scores. Evidence of correlation between contact characteristics and job contact effects is not, however, uniform. While Marsden and Hurlbert agree with Lin, Vaughn, and Ensle (1981) and with Lin, Ensle, and Vaughn (1981) with respect to occupational prestige, they conclude that "the net effects of the social resource variables (for other outcomes such as wages) can be summarized simply: there are none." They conclude that these findings are consistent with those of Bridges and Villemez (1986), who find no effects of tie strength on income.

The third branch of sociological research examines the role of employer heterogeneity on contact effects. It points to important differences in the use of referrals in different industries, perhaps reflecting differences in corporate culture. The sociology research in this area appears to be ahead of its counterpart in economics in assessing the consequences of employer heterogeneity. According to Roberto Fernandez and Emilio Castilla (2001), employers reap returns from referrals for three reasons. Referrals provide a large pool of qualified applicants so that less screening is required to fill positions. Referred applicants have

more information about the nonpecuniary aspects of employment and, therefore, are potentially better matches. Finally, connections between new hires and incumbent employees can make the job transition smoother, as well as create additional loyalties and attachments to the job. More generally, Peter Marsden and Elizabeth Gorman (2001) argue that information provided to employers through referrals may reduce employer uncertainty about the prospective worker's productivity.

The effects of job contact information are, therefore, likely to be higher in firms and industries where high-quality information about workers' likely performance is important. These include conditions "when performance and skills are difficult to observe, when staffing strategy is flexible, when the use of networks is a central component of performance, and when selection errors are costly (p. 108)." Consistent with this prediction, Marsden and Gorman present evidence that contacts are more likely to be used when filling managerial, professional, or sale/service positions and are less likely to be used in the public sector and in establishments that are part of multi-site firms. Complementary work by Elliott (1999) found differences in informal contacts by occupation. General laborers (defined as all nontechnical positions lacking managerial authority, 1990 Census Occupation Codes 243-902) and those in managerial positions who found their jobs through informal contacts had significantly lower wages than those who found their jobs without an active search.

Intrafirm analyses of job contact effects also point to the importance of context. Trond Petersen, Ishak Saporta, and Marc-David Seidel (2000) use data on all 35,229 job applicants to a mid-sized high-technology organization and find that all differences in job offers that are attributed to gender disappear once age and education are accounted for. Similarly, all effects of race disappear once the referral method is taken into account. That is, when one controls only

for age, education, and rating at first interview, race has a strong impact on the likelihood of having a second interview and on the increase in the salary offer. In their data, personal and professional contacts account for 60.4 percent of applicants and 80.8 of those receiving offers, and there is also an effect of being contacted by headhunters. Thus, the apparent and perhaps real meritocracy characterizing the high-technology industry raises additional questions on the role of access to job information networks as a force in persistent inequality.

Using data from a high-technology firm, Joel Podolny and James Baron (1997) find that intra-organizational mobility is enhanced by having a large network of informal ties that supply access to information and resources. Yet, availability of a small dense network of social contacts with high closure and cohesiveness is no less important in helping shape one's organizational identity and career goal expectations. This highlights the importance of how social network structure and content interact in determining careers within organizations.

Differences between industries and employers may also account for ethnic and race variations in contact effects. Roger Waldinger (1996) shows that, both historically and currently, ethnic groups have established specific occupational and employment niches that facilitate employment and training of members of their group and that limit access of outsiders. Ethnic newcomers to New York found their way to the bottom of the job ladder associated with the niche and then gradually work their way upward through the specialized economic activities associated with the niche. Early examples of ethnic niches include Jews in commerce and clothing manufacture and Italians in laboring jobs in construction and longshoreman work. More recently, occupational niches include African-Americans in the public sector, West Indians in hospitals, nursing homes, and health services, Chinese in restaurants, laundries, the garment trade,

and small-scale retail trade, and Dominicans in garments, restaurants, hotels, and a few other light manufacturing and retail trades.

These ethnic-group niches have important implications for the usefulness of job contacts and connections for ethnic-group members entering the labor market or changing jobs. Consider, for example, the large concentration of African-Americans in public service. On the plus side, it reduces their experience of discrimination and thus raises black earnings relative to whites. Resulting job contacts and connections may lead to a greater likelihood of job offers and to more rapid career advancement upon accepting the offers. On the minus side, the large concentration of African-Americans in the public sector is mirrored by their declining presence in the private sector and thus is associated with lower access to contacts, networks, and training opportunities. Moreover, if the public sector niches held by African-Americans require relatively high levels of skill, job information about these niches may not be especially useful for low-skilled African-Americans.

### 3.2 *Models of Exogenous Job Information Networks*

Models derived from research by economists on exogenous job networks have outlined the specific implications of social structure in more detail than some of the sociological work described above. By exogenous, we mean that the network of connections (or, in more mathematical language, the graph that describes these connections) among individuals is given. Dale Mortensen and Tara Vishwanath (1994) show that the equilibrium wage distribution increases with the probability that the offer is from a contact. Their argument is based on the premise that wages received from jobs found through contacts reflect the distribution of wages earned by individuals who are in contact with one another. This distribution, in turn, stochastically dominates the distribution of wage offers across employers. Like Bridges

and Villemez (1986) referred to earlier, James Montgomery (1992) examines the link between wages and tie strength and concludes that, while weak ties increase reservation wages, this does not imply a similar “relationship between wages and the type of tie actually used to find a job.” Intuitively, weak ties are more likely to generate offers than strong ties. Workers who accept weak-tie offers are likely therefore to have received fewer total offers and be less selective in the jobs that they choose than those who accept strong-tie offers. This indicates that the empirical finding of no relationship between tie strength and wages in the Bridges and Villemez study does not imply that tie strength is irrelevant for determining job outcomes. Montgomery’s work is a notable example of research by an economist that has helped bridge the gap between economics and sociology in this area.

A number of more general models examine additional detail about the interaction between contact and relational heterogeneity. They highlight the specific characteristics of relations between contacts and job seekers that alter contact effects. An example of such a model is Montgomery (1991), who suggests that the main social component is *inbreeding social bias*. That is, each person is more likely to have a social tie to a younger person of the same type as herself. Thus, a social tie implies that a referral possesses informational value. In Montgomery’s model, each individual lives for two periods, making an education decision in the first period, which is observable, and working in the second. Individuals may be of two types. Each individual knows at most one person in the older (and currently employed) generation, possessing a social tie with probability  $\tau$ . Conditional on holding a social tie, a worker knows someone of the same type with probability  $\alpha$ ,  $\alpha \leq \frac{1}{2}$ . Some young persons may have several social ties while others have none. Those who do have social ties receive offers from the employers of their acquaintances, but

those who do not are hired through the formal market. Firms may choose technology that makes either type fully productive, except that choice along with that of the wage rate must be made before the worker’s type is known.

The model is closed by equating the percentage of those educated with the percentage of those facing education costs who find it advantageous to acquire information. The possibility of multiple equilibria depends critically upon the properties of the distribution of education costs across the population. A key element in Montgomery’s theory is the derivation of the probability that an individual with a referral accepts a job offer, as a function of the offer:  $a(w) = e^{-\tau n(1-F(w))}$ , where  $F(w)$  is the distribution function of referral wage offers and  $n$  the steady-state fraction of educated workers. In this model, a higher probability of a social tie and a higher percentage of educated workers decrease the probability of acceptance but increase wage dispersion. While the former is a straightforward supply effect, the latter is subtle. Increased inbreeding by a group is shown to be associated with larger differences from other groups. Selection operates over time via network density parameters and inbreeding. Individuals pass on their advantages to kin and social acquaintances. These factors work to perpetuate and strengthen inequality over time. Kenneth Arrow and Ron Borzekowski (2004) show by means of simulations that differences in the number of ties workers have with firms can induce substantial inequality and can explain roughly 15 percent of the unexplained variation in wages and a substantial part of the disparity between black and white income distributions.

Kaivan Munshi (2002) studies transmission of job information among Mexican migrants to the U.S. labor market. He uses a model of referrals similar to Montgomery’s and examines changes in the size and vintage within given destination communities in order to determine whether those characteristics

affect migrant employment. His findings confirm that community-based social interactions are important in matching Mexican migrants and U.S. firms, and appear to improve labor-market outcomes among migrants, with smaller and younger networks substantially reducing the employment probabilities of Mexican migrants.

Montgomery (1994) models the impact of social interaction on employment transitions and inequality in a way that links the notion of strong versus weak ties to the social structure. In his model, social structure consists of a large number of small groups, or *dyads*, groups of two connected individuals. In each dyad, both members are employed, or only one is employed, or both are unemployed. The relationship between two members of a dyad is a strong tie. Individuals interact with others at a rate  $\tau$  per unit of time, and such interaction may lead to a match with one's dyad partner with probability  $\omega$ , or it may lead to a random match with someone else from the entire population, with probability  $1-\omega$ . In the latter case, because of random matching, the individual has an infinitesimal probability of interacting again with the same person. For this reason, random matches are construed as weak ties. By varying the probability of interaction with one's strong tie, one may, in effect, model different social settings. Jobs break up randomly at a rate  $\delta$ , so that either a strong or weak tie may be employed or unemployed. The job finding rate for each person depends on the employment status of her contact and on her general ability to collect information on job openings. Although individuals who make up each dyad do not change over time, their employment status does change and so does the employment situation in each dyad.<sup>10</sup> As in Montgomery's earlier work, social interactions are characterized by inbreeding bias, whereby an unemployed individual's random match contact is

employed with probability less than or equal to the average employment rate in the population. The combination of a rigid social structure with inbreeding bias in employment status implies that random matching is less useful to individuals and the employment status of one's dyad partner is critical. Using this model, Montgomery shows that a higher proportion of weak-tie interactions reduces employment inequality. It also increases the steady state employment rate, provided that inbreeding by employment status among weak ties is sufficiently small.

It would be interesting to generalize the model of social structure employed by Montgomery, by assuming groups of different sizes. For example, one may invoke a random graphs setting (Paul Erdős and Alfred Renyi 1960; Ioannides 1997), where a fraction of the entire economy may be in groups whose sizes are denumerable but possibly large. However, unless membership to groups of different sizes confers particular advantages of a permanent nature with consequences for economic inequality, such as permanent effects on the incidence of unemployment, a model with a more complicated size distribution of social groups will not add much to the story. The literature must also address the fact that the availability of different informational technologies might provide incentives for strategic behavior by individuals in possession of job-related information. Such strategic issues in information dissemination are not well understood. This is particularly evident, as we see further below, when social networks are the outcome of individual uncoordinated decisions.<sup>11</sup>

### 3.3 *The Work of Calvó-Armegnol and Jackson*

Two recent path-breaking papers, Antoni Calvó-Armegnol and Matthew Jackson (2002;

<sup>10</sup> Calvó-Armegnol, Thierry Verdier, and Yves Zenou (2004) explore the concept of a dyad in the context of the labor market and, in addition, introduce criminal activities as an option within a given social structure.

<sup>11</sup> In a world where individuals have established relations with one another, the resulting social structure may display certain "holes." Such *structural holes* offer entrepreneurial opportunities for information access, timing referrals and control. See Burt (1992).



2003), explore the implications of exogenous information networks. Both papers use the following model of the transmission of job information among workers. A network of contacts among  $n$  individuals, the social structure, is defined by means of an  $n \times n$  matrix  $\mathbf{G}$ , of intensities of social attachments:  $g_{ij} > 0$ , if  $i$  is linked to  $j$ ;  $g_{ij} = 0$ , if  $i$  is not linked to  $j$ . This formulation combines the notion of an adjacency matrix in graphs with the notion of varying intensities of social contacts and allows for the network to be directed. That is, if individual  $i$  hears of a job opening, she tells individual  $j$  if  $g_{ij} > 0$ . However, unless  $g_{ji} > 0$ , individual  $j$  will not pass on such information to  $i$ . The transmission of job information to each worker through the network at the beginning of each period results in new employment. An unemployed individual who hears of a job opening keeps it to himself. An employed individual who hears of a job opening passes it on to each of her social contacts with probabilities that are proportional to the respective relative weights. For example, an individual  $i$ 's unemployed contact  $j$  will hear from  $i$  with probability equal to the product of the probability that  $i$  hears directly of a job opening, which is assumed to be a function of all agents' wages in the previous period, times the relative weight of  $j$ 's social strength, which is equal to  $g_{ij}$  divided by the sum of the weights of all contacts who are unemployed. The weights of social attachment express a continuous counterpart of Granovetter's notion of strong versus weak ties, and thus generalize it.

Calvó-Armegnol and Jackson (2002) assume that the expected number of offers that agent  $i$  receives is a nondecreasing function of the wages of that agent's contacts in the previous period and a nonincreasing one in agent  $i$ 's own wage. These assumptions imply a set of "altruistic" values about social exchange that influences the passing around of job-related information. Calvó-Armegnol and Jackson determine an agent's wage by assuming that it is a nondecreasing function of the past wage and of

the number of employment opportunities the agent has in hand. This function allows for substitution among previous wage status and current employment prospects. Turnover in the job market is ensured by random breakup of jobs. The paper distinguishes the effect of social connectedness (one agent's expected job offer is sensitive to another agent's past wage and vice versa), and the passing of job-related information between agents.

Using this model, Calvó-Armegnol and Jackson develop explanations for several important stylized facts about labor markets. First, information passed from employed individuals to their unemployed acquaintances makes it more likely that their acquaintances will become employed. This generates positive correlation between employment and wages of networked individuals *within* and *across* periods. Second, duration dependence and persistence in unemployment may be explained by recognizing that when an individual's direct and indirect social contacts are unemployed, the likelihood of obtaining information about jobs through contacts is reduced. Such duration dependence is well-documented; see, for example, Devine and Kiefer (1991), Lisa Lynch (1989), and Gerard van der Berg and Jan van Ours (1996). Third, the likelihood of dropping out of the labor force is higher for an individual whose social contacts have poor employment experience. This can lead to substantial differences in drop-out rates across groups. Moreover, small differences in initial conditions of different individuals and in network structure can lead to large differences in drop-out rates. Fourth, higher initial drop-out rates for a set of networked individuals imply that its short-run as well as its steady state distribution of unemployment and wages will be worse (in the sense of first-order stochastic dominance). Contagion effects then cause inequality in wages and employment, because those remaining in the labor force will have fewer direct and indirect acquaintances on the job,

and that in turn will hamper their job information prospects. It is hard to explain such an effect outside of a social network model.

Particularly noteworthy are results that Calvó-Armegnol and Jackson (2002) obtain about the key role of drop-out rates. To do so, they work with a specific case of the model in Calvó-Armegnol and Jackson (2003). In it, all jobs are identical and they offer equal wage rates. Only one agent receives information about a job opening and only if she is unemployed. The paper presents a number of examples, each with different explicit structures, that help demonstrate the subtle role of networks. For example, if three agents are connected according to a path, the two end agents are competitors for job information in the short run, but their outcomes are positively correlated in the long run. That is so because their presence helps the center agent return to employment if she becomes unemployed. With more complex social network topologies, an agent's likelihood of being unemployed depends on her position within the network. The average unemployment rate increases with "close-knitnes," because more extensive social ties make possible greater diversification of information sources. Calvó-Armegnol and Jackson prove that, under certain general conditions, employment status across any arbitrary periods is correlated among all interconnected agents and that there is duration dependence in unemployment.

These authors explain duration dependence as a social effect: the longer an individual is unemployed the more likely it is that her "social environment is poor," making future employment prospects unfavorable. This explanation for duration dependence complements the more commonly stated ones, such as unobserved heterogeneity and the like. This effect, essentially a network externality, is also responsible for stickiness in aggregate employment dynamics. The closer the economy is to very high employment (or unemployment), the harder it is to

leave that state. For similar reasons, parts of the economy can experience a boom while simultaneously other parts of the economy are experiencing a bust.

Differences in initial conditions combine with differences in the collective employment histories and with different network dynamics of two otherwise identical networks to produce sustained inequality of wages and drop-out rates that feed on each other. So, in the model of the two Calvó-Armegnol and Jackson papers, history matters and is responsible for producing income inequality for reasons that are very different from those due to inequalities in human-capital investments (Loury 1981), or in access to community-based opportunities (Steven Durlauf 1996a,b). This implies that interventions in the labor market, such as providing incentives for individuals not to drop out, are likely to have long-lasting effects.

The design of such interventions should reflect the topology of the network. It would be more effective to target groups of agents who are highly connected, taking advantage of social attachment effects among agents, instead of targeting the same number of uniformly connected individuals.<sup>12</sup> Similarly, institutions that seek to "network" otherwise isolated individuals can potentially bring about socially desirable outcomes.<sup>13</sup> These results depend on essentially altruistic assumptions about social exchange in the context of social interactions, in ways that are conceptually similar to spatial interactions as modelled by Thomas Schelling (1971, 1978).

### 3.4 *Proximity, Information Sharing, and Neighborhood Effects*

Several recent economic studies emphasize network effects as neighborhood

<sup>12</sup> Unfortunately, the technical problem of finding which individuals should be targeted is computationally very difficult in general (David Kempe, Jon Kleinberg, and Éva Tardos 2003).

<sup>13</sup> The importance of network effects on the drop-out rate is also argued by D. Lee Heavner and Lance Lochner (2002), though the results are not as dramatic.

effects: they examine whether it is appropriate to associate geographic proximity with facilitation of information flow. This question, of course, is identical to the question addressed by the empirical literature on the economics of social interactions. Even if we have compelling evidence of correlations in the behavior of individuals who are in physical and social proximity to one another, we wish to know what explains such correlations. That is, we wish to know whether we see correlations among such individuals because they share the same sources of information (a correlated effect), because they share individual characteristics as a result of self-selection (a contextual, or exogenous social, effect), or because they learn from one another's behavior (an endogenous social effect) (Charles Manski 2000).

Georgio Topa (2001) finds geographic correlations in patterns of unemployment across neighborhoods and cites them as evidence of positive correlation between employment and wages of networked individuals. He points out that high unemployment rates were concentrated in relatively few areas of Chicago in 1980 and 1990. Using census tracts as units of observation, he assumes that residents of adjacent tracts exchange job information. He finds that high unemployment in one tract is associated with more unemployment in neighboring tracts than can be explained by the characteristics of the neighboring tracts alone. Timothy Conley and Topa (2003a) find that socioeconomic characteristics (and in particular ethnic and occupational distance) explain a substantial component of the spatial dependence in unemployment. Using similar data for the Los Angeles Standard Metropolitan Statistical Area (SMSA), Conley and Topa (2003b) show that local interactions perform well in explaining the spatial correlation patterns present. In addition, using data on the distribution of individual unemployment spells in-progress, they show that their model of

interactions is consistent with the Calvó-Armegnol and Jackson (2003) explanation of duration dependence in unemployment discussed above.

A conceptually related study by Peter Hedström, Ann-Sofie Kolm, and Yvonne Åberg (2003) emphasizes transitions out of unemployment, using the Pissarides model (Pissarides 2000) with data on *all* 20- to 24-year-olds living in Stockholm during the 1990s. Both of those papers produce evidence for partial identification of social interactions in unemployment.

Bruce Weinberg, Patricia Reagan, and Jeffrey Yankow (2000) provide some evidence of non-monotonic neighborhood effects on labor-market outcomes. They link confidential street address data from the NLSY79 with measures of neighborhood social characteristics at the census tract level for 1990 and measures of job proximity based on the 1987 censuses of manufacturing, retail trade, and services. They show that one standard deviation increase in neighborhood social characteristics and in job proximity raises individuals' hours worked by 6 percent and 4 percent in the average, respectively. Such social interactions have nonlinear effects. The greatest impact is in the worst neighborhoods. Being in a disadvantaged neighborhood is more important than the labor activity of one's neighbors *per se*. Social interaction effects are also larger for less-educated individuals and for Hispanics, but not for blacks compared to whites.

While these works are in broad agreement, recent research by Philip Oreopoulos (2003) finds that when neighborhoods are not selected, neighborhood quality plays *little* role in determining a youth's eventual earnings, likelihood of unemployment, and welfare participation. In contrast, family differences, as measured by sibling outcome correlations in a relatively homogeneous sample of low-income families living in Toronto public housing, account for up to 30 percent of the total variance in earnings. These findings are particularly significant

because the respondents in that study had been administratively assigned to different public-housing residences, and therefore the assignment process should have removed much of the selection across neighborhood types, according to the author.

The recent study that makes the strongest and most compelling case to date for the effects of geographical proximity on job market outcomes is Patrick Bayer, Stephen Ross, and Georgio Topa (2004). They document that people who live close to each other, defined as living in the same census block, also tend to work together, defined as working in the same census block: the baseline probability of working together is 0.93 percent compared to 0.51 percent at the block-group level (a collection of ten contiguous blocks). Their findings are robust to the introduction of individual controls in the form of a number of socio-demographic characteristics and block-group fixed effects. More specifically, these authors examine the hypothesis that agents interact very locally with their social contacts, exchanging information about jobs. Let:  $i$  and  $j$  be individuals who reside in the same census block group but not in the same household;  $W_{ij}^b$  a dummy variable that is equal to one, if  $i$  and  $j$  work in the same census block;  $R_{ij}^b$  is a dummy variable that is equal to one, if  $i$  and  $j$  reside in the same census block;  $X_{ij}$  a vector of socio-demographic characteristics for a matched pair (a concept to be clarified shortly below) ( $i, j$ ); and,  $\rho_g$  a residential block-group fixed effect which serves as the baseline probability of an employment match for individuals living in the same block group. Then their hypothesis may be examined in terms of a regression:

$$W_{ij}^b = \rho_g + \beta'X_{ij} + (\alpha_0 + \alpha_1'X_{ij}) \cdot R_{ij}^b + \varepsilon_{ij}. \quad (1)$$

These authors' test for the presence of social interactions due to proximity boils down to testing for the statistical significance of the term  $(\hat{\alpha}_0 + \hat{\alpha}_1'X_{ij})$ . They include both the baseline probability  $\hat{\rho}_g$  and matched pair's covariates in levels,  $\beta'X_{ij}$ , to control for any observed and unobserved factors that may

influence employment locational choices at the block-group level. For example, this controls for features of the urban transportation network that might induce clustering in both residence and work location. Also, worker characteristics might be correlated with both residential location preferences and work location, if firms sort along the same variables. Their empirical strategy addresses several additional potential pitfalls, including possible sorting below the block level and the possibility of reverse causation. After they estimate the social interactions effect they consider whether the quality of the matches available in an individual's block affects employment, labor-force participation, and wage outcomes.

Bayer, Ross, and Topa use data from the 1990 U.S. Census for the Boston metropolitan area for all households that responded to the long U.S. Census form, and choose individuals who did not reside in the same household, were U.S.-born and aged between 25 to 59, and employed at the time, thus ending up with 110,000 observations. From these data, about four million observations on matched pairs were constructed by matching up individuals in pairs, in a city with 2,565 block groups with an average of ten blocks each.

Bayer et al. find that social interactions are stronger when a pair of individuals are more likely to interact because of education, age, and the presence of children<sup>14</sup>; interactions are stronger when one of the two individuals is strongly attached to the labor market, and are weaker when both are drop-outs, young, or married females. In terms of the magnitude of the impact of match quality, a one standard deviation increase in referral opportunities raises labor-force participation by one percentage point, weeks worked by about two thirds of one week, and earnings by about two percentage points. This study is also significant for its reliance on different geographical scales for identification.

<sup>14</sup> Assortative matching of this type in social networks has been documented by Peter Marsden (1987).

Two other studies, which preceded Bayer et al., sought to identify “network effects” by using concepts of proximity similar to those of Bayer et al. Both seek to establish that individuals in close proximity share information. Therefore, they are not only methodologically similar to Bayer et al. but also relevant to those interested in establishing information sharing among individuals in close proximity to one another. Marianne Bertrand, Erzo Luttmer, and Sendhil Mullainathan (2000) consider the impact of social networks on welfare participation. They emphasize methods that allow them to distinguish between the effects of networks from those of unobservable characteristics of individuals and of the communities in which they live. Like Bayer et al., they attempt to distinguish between the effects of mere geographic proximity and of information transmission made possible by proximity. In particular, they rely on language spoken and examine whether being surrounded by others who speak the same language increases welfare use more for individuals who belong to high welfare-using groups. Individuals interact more with others who speak the same language and are therefore more likely to be influenced by other members of that group. They obtain highly significant and positive coefficients on the interaction between contact availability and mean welfare participation of one’s language group and interpret these findings as evidence of network effects.

Anna Aizer and Janet Currie (2002) examine “network effects” in the utilization of publicly funded prenatal care. These authors consider women as belonging to a network if they live in the same neighborhood (defined as the areas of five-digit zip code) and belong to the same racial or ethnic group. They use data on take-up of publicly funded prenatal care, which originate in vital statistics from California’s Birth Public Use files from 1989 to 2000. They find evidence in favor of their hypothesis that pregnant women are most likely to be influenced by new mothers from the same area and ethnic

group in terms of their own use of public prenatal-care programs. Such use is highly correlated within groups defined using race/ethnicity and neighborhoods, and persists even after accounting for unobserved characteristics by including zip code-year fixed effects. However, the richness of their data (which are abstracted from birth certificates and include more than 3.5 million observations) allows them to test whether such estimated effects represent information sharing within groups. This is accomplished by including fixed effects for the hospital of delivery interacted with the year of delivery. The results on the estimated effects of “networks” are then either reduced or eliminated and thus cast doubt on the idea that the observed correlations can be interpreted as evidence of information sharing. They point instead to differences in the behavior of the women involved and of the institutions serving different groups of low-income women as the primary explanation for group-level differences in the take-up of this important public program. They examine the role of institutions by comparing the behavior of foreign-born with that of native-born Hispanic women. They find that “network effects” are quite similar for both those groups of Hispanic women, in contrast to their expectation that foreign-born women will have greater informational requirements. They conclude, therefore, that it is differences in the behavior of institutions and not information sharing that explains the established correlations between neighborhood and ethnic group membership in prenatal care use.

Rafael Lalive (2003) also examines social interactions among unemployed individuals. This empirical study exploits an unusual quasi-experimental setting created by selective extension of unemployment benefits from the Austrian government to individuals who resided in certain regions and were employed (or had been employed) by a certain group of industries. Evidence of social interactions in unemployment behavior



measured in terms of length of unemployment spells takes the form of both direct effects among individuals who are entitled to the extended benefits and indirect effects through the impact of the program's extension on the behavior within the reference group. Their methodology is interesting because their identification of social interactions uses a linear model with the dummy variable indicating that an individual is aged at least fifty years and has continuous work history as an individual effect and with its corresponding group mean as a contextual effect. Their approach is made possible because of the Austrian government's "partial-population intervention." This route to identification of social interactions model was discussed by Robert Moffitt (2001); that is, the endogenous social interactions coefficient is disentangled from the direct effect of extended benefits by distinguishing two groups of the population and by comparing reduced forms estimated with data for those affected with estimates for those not affected by the policy. This result is also particularly relevant in explaining spatial variation in unemployment, an issue of great interest in large economies.

### 3.5 *The Role of Job Referrals*

Krauth (2000) focuses on spatial proximity effects by studying the consequences of employers' using their social ties with their employees to make inferences about unobserved components of the productivity of their workers' social contacts. He shows that there is a critical value for neighborhood human capital below which long-run employment at equilibrium is low and above which it is high. The critical value depends on the strength of social contacts.

Lisa Finneran and Morgan Kelly (2003) examine theoretically the role of job referrals with special emphasis in the persistence of inequality. Workers differ in terms of skills, and such differences are *ex ante* unobservable by employers. Each individual is a member of a hierarchical referral network.

Employees may refer their own acquaintances they believe to be qualified for employment. If those are hired, they in turn refer their acquaintances. Each step in the referral process is stochastic and reflects a whole host of factors describing the labor market. Their central result is that the density of referral linkages exhibits threshold behavior. Above a threshold, workers throughout the hierarchy are referred for employment with probability one; below it, workers' probability of referrals falls exponentially as one moves down the network so that average income falls and workers at very low levels are referred with probability zero. Referrals are more valuable than anonymous matching because they convey information about employees' qualifications, reduce recruiting and training costs, and lower monitoring costs. Finneran and Kelly establish the value of referrals in a general network, where the number of potential ties by each worker and the probability of forming ties all differ across the network. Given a set of potential direct referrals with a large number of potential connections  $n$  and a set of workers who are always guaranteed employment, the measure of paths that connect those who are always guaranteed employment with other individuals in a network who are far away from them (in terms of the number of required referrals) is increasing in the number of actual referrals made. As the size of the economy grows, there exists a critical number of linkages, which varies slowly with  $n$ , such that the probability for any group of workers who are far in terms of linkages from those who are always guaranteed employment to be linked with them through referrals tends to one, when the number is above the critical value, and to zero, when it is below it. As in the result of Calvó-Armegnol and Jackson, this is due to the statistical properties of networks composed of workers who are otherwise identical.

Krauth (2003b) models search for jobs, where individuals' social acquaintances

provide referrals to potential employers. The model assumes a social structure, represented by a directed graph, which is exogenously given but may possibly be time varying, and may vary stochastically as well, but remains exogenous. Firms hire workers but do not observe their quality directly. A worker's past employment and social connections affect her current employment prospects. Krauth proposes a model of strong versus weak ties that is intended to express Granovetter's concept of weak versus strong ties as follows: a social tie from agent  $i$  to agent  $j$  is defined as strong if  $j$  also has a social tie to one or more of  $i$ 's other friends; it is weak, otherwise. The model involves starting from a network with only strong ties and switching some of the social connections randomly with probability  $p$ . For large networks, the probability that this process will generate another strong tie is close to 0, and the fraction of weak ties in the resulting network is approximately  $p$ . Krauth uses simulations to show that the long-run probability of employment is increasing with the proportion of weak ties. Weak ties appear to be a way for an individual to diversify her social resources. When individuals are friends of one another (they are connected through strong ties), their employment statuses are correlated and this increases the variance in the number of employed friends. Therefore, a network with more weak ties is associated with smaller inequality in the distribution of employed friends and thus with a higher overall employment rate. Troy Tassier and Filippo Menczer (2002) also study the role of referrals in labor-market outcomes.

Empirical evidence on the interaction among individuals and their social contacts and employers through job referrals is not as extensive. According to Loury (2003), who works with the National Longitudinal Survey of Youth, personal contacts have significant wage effects for young men only when their contacts are older-generation male relatives who know the boss or arranged an interview

for the job-seeker. Simon and Warner (1992) presented evidence that those who found out about their jobs through an acquaintance inside the firm had higher starting salaries, while those who found out through an acquaintance outside the firm had lower starting salaries. They attributed this finding to reductions in employer uncertainty about worker productivity.

Economics research has explored the salient aspects of contact and relational heterogeneity that influence job-contact prospects for individuals, but there is little comparable work on the effects of employer characteristics. In a notable exception, the varying role of referrals in the U.S. industrial sector has been studied directly by Adrianna Kugler (2002). She finds that the observed positive correlation between industry wage premia and use of employee referrals when industry-level data are used disappears when she controls for sector of employment using micro data from the National Longitudinal Survey of Youth.

Relying on data from the European Community Household Panel, Pellizzari (2004a) reports substantial cross-country variation in the effects of contacts on earnings. In some cases, contacts result in wage premiums and in others workers who found their jobs through contacts earn less than those using formal sources. The latter largely occur in industries where firms invest substantially in formal recruitment activities. Firms are more likely to undertake such investments for high productivity jobs where the costs of turnover are substantial. When large investments are made, workers found through formal recruitment average higher productivity than those found through other means. Pellizzari (2004b) confirms this by using data from the Survey of Employers' Recruitment Practices for the United Kingdom in 1992.

### 3.6 Evolutionary Models of Social Structure

Next we discuss briefly some connections of the neighborhood-effects literature with the literature on evolutionary models of

social structure. Specifically, this literature studies interactions through games individuals play with members of a population where a social state is defined as adoption of a norm or other institutions. First, it is interesting to contrast the notion of weak versus strong ties with global versus local interaction in evolutionary models of social structure. Groups whose members are connected with strong ties are typically small and close-knit. Second, as emphasized by Robert Dietz (2002), the evolutionary learning literature involves ideas that are conceptually related to social interactions.

A particularly noteworthy finding in this literature is a result of Glenn Ellison (1993), according to which if individuals interact with members of a large population then existing behavior (or social conventions, historical forces, etc.) are likely to dominate. On the other hand, if they interact with a small number of neighbors, then cooperative outcomes and thus coordination is more likely. So, interactions involving small neighborhoods are more likely to be determined by evolutionary forces. The results of Ellison have been generalized by Peyton Young (1998) as follows.<sup>15</sup> When individuals interact mainly with small groups of neighbors, then “shifts of regime can occur exponentially faster than in the case of uniform interaction ... . All else being equal, the smaller the size of the neighborhood groups, and the more close-knit the groups are, the faster the transition time for the whole population (Young 1998, pp. 98–99). This suggests an important role of close-knit groups for social learning, which in the context of the literature reviewed here may be interpreted as that of strong ties. This contrasts with the role that Granovetter has

ascribed to weak ties in the interpersonal flow of job-related information. Clearly additional research is needed.

#### *4. Strategic Network Formation and Endogenous Job Information Networks*

If social networks are determined by uncoordinated actions of individuals, then several of their features are of interest. First, how many others is an individual in contact with to exchange job-related information? Second, how does this number vary among individuals within the economy, and how might it depend upon individual characteristics? And, third, what is the topology of the associated network? Is everyone directly connected with everyone else, is there a single individual through whom everyone is connected, or is there some other stylized pattern of connections that is discernible in social networks? We review the existing literature while recognizing that it has not, to date, succeeded in delivering endogenous outcomes with respect to all these features simultaneously. The fast-developing literature on strategic network formation, which seeks to motivate the creation of social contacts in terms of optimizing behavior by individuals, has not, until recently, emphasized job-information networks, although, as we see shortly, important progress has been made. The strategic network formation literature has been eloquently reviewed recently by Bhaskar Dutta and Matthew Jackson (2002), Goyal (2003), and Jackson (2003). So we will touch on it only very briefly.

##### *4.1 Strategic Models of Network Formation*

The principal contributions in this literature, including Matthew Jackson and Alison Watts (2002) and Watts (2001), aim at axiomatic descriptions of network-based concepts. Important such concepts are: efficiency, with a network being efficient if there is no other network that leads to higher payoff for all of the members; stability, with a network being stable if no individual would

<sup>15</sup> Regimes are described with stochastically stable states. The concept of stochastically stable dynamic equilibrium (Young 1993, 1998) is particularly appropriate to circumstances where a system is subject to repeated shocks, that is when the system is shocked repeatedly and before it has a chance to recover, it is shocked again, and again. In such settings, some states will occur more frequently than other states in the long run.

benefit by severing a link and no two players would benefit by forming a new link; and the notion of a Nash network, where all members are playing Nash equilibrium. The models in the strategic network formation literature make links endogenous by means of strategic considerations; that is, maintenance (or creation) of links between two individuals requires that they both consent to it, whereas severance can be done unilaterally. The utility each member derives from being a member of a network, that is, from being connected with others who may themselves be connected with others, typically depends additively upon the number of other agents each agent is connected with, minus the costs of maintaining connections. Some authors make an allowance for proximity, by means of a decay factor that depends on the number of intervening agents. Others, like Venkatesh Bala and Sanjeev Goyal (2000), discussed in more detail below, distinguish between one- or two-way communication. As Jan Brueckner (2003) and Jackson (2003) demonstrate, these assumptions are quite crucial for the results.

Matthew Jackson and Asher Wolinsky (1996) show the equilibrium network is empty if linkage costs are high; it is a wheel network (where each agent is connected with two other agents thus forming a wheel, or a circle) if linkage costs are moderate; and it is a complete network if the linkage costs are low. The two extreme outcomes are quite intuitive. The wheel outcome is also intuitive when one recognizes that it is associated with two connections per person, which is the minimal symmetric outcome. This demonstrates the sensitivity of network topology to parameter values and suggests that in practice different topologies may emerge in a given economy for different sets of problems.

The recent resurgence of interest in job information networks has benefitted by extending several of the concepts proposed by this literature. In particular, Calvó-Armegnol (2004) suggests that conditions that lead to different network topologies,

that are obtained endogenously, are important for the functioning of job-information networks. That is, the information flows associated with two different chains of contacts of identical length but in different topologies are generally different. We return to this work in detail further below.

Bala and Goyal (2000) also model endogenous network formation, where each individual derives utility that is proportional to the number of other agents she is connected with directly and indirectly, net of the costs of maintaining those connections. Unlike Jackson and Wolinsky (1996), however, theirs involves *directed* links. They define one-way communication as your having access to another person's information. An one-way link does not imply that other person has access to yours, which would be two-way communication (undirected links). Bala and Goyal show that, with one-way communication, Nash networks are either minimally connected and form a wheel (each player forms exactly one link) or empty. In other words, information is either shared with *everyone*, or there is *no* sharing. Bala and Goyal also study the dynamics of link formation by assuming a naive best-response rule with inertia, that is, an agent may choose, with fixed probabilities, either a myopic pure strategy best-response, or the same action as in the previous period. They show that irrespective of the number of agents and from any initial starting pattern of interconnections, the dynamic process *self-organizes*, by converging in finite time with probability 1 to the unique limit network. The limit is the wheel if the linkage costs are small, or either the wheel or the empty network if the linkage costs are large.<sup>16</sup> With two-way communication the results are quite

<sup>16</sup> These results may be generalized by restricting the information available to agents, that is, by assuming only local information—each agent knows the residual set of all those she is connected with, that is those her neighbors can access without using links to her—and by allowing observation of successful agents—there is some chance that she receives information from a “successful” agent, that is a person who observes the largest subset of people in the economy without assistance from her own links.

different: Nash networks are either “center-sponsored” stars (where an agent forms the network by connecting himself with all others, occupies the central position, and pays for all links), or the empty network.

It is interesting that experimental evidence that has been obtained recently provides support for the Bala and Goyal model. Armin Falk and Michael Kosfeld (2002) report that the prediction based on strict Nash equilibrium works well in the one-way communication model, with subjects forming the wheel or the empty network in a majority of cases. In contrast, the predictions based on Nash and on strict Nash fail for the two-way communication model: the subjects do not form the center-sponsored star nor the empty network in any of the experiments. The authors attribute their results to the subjects’ sensitivity to fairness considerations, which is a well-known factor affecting game outcomes in experimental settings.

Brueckner (2003) extends the basic assumptions of this literature by endogenizing the probability of a link and of linking costs. This extension assumes that individuals value only their direct connections, involves a simple mathematical structure, and derives some properties that would seem to be relevant outside the confines of those particular models. For example, identical individuals will spread their efforts uniformly to create social acquaintances, thus bringing about symmetric outcomes and ruling out inherently asymmetric network topologies like that of the star. However, asymmetric outcomes are possible if individuals’ social attractiveness differs—individuals can have magnetic personalities—or if individuals have different sets of social acquaintances.

The assumptions these models employ do not make them readily applicable to the study of exchange of information about jobs. Still, the experimental evidence on network formation and the sensitive dependence of endogenous network topology on costs relative to benefits suggests that cultural factors may be important in the determination of

real-life job information networks. Different individuals may value differently the payoffs from being connected with others relative to the costs of doing so.

#### 4.2 *Endogenous Job Information Networks*

Social interactions associated with endogenous job information networks may be quite different from others, such as those inspired by constraint, preference or expectations interactions, to use the terminology of Manski (2000). The theoretical predictions of Calvó-Armegnol and Jackson (2002, 2003)<sup>17</sup> depend on ad hoc assumptions about social exchange: the network of social interactions is given. By varying network characteristics and parameters, one may explore potential consequences of primitive behavioral assumptions about individuals’ valuations of social interactions, especially with respect to different types of individuals’ propensities to transmit job-related information.

What do we know about the formation of the networks used for acquiring and disseminating job information? Scott Boorman (1975) was the first to ask formally how social groups accommodate the transmission of job-related information. He presents an analytical model of transmission of job-related information through contacts, where individuals choose how to allocate effort over maintaining strong and weak contacts. Strong contacts are given priority in the transmission of job-related information but require more time than weak ones to maintain. Choices over strong versus weak contacts by all members of the society determine a rudimentary social structure.

Let  $\mu$  and  $\delta$  denote the probability that a person will need a job at a particular point in time, and that she hears *directly* of a vacant job, respectively. If  $S$  and  $W$  denote the

<sup>17</sup> Pierre Cahuc and Francois Fontaine (2002) allow for individuals to choose between job matching through social networks and (costly) individual search methods. Such an extension appears to overturn several standard results. Competitive search may be over- or under-utilized and multiple equilibria are possible.



number of strong and weak contacts, respectively, then the probability that a person will get a job through her contacts may be computed as the one minus the probability that the person will not get a job either from any of her strong or her weak ties. The latter two probabilities may be obtained from elementary but tedious combinatoric computations.<sup>18</sup> The probability that a person will get a job is written as:

$$1 - \left[ 1 - \delta(1 - \mu) \frac{1 - (1 - \mu)^S}{\mu S} \right]^S \left[ 1 - \delta(1 - \mu)^{S-1} \frac{1 - (1 - \mu)^W}{\mu W} \right]^W. \quad (2)$$

Maximizing this probability, subject to a time constraint,  $W + \lambda S = T$ , where  $\lambda$  denotes the extra units of time required to maintain a strong tie, allows us to study whether strong or weak contacts are more likely to be chosen for different values of the parameters. Boorman's probabilistic approach has recently been taken up by Calvó-Armegnol (2004), discussed below.

It turns out that if the probability of needing a job is small,  $\mu \ll 1$ , Boorman's model implies that the equilibrium where all individuals choose weak ties is stable. The opposite is true when  $\mu \approx 1$ . These results have an intuitive appeal. The only reason for investing in strong contacts is the concern that one's weak contacts will be preempted by the demands of their own needy contacts. As the probability that anyone needs a job decreases this contingency becomes less important. Boorman's model does not use tradeoffs facing workers searching for jobs, but it does portray the properties of the communication network in a uniform symmetric setting, where each individual maintains both strong and weak ties.

Boorman's path-breaking work took a long time to influence the economics literature.

This is quite surprising in view of the fact that it is a model of endogenous (job) information network, where agents choose the number of links, which does not require strategic considerations. Curiously, the development of strategic models more generally seemed to have provided an impetus for the development of non-strategic models, as well. Calvó-Armegnol (2004) develops the first precise model of a contact network deliberately aimed at passing job-related information and Calvó-Armegnol and Yves Zenou (2001) explore its implications for labor-market-wide matching. These papers, unlike Granovetter and Boorman, do not distinguish between strong and weak contacts.<sup>19</sup>

In Calvó-Armegnol (2004), all workers are initially employed; they may lose their jobs with a constant probability  $b$ , and hear of a new job opportunity with probability  $a$ . If a worker hearing of a job is unemployed she takes it; if she is employed, she passes the information on to her unemployed direct contacts. A worker is employed and hears of a job with probability  $\alpha = a(1 - b)$ , and is unemployed and does not hear from her contacts about jobs with probability  $\beta = b(1 - a)$ . Let  $g$  denote a network of contacts,  $g^N$  the set of all subsets of the set of all individuals of size 2, that is the complete graph among  $N$  individuals, and  $G = \{g | g \subset g^N\}$ . Given  $g \in G$ , the set of an individual's direct contacts in  $g$  is denoted by  $N_i(g)$ . The probability that an

<sup>18</sup> See *ibid.* and Calvó-Armegnol (2004), Proposition 1, for details. Actually, the latter does not distinguish between strong and weak ties.

<sup>19</sup> The earliest model of word-of-mouth communication that we are aware of is Strand (1983), who is interested in intrafirm wage dispersion. The concept of word-of-mouth communication used by Calvó-Armegnol and Zenou is similar to Glenn Ellison and Drew Fudenberg (1995), although the latter stresses the efficiency of social learning. The latter paper's finding that social learning is often more efficient when communication between agents is fairly limited. In a model of word-of-mouth communication, this is understood as sampling from a given sample of other participants, with some fraction of players ignoring the information and not changing their decisions and the remainder adopting the choice that appears to be best based on their own nonoptimal sample. This property of limited communication is conceptually relevant to the role of weak ties in social networks, as we discussed in subsection 3.6.

individual  $i$  receives job information who from one of her direct contacts  $j$ ,  $j \in N_i(g)$ , who is assumed to be informed, is given by  $\frac{1-(1-b)^{n_i(g)}}{bn_i(g)}$ , where  $n_i(g) = |N_i(g)|$ . (This derivation is, of course, closely related to Boorman's, *op. cit.*) Therefore, the probability that  $i$  does not actually find a job thanks to  $j$  is given by  $q(n_i(g)) = 1 - \alpha \frac{1-(1-b)^{n_i(g)}}{bn_i(g)}$ , and the probability that individual  $i$  actually gets a job through her contacts is:

$$P_i(g) = 1 - \prod_{j \in N_i(g)} q(n_j(g)). \quad (3)$$

This probability is larger, the greater an individual's set of direct contacts. A larger set of contacts broadens the information channels available to  $i$ , but not the number of direct contacts as such. This probability decreases the larger is an individual's indirect contacts through any of his direct contacts,  $n_j(g)$ ,  $j \in N_i(g)$ . That is, having more indirect contacts increases the competition for information. This basic relationship determines the return to adding and severing links among any two individuals. Doing so affects the information flow for those directly affected as well as for their direct contacts. This expression also implies an aggregate unemployment rate given by:

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

Calvó-Armegnol (2004) uses this model to examine properties of symmetric equilibrium networks, when a link between any two agents, which is undirected and costly to both of them, is initiated only if it is mutually advantageous. The model also implies tradeoffs associated with the topologies of the networks of contacts. Networks with the same total number of contacts but different topologies imply different aggregate unemployment rates. It is particularly simple to consider topologies of regular graphs, where all individuals have the same number of direct contacts, that is, all nodes

have the same degree,  $\nu$ . In that case, the tradeoffs between the number of direct and indirect contacts on an agent's employment probability implies that it attains a maximum over the set of different degrees,  $(1, \nu)$ . Where an agent's employment probability increases, it is also the case the marginal effect of increasing the network's degree is negative. While increasing the number of direct links improves the employment probability, it also does so for everyone, thus also increasing the number of indirect links, which are detrimental to the likelihood of employment for sufficiently high values of the network's degree. In other words, direct contacts are beneficial because they improve an individual's information sources, but contacts that are two-links away are detrimental because they create competitors for the information possessed by a direct contact. This *rivalry* is also the reason that the sign and intensity of the payoff spillovers that agents exert on one another are very much dependent on the geometry of the network. This is also a reason more general analyses are difficult.

Calvó-Armegnol also considers asymmetric networks. In fact, with the same parameters, both symmetric and asymmetric networks are possible, but they cannot be "too asymmetric." This model is the only one to date that has employed successfully a model of strategic network formation to the job market context. Interestingly, individual payoffs in this model do not, unlike the specific models in Bala and Goyal, contain a component that is linear in the number of other agents each agent is connected with. This could explain why it is so much more difficult to study endogenous network topology in the general case in Calvó-Armegnol's model.

Calvó-Armegnol and Zenou (2001) explore the implications of the model in Calvó-Armegnol (2004) for aggregate matching properties of an economy. Aggregate matching is increasing and concave in both the unemployment and vacancy rates. However, hearing through both direct and indirect

contacts implies that the impact of network size is not monotonic. This is so, as we argued above, because such an increase increases the potential number of unemployed workers who are connected directly to an employed informed worker.

Specifically, if  $1-u$  the probability that a worker is employed and  $s$  is the number of other (randomly drawn) workers each worker is in direct contact with (the degree of the symmetric, or balanced, social network), then each worker meets  $us$  unemployed workers and  $(1-u)s$  employed workers in each period. Under the assumption that information is passed by employed to unemployed workers only and the vacancy rate represents the probability that an unemployed individual will hear of a job vacancy directly, than the individual probability of finding a job through social contacts is given by:

$$P(s, u, v) = 1 - \left( 1 - v(1-u) \frac{1-(1-u)^s}{us} \right)^s. \quad \text{The}$$

matching function is given by  $m(s, u, v) = u[v + (1-v)P(s, u, v)]$ .

The properties of the matching function with respect to unemployment and vacancy rates are the same as in the earlier job matching literature; they differ only with respect to network degree. In this case, the matching function is not only not homogeneous of degree one, as in Pissarides (2000), but not even monotonic. When the network degree increases, unemployed workers hear about more vacancies through their social network. At the same time, it is more likely that information about multiple vacancies will reach the same unemployed worker. It is therefore important to see whether this non-monotonicity is present in the data, which is an open question empirically, to the best of our knowledge. The properties of the matching function affect the equilibrium level of unemployment in the economy. Matching is increasing in network size, for sparse networks, and decreasing for dense ones. These findings

suggest that it is important to research further the aggregate the properties of different types of social networks with respect to matching.<sup>20</sup>

### 5. Towards an Integration of Job information Networks and Sorting

The interconnection of individuals through job information networks clearly gives rise to sorting phenomena in both the economic and social spheres. Sorting, on the other hand, has typically been investigated by the economists in a life-cycle context. This section examines the interplay of those two forces.

A well-established literature has investigated how the intertemporal evolution of human capital is affected by the human capital of parents, of the ethnic group to which the individual belongs, and of the individual's neighborhood. The natural relationship between parents and children may affect variables (such as "innate ability") that play an important role in the perpetuation of inequality, but are not subject to choice. On the other hand, mating does involve choice, and the human capital of spouses is not independent of one another across the population. Parents' choice of human-capital investment for their children is affected by their own human capital.

A prominent example of this literature is Michael Kremer (1997), who studies individuals' schooling as a function of that of the parents and of the mean schooling in one's neighborhood of upbringing. He finds strong neighborhood effects; that is, mean schooling in the neighborhood of one's upbringing has a coefficient that is roughly the same as that of the parents' schooling. This effect is not sufficient, however, to explain a large role for residential sorting in the inequality of earnings across

<sup>20</sup> The recent exhaustive review of the literature on the matching function by Barbara Petrongolo and Christopher Pissarides (2001) does not discuss at all matching aspects of social networks.

the population.<sup>21</sup> George Borjas (1992) regresses individuals' schooling against schooling of parents and the average schooling of the ethnic group to which an individual belongs. Borjas, too, finds strong ethnic effects. Borjas (1995) allows, in addition, for a potential link between parental and ethnic capital, on one hand, and residential segregation, on the other, and again finds a strong ethnic effect. Borjas (1998) finds that, in addition, schooling is affected by the presence and skill levels of other ethnic groups in the neighborhood of one's residence, with lower segregation by ethnicity associated with more schooling for an individual and for her ethnic group. He also allows for potentially complex interactions between one's ethnic group and the distribution of socioeconomic characteristics in one's neighborhood of upbringing and obtains statistically significant results.

Job information networks can have complex neighborhood effects, too. They affect different individuals' access to information about job opportunities and thus have bearing for individuals' abilities to market their labor services. Such effects imply a dependence among individuals' neighborhood of residence, social connections, and status and terms of employment. These effects operate within much shorter time frames than the time span between the influence of upbringing and of parents' characteristics and offspring human capital. It is thus appropriate to allow for different time scales.<sup>22</sup> By defining

<sup>21</sup> Working with the same data, Ioannides (2002) finds strong nonlinear effects, which imply multiple equilibria. Unfortunately, like Kremer's, Ioannides' results are not causal, in that the endogeneity of neighborhood choice by parents is not accounted for.

<sup>22</sup> In modelling physical and engineering processes, one often distinguishes between different time scales. See also, Young (1998) on the notion of "event" time, which marks numerous distinct events that may be compressed into short intervals of "real" time. In the absence of different time scales, these considerations would produce a *contemporaneous* cross-sectional effect. We thank Giulio Zanella for directing our attention to James Meade (1976), for a discussion of transmission of inequality based on a concept of effects of social contacts operating in different frequencies.

labor income as the product of human capital, which represents income earning capacity measured in efficiency units, and the appropriate wage rate, which represents its current market price per efficiency unit, we may separate intertemporal effects, such as the parental effect, the ethnic group effect and the neighborhood of upbringing effect, from social network effects on individuals' access to job-related information. The former effects operate at *life-cycle frequencies*, indexed by period  $t=0,1,2, \dots$ , while the latter operate at nearer to *business-cycle frequencies*, indexed by  $\pi$ , which indicates intervals of time within each discrete life cycle period  $t$ . They are much shorter than life cycle frequency and account for employment-related events. These two sets of effects would typically not be independent. The social connections of one's parents are related to the pattern of social connections within one's ethnic group and may also influence one's own social connections.

The intertemporal evolution of income-earning ability, human capital for short, of individual  $i$  who belongs to ethnic group  $e$ ,  $h_{i,e,t}$ , reflects such intertemporal effects as the parental effect, which operates through the *natural* parental relationship between individuals  $i'_{e,t-1}$  and  $i''_{e,t-1}$ , the parents of individual  $i_{e,t}$ , assuming for simplicity that both of individual  $i$ 's parents belong to the same ethnic group, the ethnic effect,  $h_{e,t}$ , and the neighborhood effect,  $h_{\nu(i),e,t-1}$ , where  $\nu(i)$  indicates the neighborhood of individual  $i$ 's upbringing. We may combine Kremer (1997) and Borjas (1992; 1995; 1998) and write an equation for the law of motion of human capital as follows:

$$H_{i,e,t} = H(h'_{i',e,t-1}, h''_{i'',e,t-1}; h_{e,t}, h_{\nu(i),e,t-1}), \quad (4)$$

which allows the ethnic effect and the neighborhood effects to interact,  $h_{\nu(i),e,t-1}$ . A complete description of the intertemporal evolution of income earning ability requires description of the dynamic evolution of the ethnic effect.

Let  $S_{i,e,\pi}$  denote the event that individual  $i$  is employed,  $S_{i,e,\pi}=1$ , or unemployed,

$S_{i,e,\pi}=0$ , at a business-cycle point  $\pi$  of her life cycle period  $t$ . Following Calvó-Armegnol and Jackson, *op. cit.*, we normalize wages so that  $W_{i,e,t}=0$ , if  $i$  is unemployed. Wage setting may be expressed as a function of one's wage in the previous (business cycle) period and of the number of new job opportunities individual  $i$  has as of time  $\pi$ ,  $O_{i,e,\pi}$ ,  $W_{i,e,t}=w(W_{i,e,\pi-1}, O_{i,e,\pi})$ , where the index  $\pi-1$  is defined within the time scale of business cycle frequencies. We may now write an equation for the intertemporal evolution of labor income,

$$Y_{i,e,t}=H_{i,e,t}W_{i,e,\pi}S_{i,e,\pi}. \quad (5)$$

We may obtain the full dynamic flavor of Eq. (5) by contemplating the dynamic evolution of the probability of employment and of the number of new opportunities. For example, recall the probability of  $i$ 's getting a job through her contacts according to Calvó-Armegnol (2004), Eq. 3) above. That theory implies that the employment probability depends on the size of the set of contacts,  $n_i=|N_{i,t}(g_t)|$ , where  $g_t$  denotes the graph describing a particular realization of social networks at time  $\tau_t$ .

The graph describing individual  $i$ 's social contacts will not necessarily be *regular* (all individuals having the same number of contacts with others) and will evolve over (business cycle) time in a way that exhibits dynamic dependence. Therefore, in principle, we can describe the evolution of the probability of getting a job through one's contacts as a function of the social networks the individuals have access to. These will emerge as a result of individual incentives that reflect strategic considerations associated with network formation. That is,  $S_{i,\pi}$  must be derived as a function of  $N_{i,t}(g_t)$ .<sup>23</sup> We note that the discussion of empirical

research earlier in the paper suggests that the efficiency wage rate, the set of job opportunities and the employment probability all depend on one's ethnic group. It is fair to say that the empirical literature suggests strong persistence in ethnic composition and income distribution of neighborhoods.

The empirical research reviewed above offers separate glimpses on the joint distribution. Eq. (5), along with (4) and a description of the dynamics of human capital by ethnic groups encapsulate the joint effects of human capital and access to job opportunities on the distribution of earned income while accounting for the fact that those effects operate at different time scales. Conceptually, one may adapt the method pioneered by Loury (1981) and the tools of Carl Futia (1982) to describe the equilibrium joint distribution of these characteristics as an invariant distribution associated with the law of motion of income-earning ability, ethnic effects, neighborhood effects, and job-information effects. It is unlikely that this description can ever be reduced to a single dimension. However, it would also be interesting to adapt Loury's essentially deterministic approach to a stochastic one, incorporating the tools of evolutionary stability employed by Young (1998). Further theoretical research is likely to allow deeper analysis of the impact of job-information networks on inequality. This entirely new approach is crucial for deeper understanding of the lifetime income distribution.

There has been a fair amount of success in describing the equilibrium distribution of income, with an emphasis on the impact of sorting on human capital formation in life cycle frequencies. Our understanding of the impact of job-information networks and their role as a force of inequality is much less developed. They are potentially very important, in part because network formation depends on sorting of individuals' *own* characteristics. It is interesting to speculate how sorting by *own* characteristics in choosing whom to associate with, rather than passively

<sup>23</sup> In view of Niekke Oomes (2003), who shows that if labor can be hired in continuous quantities, the long run distribution of employment in spatially separated markets is uniform, we conjecture that persistence of non-trivial effects of social networks on job-related outcomes is intimately related to the presence of a labor-market participation decision.



reacting to standard norms of behavior in groups, underlies an independent role of ethnicity as conjectured by Borjas.

Kremer (1997, p. 135) notes that "to the extent that people learn from classmates and co-workers, sorting by an individual's *own* academic ability or productivity in schools or workplaces may have larger effects on inequality than sorting by *parental* characteristics, since an individual's future characteristics are presumably more highly correlated with his or her current characteristics than with parental characteristics." As Kremer also notes, this is the kind of sorting that most people would regard as egalitarian, presumably because it is based on individuals' free choice of association," but it may be most likely to significantly "increase inequality." The phenomenon of segregation by skill in firms, that Kremer and Eric Maskin (1996) have analyzed, is particularly relevant in this context. Firms are, metaphorically speaking, neighborhoods. Referrals among individuals who have been coworkers involves selection through one's own characteristics and is closely related to the properties of technologies used by firms. It thus provides a route for technology to affect equality of earnings. Further work in this area appears to be particularly fruitful.

Research on the dynamics of inequality to date has emphasized the role of neighborhood effects in either the intergenerational dynamics of human capital or the labor supply decisions separately from one another. The framework we sketched above suggests that it would be fruitful to look at both sets of decisions jointly. Henry Overman (2002) is a rare example that allows for both types of spillovers. That paper uses data on a sample of Australian teenagers to test for neighborhood effects on school dropout rates at two different spatial scales. Overman finds that educational composition of the larger neighborhood can influence the dropout rate, possibly reflecting the structure of local labor market demand. He also finds, more surprisingly, that low socioeconomic status of the

immediate neighborhood is associated with lower dropout rate.

## 6. *Suggestions for Future Research*

The specific model proposed in the previous section provides an overarching theme that helps integrate life-cycle and business-cycle forces into a model of job-information networks and sorting. At the same time, a number of other concrete issues may be addressed directly and may thus complement the overarching theme. They are briefly discussed next in this section.

Theoretical issues needing further attention abound. The issue of strong versus weak social ties is a natural one. It has already been generalized by the exogenous job-information networks literature. It may be pursued further along the lines of the methods employed by the endogenous job-information networks literature, where recent contributions have not distinguished social tie strength. Similarly, global versus local interactions among individuals provide a tempting parallel to strong versus weak ties and therefore deserve additional theoretical attention. The findings of this paper point to a need to understand better the informational and social infrastructure of the modern economy. In this context, a particularly glaring weakness of the theoretical and empirical literature is almost total lack of research on the role of professional intermediaries ("headhunters") throughout the job market, in spite of anecdotal evidence of the increasing importance of such intermediaries, and especially outside its traditional territory of executive search. An economy's social and informational infrastructure is also important for understanding the role of institutions in facilitating individuals' access to resources.

We stress the fact that network topologies as equilibrium outcomes are very sensitive to parameter values and therefore it is important for a model to express the particular circumstances of the problem. The strategic network formation literature has examined

how the economy self-organizes under different assumptions about expectations. The exogenous social interactions literature has explored the dynamics of different topologies. Combining these two approaches deserves further attention.

Research on the impact of the information technology revolution on the job market is only just beginning. Richard Freeman (2002) provides evidence that computerization and use of the Internet are associated with greater hours as well as higher wages. Evidence reported by Kuhn and Skuterud (2000) suggest increasing use of the internet for the purpose of job search. We know very little about the impact of the internet on the economy generally, let alone on recruitment and job search.

Both theoretical and empirical research on firms' recruitment practices also seems likely to yield big payoffs. This research to date has explored existing models of matching to considerable advantage. However, the methodology of strategic network formation lends itself equally well to such a task. Wage premiums and wage penalties associated with finding jobs through personal contacts are the joint outcome of firms' recruitment efforts and individuals' job search. We cannot identify the role of information through social interactions without accounting for both sides of the market. This is particularly important if one recognizes the conceptual links between neighborhood effects and network effects and the econometric issues they pose when it comes to the identification of endogenous versus exogenous effects, which we discussed earlier in this paper. Institutional and cultural differences across different countries in how social contacts facilitate job contacts and how use of intermediaries and formal sources differ need to be better measured and understood.

An important benefit here would be for economists to learn from the multidimensional picture that the network-based theories of mathematical sociology confer. At the heart of the sociological literature is the

belief that network-based models are indispensable for modelling more than just trivial social interactions. As Harrison White (1995) emphasizes, further theorizing on social networks is likely to pay off even within sociology, where in spite of technical achievements in social-network measurements, modelling "network constructs have had little impact so far on the main lines of sociocultural theorizing ..." (p. 1059). White sees an important role for studying social interactions through interlinking of different individual-based networks associated with social discourse. Granovetter (2000) urges sociologists to go beyond merely emphasizing "the embeddedness of action in social networks" and states that a "focus on the mechanics of networks alone ..." is insufficient to "lead us toward the more complex synthesis that we seek in understanding the economy" (p. 23). In view of this, it appears that distinguishing between the motives that prompt individuals to engage in social networking deserve attention in future research.

## *7. Conclusions*

Most of the initial economics research on informal contacts aggregated the effects of informal contacts and networks. It has assessed the role of job contacts on outcomes by comparing outcomes with to outcomes without job contacts. The new strands in theoretical and empirical economic research examined in this paper build on sociological analyses and point out that contact effects are complex and vary due to individual, contact, relational, and employer heterogeneity. The new literature identifies the specific ways in which the effects of informal networks depend on differences among job seekers themselves, on the characteristics of the contacts they use, on the relationship between the job seekers and their contacts, and on features of the work environments where individuals are seeking jobs. The research makes clear that these

components do not operate in a vacuum but instead interact with each other to produce the variation we observe in the use and effects of informal networks. This has been confirmed by the new theoretical research that emphasizes the emergence of social networks from individuals' uncoordinated actions and finds that the resulting networks are very sensitive to parameter values.

The research reviewed here suggests that heterogeneity in network effects is important in a variety of contexts. It can help account for changes in wage and employment inequality across time. It clarifies the

mechanism behind correlations in observed outcomes within social groups. Thus research has already used network analysis to elucidate the origins of previous unexplained similarities in outcomes by race, ethnicity, and gender. Furthermore, it identifies the source of some neighborhood correlations in labor-market outcomes. At the same time, there are a number of promising areas where research is needed. In particular, the importance of employer characteristics and the role of the internet in altering the role of informal contacts in the future are topics that deserve special attention.

## Appendix

Table 1, Table 2

TABLE 1 Education and Methods of Job Search										
Category	1	2	3	4	5	6	7	8	Full	All
	did nothing	pub. agency	priv. agency	curr. emplr	other emplr	friend acquai.	ads	other activ.	searchers	PSID
Unemployed										
Sample frequencies	11.5	21.8	9.5	5.7	29.4	15.5	33.5	31.0	5.8	100
Years $\leq 8$	17.9	20.5	18.2	24.2	21.0	23.3	16.9	14.4	17.0	16.7
8 < Years < 11	41.8	25.2	25.5	30.3	28.7	28.9	27.2	30.6	31.6	17.9
Years = 12	26.9	32.2	25.5	30.3	28.7	27.8	32.3	28.9	30.8	31.0
Years = 12 + nonac.	7.5	18.7	25.5	15.2	17.0	12.2	15.4	17.8	14.6	18.7
13 < Years < 15	4.5	9.5	5.5	0.0	3.5	6.7	6.7	5.0	4.3	9.4
BA + adv.	1.5	6.2	0.0	0.0	1.2	1.1	1.5	3.3	1.7	6.2
Searching on-the-job										
Sample frequency	60.5	6.3	3.0	2.0	9.4	8.5	16.0	17.0	8.1	100
Years $\leq 8$	7.1	9.8	16.7	6.3	13.2	11.6	13.2	6.6	8.3	16.7
8 < Years < 11	17.2	17.7	12.5	12.5	13.2	14.5	11.6	8.0	14.3	17.9
Years = 12	33.7	41.2	25.0	31.3	34.2	29.0	38.0	38.7	34.9	31.0
Years = 12 + nonac.	27.2	25.5	25.0	43.8	22.4	21.7	18.6	22.6	25.3	18.7
13 < Years < 15	9.4	3.9	16.7	6.3	15.8	13.0	14.0	18.3	11.9	9.4
BA + adv.	5.3	2.0	4.2	0.0	1.32	10.1	4.7	5.8	5.2	6.2

*Notes:* The categories are whether: 1. did nothing; 2. searched with a public employment agency; 3. searched with a private employment agency; 4. checked with the current employer; 5. checked with other employer; 6. checked with friend or relative; 7. placed or answered ads; or, 8. engaged in other activity. The results are summarized in the following table. The entries in the lines labelled "sample frequencies" are not mutually exclusive—some respondents may be engaged in more than one method—and thus do not add up to 100. The entries for educational attainment sum up to 100 in each column. The column labelled "Full" gives the educational attainments for the respective subsample of unemployed and those searching on the job in the 1993 sample of the PSID. The column labelled "All" gives the educational attainments for the entire 1993 sample of the PSID.

TABLE 2  
Urban Size and Methods of Job Search

Category	1	2	3	4	5	6	7	8	Full	All
	did nothing	pub. agency	priv. agency	curr. emplr	other emplr	friend acquai.	ads	other activ.	searchers	PSID
Unemployed										
Sample frequencies	11.5	21.8	9.5	5.7	29.4	15.5	33.5	31.0	5.8	100
> 500,000	38.20	27.17	15.60	35.10	13.17	51.11	22.21	23.69	23.86	16.02
[100000, 500000)	12.05	19.73	10.95	3.20	34.59	14.48	19.07	21.66	20.99	24.15
[50000, 100000)	1.69	7.28	15.34	21.16	7.12	8.37	15.61	6.86	9.39	11.76
[25000, 50000)	17.14	7.88	30.43	26.91	7.53	9.87	13.58	16.94	14.36	13.44
[10000, 25000)	3.31	14.57	22.81	5.88	17.94	7.39	20.86	18.36	14.30	15.74
10,000 >	27.62	23.38	4.87	5.21	17.14	8.78	8.11	12.16	15.85	17.38
Employed										
Sample frequency	60.5	6.3	3.0	2.0	9.4	8.5	16.0	17.0	8.1	100
> 500,000	16.19	6.36	7.85	.00	12.28	22.43	14.03	10.17	14.79	16.02
[100000, 500000)	30.77	22.63	22.92	19.27	27.47	22.24	28.45	27.48	30.09	24.15
[50000, 100000)	11.67	13.15	41.89	29.72	25.93	17.68	18.38	18.94	13.43	11.76
[25000, 50000)	12.21	13.29	.00	21.76	12.43	17.49	18.04	10.90	12.90	13.44
[10000, 25000)	13.68	5.98	2.18	1.33	6.73	5.81	10.42	16.27	13.08	15.74
10,000 >	12.10	38.60	25.16	27.93	15.17	14.34	10.68	16.25	13.44	17.38

*Notes:* The categories are whether: 1. did nothing; 2. searched with a public employment agency; 3. searched with a private employment agency; 4. checked with the current employer; 5. checked with the other employer; 6. checked with friend or relative; 7. placed or answered ads; or, 8. engaged in other activity.

The entries in the lines labelled "sample frequency" are not mutually exclusive—some respondents may be engaged in more than one methods—and thus do not add up to the number in column "Full". The column labelled "Full" gives the relative geographical distribution of the two respective categories, unemployed and employed looking for job, for the entire 1993 sample of the PSID. "All" gives the geographical distribution of the entire 1993 sample of the PSID. All calculations are weighted by means of the latest weight in PSID.

The geographical categories are defined in terms of the size of the largest city in the county of a household's residence. The categories are: SMSA with largest city 500,000 or more; SMSA with largest city between 100,000 and 499,000; SMSA with largest city 50,000 to 99,999; non SMSA with largest city 25,000 to 49,999; non-SMSA with largest city 10,000 to 24,999; non SMSA with largest city less than 10,000.



## REFERENCES

- Aizer, Anna and Janet Currie. 2002. "Networks or Neighborhoods? Correlations in the Use of Publicly Funded Maternity Care in California," NBER work. pap. 9209.
- Anderson, Carolyn J.; Stanley Wasserman and Bradley Crouch. 1999. "A p\* Primer: Logit Models for Social Networks," *Soc. Networks* 21, pp. 37–66.
- Arrow, Kenneth J. and Ron Borzekowski. 2004. "Limited Network Connections and the Distribution of Wages," work pap., Department of Economics, Stanford U.
- Bala, Venkatesh and Sanjeev Goyal. 2000. "A Noncooperative Model of Network Formation," *Econometrica* 68:5, pp. 1181–229.
- Bayer, Patrick; Stephen L. Ross and Giorgio Topa. 2004. "Place of Work and Place of Residence: Informal Hiring Networks and Labor Market Outcomes," work. pap. Yale U.
- Beggs, John and Hurlbert, Jeanne. 1997. "The Social Context of Men's and Women's Job Search Ties: Membership in Voluntary Organizations, Social Resources, and Job Search Outcomes," *Sociol. Perspect.* 40:4, pp. 601–22.
- Bertrand, Marianne; Erzo F. P. Luttmer and Sendhil Mullainathan. 2000. "Network Effects and Welfare Cultures," *Quart. J. Econ.* 115:3, pp. 1019–55.
- Bewley, Truman F. 1999. *Why Wages Don't Fall During a Recession*. Cambridge, MA: Harvard U. Press.
- Blau, David. 1992. "An Empirical Analysis of Employed and Unemployed Job Search Behavior," *Ind. Lab. Relat. Rev.* 45, pp. 738–52.
- Blau, David and Philip Robins. 1992. "Job Search Outcomes for the Employed and Unemployed," *J. Polit. Econ.* 98:3 pp. 637–55.
- Boorman, Scott A. 1975. "A Combinatorial Optimization Model for Transmission of Job Information through Contact Networks," *Bell J. Econ. Manage. Sci.* 6, pp. 216–49.
- Borjas, George J. 1992. "Ethnic Capital and Intergenerational Mobility," *Quart. J. Econ.* 107:1, pp. 123–50.
- . 1995. "Ethnicity, Neighborhoods, and Human Capital Externalities," *Amer. Econ. Rev.* 85:3, pp. 365–90.
- . 1998. "To Ghetto or Not to Ghetto: Ethnicity and Residential Segregation," *J. Urban Econ.* 44, pp. 228–53.
- Bortnick, Steven and Michelle Ports. 1992. "Job Search Methods and Results: Tracking the Unemployed," *Monthly Lab. Rev.* 115:12, pp. 29–35.
- Bradshaw, Thomas. 1973. "Jobseeking Methods Used by Unemployed Workers," *Monthly Lab. Rev.* 96:2, pp. 35–40.
- Bridges, William and Wayne Villemez. 1986. "Informal Hiring and Income in the Labor Market," *Amer. Sociol. Rev.* 51:4, pp. 574–82.
- Brooks-Gunn, Jeanne; Greg J. Duncan, Pamela Kato Klebanov and Naomi Sealander. 1993. "Do Neighborhoods Influence Child and Adolescent Development?" *Amer. J. Sociol.* 99:2, pp. 353–95.
- Brueckner, Jan. 2003. "Friendship Networks," work. pap. econ. dept. U. Illinois.
- Brueckner, Jan; Jacques-Francois Thisse and Yves Zenou. 1999. "Why Is Central Paris Rich and Downtown Detroit Poor? An Amenity-Based Theory," *Europ. Econ. Rev.* 43:1, pp. 91–107.
- Burt, Ronald S. 1980. "Models of Network Structure," *Ann. Rev. Sociol.* 6, pp. 79–141.
- . 1992. *Structural Holes*. Cambridge, MA: Harvard U. Press.
- . 2000. "Network Structure of Social Capital," in *Research in Organizational Behavior*, vol. 22. Robert Sutton and Barry Staw, eds. Elsevier Science.
- . 2001. "Structural Holes versus Network Closure as Social Capital," in *Social Capital: Theory and Research*. Nan Lin, Karen Cook and R. S. Burt, eds. Aldine de Gruyter.
- Cahuc, Pierre and Francois Fontaine. 2002. "On The Efficiency of Job Search with Social Networks," discuss. pap. 583, U. Paris 1-EUREQua.
- Calvó-Armignol, Antoni. 2004. "Job Contact Networks," *J. Econ. Theory* 115:1, pp. 191–206.
- Calvó-Armignol, Antoni and Matthew O. Jackson. 2002. "Networks in Labor Markets: Wage and Employment Dynamics and Inequality," work. pap. Caltech and U. Autònoma de Barcelona; rev. April 2003.
- . 2003. "The Effects of Social Networks on Employment and Inequality," work. pap. Caltech and U. Autònoma de Barcelona; forthcoming *Amer. Econ. Rev.*
- Calvó-Armignol, Antoni; Thierry Verdier and Yves Zenou. 2004. "Strong and Weak Ties in Employment and Crime," IUI Conference on Networks: Theory and Applications; Vaxholm, Sweden.
- Calvó-Armignol, Antoni and Yves Zenou. 2001. "Job Matching, Social Network and Word-of-Mouth Communication," work. pap., U. Southampton, May; IZA discuss. pap. 771, 2003.
- Coleman, James S. 1990. *Foundations of Social Theory*. Cambridge, MA: Harvard U. Press.
- Conley, Timothy and Giorgio Topa. 2003a. "Socio-Economic Distance and Spatial Patterns in Unemployment," *J. Appl. Econometrics*, forthcoming.
- . 2003b. "Dynamic Properties of Local Interaction Models," forthcoming in *The Economy as an Evolving Complex System*, III. Laurence Blume and Steven Durlauf, eds. Menlo Park, CA: Addison-Wesley.
- Corcoran, Mary; Linda Datcher and Greg Duncan. 1980. "Information and Influence Networks in Labor Markets," in *Five Thousand American Families*, vol. VIII. Greg Duncan and James Morgan, eds. Institute Social Research, U. Michigan, pp. 1–37.
- Coulson, N. Edward; Derek Laing and Ping Wang. 1997. "Spatial Mismatch in Search Equilibrium," work. pap. Pennsylvania State U.
- Crane, Jonathan. 1991. "The Epidemic Theory of Ghettos and Neighborhood Effects on Dropping Out and Teenage Childbearing," *Amer. J. Sociol.* 96:5, pp. 1226–59.
- Cutler, David M. and Edward L. Glaeser. 1997. "Are Ghettos Good or Bad?" *Quart. J. Econ.* pp. 827–72.
- Dasgupta, Partha and Ismail Serageldin. 2000. *Social Capital, A Multifaceted Perspective*. Washington DC: World Bank.

- Datcher, Linda. 1982. "Effects of Community and Family Background on Achievement," *Rev. Econ. Statist.* 64:1, pp. 32–41.
- . 1983. "The Impact of Informal Networks on Quit Behavior," *Rev. Econ. Statist.* 65:3, pp. 491–95.
- de Bartolome, Charles A. M. 1990. "Equilibrium and Inefficiency in a Community Model with Peer Group Effects," *J. Polit. Econ.* 98:1, pp. 110–33.
- Devine, Theresa and Nicholas Kiefer. 1991. *Empirical Labor Economics: The Search Approach*. NY: Oxford U. Press.
- Dietz, Robert D. 2002. "The Estimation of Neighborhood Effects in the Social Sciences," *Soc. Sci. Res.* 31, pp. 539–75.
- Dodds, Sheridan; Roby Muhamad and Duncan J. Watts. 2003. "An Experimental Study of Global Social Networks," *Science* 301:5634, pp. 827–29.
- Durlauf, Steven N. 1994. "Bilateral Interactions and Aggregate Fluctuations," in *Proceedings of the First World Congress of Nonlinear Analysts*.
- . 1996a. "A Theory of Persistent Income Inequality," *J. Econ. Growth* 1:1, pp. 75–93.
- . 1996b. "Neighborhood Feedbacks, Endogenous Stratification, and Income Inequality," in *Dynamic Disequilibrium Modelling*, W. Barnett, G. Gandolfo and C. Hillinger, eds. Cambridge U. Press.
- Dutta, Bhaskar and Matthew O. Jackson. 2002. *Models of the Strategic Formation of Networks and Groups*. Berlin: Springer Verlag, forthcoming.
- . 2003. "On the Formation of Networks and Groups," in *Networks and Groups*, Dutta and Jackson, eds. Berlin: Springer, pp. 1–15.
- Elliott, James. 1999. "Social Isolation and Labor Market Isolation: Network and Neighborhood Effects on Less-Educated Urban Workers," *Sociol. Quart.* 40:2, pp. 199–216.
- Ellison, Glenn. 1993. "Learning, Local Interaction, and Coordination," *Econometrica*, 61, pp. 1047–61.
- Ellison, Glenn and Drew Fudenberg. 1995. "Word of Mouth Communication and Social Learning," *Quart. J. Econ.* 110:1, pp. 93–125.
- Erdős, Paul and Alfred Renyi. 1960. "On the Evolution of Random Graphs," *Math. Institute Hungarian Academy Sci.* 5, pp. 17–61.
- Evans, William N.; Wallace E. Oates and Robert M. Schwab. 1992. "Measuring Peer Group Effects: A Study of Teenage Behavior," *J. Polit. Econ.* 100:5, pp. 966–91.
- Falk, Armin and Michael Kosfeld. 2003. "It's All about Connections: Evidence on Network Formation," work. pap. Institute Empirical Research Econ., Zurich.
- Fernandez, Roberto and Emilio Castilla. 2001. "How Much Is That Network Worth? Social Capital in Employee Referral Networks," in *Social Capital: Theory and Research*, Nan Lin, Karen Cook and Ronald Burt, eds. NY: Aldine De Gruyter, pp. 85–104.
- Finneran, Lisa and Morgan Kelly. 2003. "Social Networks and Inequality," *J. Urban Econ.* 53:2, pp. 282–99.
- Freeman, Richard B. 2002. "The Labour Market in the New Information Economy," NBER work. pap. 9254.
- Furstenberg, Frank F. and Mary Elizabeth Hughes. 1999. "The Influence of Neighborhoods on Children's Development: A Theoretical Perspective and a Research Agenda," in *Neighborhood Poverty: Policy Implications in Studying Neighborhoods*, vol. II. Jeanne Brooks-Gunn, Greg J. Duncan and J. Lawrence Aber, eds. NY: Russell Sage.
- Futia, Carl A. 1982. "Invariant Distributions and the Limiting Behavior of Markovian Economic Models," *Econometrica* 50:2, pp. 377–408.
- Glaeser, Edward; David Laibson, Jose Scheinkman and Christine Soutter. 2000. "Measuring Trust," *Quart. J. Econ.* 115:3, pp. 811–46.
- Goyal, Sanjeev. 2003. "Learning in Networks: a Survey," forthcoming in *Group Formation in Econ.: Networks, Clubs, and Coalitions*, Myrna Wooders and Gabrielle Demange, eds. Cambridge U. Press.
- Goyal, Sanjeev and Fernando Vega-Redondo. 2004. "Structural Holes in Social Networks," work. pap. econ. dept. U. Essex.
- Granovetter, Mark. 1973. "The Strength of Weak Ties," *Amer. J. Sociol.* 78:6, pp. 1360–80.
- . 1983. "The Strength of Weak Ties: A Network Theory Revisited," *Sociol. Theory* 1, pp. 201–33.
- . 1974(1995). *Getting a Job: A Study of Contacts and Careers*, first ed., Harvard U. Press; second ed., 1995, Chicago: U. Chicago Press.
- . 2000. "A Theoretical Agenda for Economic Sociology," forthcoming in *New Directions in Economic Sociology*, Mauro F. Guillen, Randall Collins, Paula England, and Marshall Meyer, eds. NY: Russell Sage.
- Haynie, Dana L. 2001. "Delinquent Peers Revisited: Does Network Structure Matter?" *Amer. J. Sociology* 106:4, pp. 1013–57.
- Heavner, D. Lee and Lance Lochner. 2002. "Social Networks and the Aggregation of Individual Decisions," NBER work. pap. w8979.
- Hedström, Peter; Ann-Sofie Kolm and Yvonne Åberg. 2003. "Social Interactions and Unemployment," work. pap. 2003:15, Institute Labor Market Policy Evaluation, Uppsala.
- Hogan, Dennis and Evelyn Kitagawa. 1985. "The Impact of Social Status, Family Structure, and Neighborhood on the Fertility of Black Adolescents," *Amer. J. Sociology* 90, pp. 825–55.
- Holzer, Harry. 1987a. "Informal Job Search and Black Youth Unemployment," *Amer. Econ. Rev.* 77:3, pp. 446–52.
- . 1987b. "Job Search by Employed and Unemployed Youth," *Ind. Lab. Relat. Rev.* 40:4, pp. 601–11.
- . 1988. "Job Search Methods Used by Unemployed Youth," *J. Lab. Econ.* 6:1, pp. 1–20.
- Ioannides, Yannis M. 1997. "Evolution of Trading Structures," in *The Economy as an Evolving Complex System II*, W. Brian Arthur, Steven Durlauf and David Lane, eds. Menlo Park, CA: Addison-Wesley, pp. 129–67.
- . 2001. "Topologies of Social Interactions," Tufts U., econ. dept. work. pap., revised June 2004.
- . 2002. "Nonlinear Neighborhood Interactions and Intergenerational Transmission of Human Capital," in *Essays in Economic Theory, Growth and Labour Markets: A Festschrift in Honour of*

- Emmanuel Drandakis. George Bitros and Yannis Katsoulacos, eds. Cheltenham, UK: Edward Elgar, pp. 75–112.
- Jackson, Matthew O. 2003. "A Survey of Models of Network Formation: Stability and Efficiency," work. pap. Caltech; forthcoming in *Group Formation in Economics: Networks, Clubs and Coalitions*. Gabrielle Demange and Myrna Wooders, eds. Cambridge: Cambridge U. Press.
- Jackson, Matthew O. and Alison Watts. 2002. "The Evolution of Social and Economic Networks," *J. Econ. Theory* 106:2, pp. 265–95.
- Jackson, Matthew O. and Asher Wolinsky. 1996. "A Strategic Model of Social and Economic Networks," *J. Econ. Theory* 71:1, pp. 44–74.
- Jencks, Christopher and Marsha Brown. 1975. "The Effects of High Schools on Their Students," *Harvard Ed. Rev.* 45, pp. 273–324.
- Jencks, Christopher and Susan E. Mayer. 1990. "The Social Consequences of Growing Up in a Poor Neighborhood: A Review," in *Concentrated Urban Poverty in America*. M. McGeary and L. Lynn, eds. Washington DC: Nat. Academy.
- Kempe, David; Jon Kleinberg and Éva Tardos. 2003. "Maximizing the Spread of Influence through a Social Network," SIGKDD '03 Washington, DC.
- Kirman, Alan. 1983. "Communication in Markets: A Suggested Approach," *Econ. Letters* 12, pp. 101–108.
- . 1997. "The Economy as an Interactive System," in *The Economy as an Evolving Complex System II*. Brian Arthur, Steven Durlauf and David Lane, eds. Menlo Park, CA: Addison-Wesley, pp. 491–531.
- Kirman, Alan; Claude Oddou and Shlomo Weber. 1986. "Stochastic Communication and Coalition Formation," *Econometrica* 54, pp. 129–38.
- Korenman, Sanders and Susan Turner. 1996. "Employment Contacts and Minority-White Wage Differences," *Industrial Relations*, 35:1, pp. 106–22.
- Kortum, Samuel. 2003. "Book Review: *Networks and Markets*, by James E. Rauch and Alessandra Casella, eds." Russell Sage Foundation, 2001. *J. Int. Econ.* 61:1, pp. 249–52.
- Krauth, Brian V. 2000. "Social Interactions, Thresholds, and Unemployment in Neighborhoods," econ. dept. Simon Fraser U. work. pap.
- . 2001a. "The Macroeconomics of Job Networking," econ. dept. Simon Fraser U. work. pap.
- . 2003a. "A Dynamic Model of Job Networking and Persistent Inequality," forthcoming in *Heterogeneous Agents, Interactions, and Economic Performance*. Cowan and Jonard, eds. Springer.
- . 2003b. "A Dynamic Model of Job Networking and Social Influences in Employment," econ. dept. Simon Fraser U. work. pap.; forthcoming in *J. Econ. Dynam. Control*.
- Kremer, Michael. 1997. "How Much Does Sorting Increase Inequality," *Quart. J. Econ.* 112:1, pp. 115–39.
- Kremer, Michael and Eric Maskin. 1996. "Wage Inequality and Segregation by Skill," NBER work. pap. 5718.
- Kugler, Adriana. 2002. "Employee Referrals and Efficiency Wages," IZA discuss. pap. 633.
- Kuhn, Peter, and Mikal Skuterud. 2000. "Job Search Methods: Internet versus Traditional," *Monthly Labor Rev.* pp. 3–11.
- Lalive, Rafael. 2003. "Social Interactions in Unemployment," CESifo work. pap. 1077.
- Lin, Nan. 2001. *Social Capital: A Theory of Social Structure and Action*. Cambridge and New York: Cambridge U. Press.
- Lin, N.; W.M. Ensel and J.C. Vaughn. 1981. "Social Resources and Strength of Ties; Structural Factors in Occupational Status Attainment," *Amer. Soc. Rev.* 46, pp. 393–405.
- Lin, N.; J.C. Vaughn and W.M. Ensel. 1981. "Social Resources and Occupational Status Attainment," *Social Forces* 59, pp. 1163–81.
- Lippert, Steffen, and Giancarlo Spagnolo. 2004. "Networks of Relations," U. Mannheim econ. dept. work. pap.
- Loury, Glenn C. 1977. "A Dynamic Theory of Racial Income Differences," in *Women, Minorities and Employment Discrimination*. P.A. Wallace and A. Le Mund, eds. Lexington, MA: Lexington Books, ch. 8.
- . 1981. "Intergenerational Transfers and the Distribution of Earnings," *Econometrica* 49:4, pp. 843–67.
- Loury, Linda. 2003. "Some Contacts Are More Equal than Others: Earnings and Job Information Networks," Tufts U. work. pap.
- Lynch Lisa. 1989. "The Youth Labor Market in the Eighties: Determinants of Re-employment Probabilities for Young Men and Women," *Rev. Econ. Statist.* 71:1, pp. 37–45.
- Manski, Charles F. 2000. "Economic Analysis of Social Interactions," *J. Econ. Perspect.* 14:3, pp. 115–36.
- Marmaros, David. 2001. "Analysis of Peer and Social Effects on Employment Opportunities," Senior Honor Thesis, Department of Economics, Dartmouth College, June.
- Marmaros, David and Bruce Sacerdote. 2002. "Peer and Social Networks in Job Search," *Europ. Econ. Rev.* 46:4–5, pp. 870–79.
- Marsden, Peter V. 1987. "Core Discussion Networks of Americans," *Amer. Sociol. Rev.* 52, pp. 122–31.
- . 2001. "Interpersonal Ties, Social Capital, and Employer Staffing Practices," in *Social Capital: Theory and Research*. Nan Lin, Karen Cook and Ronald Burt, eds. NY: Aldine De Gruyter, pp. 105–26.
- Marsden, Peter and Karen Campbell. 1990. "Recruitment and Selection Processes: The Organizational Side of Job Searches," in *Social Mobility and Social Structure*. Ronald Breiger, ed. NY: Cambridge U. Press, pp. 59–79.
- Marsden, Peter and Elizabeth H. Gorman. 2001. "Social Networks, Job Changes, and Recruitment," in *Sourcebook of Labor Markets: Evolving Structure and Processes*. Ivar Berg and Arne L. Kalleberg, eds. NY: Kluwer Academic/Plenum Publishers, pp. 467–502.
- Marsden, Peter and Hurlbert, Jeanne. 1988. "Social Resources and Mobility Outcomes: A Replication and Extension," *Social Forces* 66, pp. 1038–59.
- Meade, James. 1976. *The Just Economy*. London: George Allen and Unwin.

- Mencken, F. Carson and Idee Winfield. 2000. "Job Search and Sex Segregation: Does Sex of Social Contact Matter?" *Sex Roles: A Journal of Research*, 42:9-10, pp. 847-64.
- Milgram, Stanley. 1967. "The Small World Problem," *Psych. Today* 2, pp. 60-67.
- Miyao, Takahiro. 1978a. "Dynamic Instability of a Mixed City in the Presence of Neighborhood Externalities," *Amer. Econ. Rev.* 68:3, pp. 454-63.
- Möbius, Markus. 2001. "Why Should Theorists Care about Social Capital?" unpub. manuscript, Harvard U. econ. dept.
- Moffitt, Robert. A. 2001. "Policy Interventions, Low-Level Equilibria, and Social Interactions," in *Social Dynamics*, Steven N. Durlauf and H. Peyton Young, eds. pp. 45-82.
- Montgomery, James D. 1991. "Social Networks and Labor Market Outcomes: Towards an Economic Analysis," *Amer. Econ. Rev.* 81:5, pp. 1408-18.
- . 1992. "Social Networks and Persistent Inequality in the Labor Market," econ. dept. Northwestern U. mimeo.
- . 1994. "Weak Ties, Employment and Inequality: An Equilibrium Analysis," *Amer. J. Sociol.* 99:5, pp. 1212-36.
- Mortensen, Dale and Tara Vishwanath. 1994. "Personal Contacts and Earnings: It Is Who You Know," *Lab. Econ.* 1:1, pp. 187-201.
- Munshi, Kaivan. 2002. "The Identification of Network Effects: Mexican Migrants in the U.S. Labor Market," econ. dept. U. Penn. work. pap.
- Myerson, Robert B. 1977. "Graphs and Cooperation in Games," *Math. Op. Res.* 2, pp. 225-29.
- Newman, Mark E.J. 2003. "The Structure and Function of Complex Networks," *SIAM Rev.* 45, pp. 167-256.
- Oomes, Nienke. 2003. "Local Trade Networks and Spatially Persistent Unemployment," *J. Econ. Dynam. Control* 27:11, pp. 2115-49.
- Oreopoulos, Philip. 2003. "The Long-Run Consequences of Living in a Poor Neighborhood," *Quart. J. Econ.* 118:4, pp. 1533-75.
- Overman, Henry G. 2002. "Neighborhood Effects in Large and Small Neighborhoods," *Urban Stud.* 39:1, pp. 117-30.
- Palmer, E.M. 1985. *Graphical Evolution*. NY: Wiley Interscience.
- Pellizzari, Michele. 2004a. "Do Friends and Relatives Really Help in Getting a Good Job?" CEP discus. Pap. 623, London School Econ.
- . 2004b. "Employers; Search and the Efficiency of Matching," preliminary, London School Econ.
- Petersen, Trond, Ishak Saporta, and Marc-David L. Seidel. 2000. "Offering a Job: Meritocracy and Social Networks," *Amer. J. Sociol.* 106:3, pp. 763-816.
- Petrongolo, Barbara and Christopher A. Pissarides. 2001. "Looking into the Black Box: A Survey of the Matching Function," *J. Econ. Lit.* 39:2, pp. 390-431.
- Pissarides, Christopher A. 2000. *Equilibrium Unemployment Theory*. Cambridge: MIT Press.
- . 2001. "The Economics of Search," in *International Encyclopedia of the Social and Behavioural Sciences*, Amsterdam: Elsevier.
- Podolny, Joel M. and James N. Baron. 1997. "Resources and Relationships: Social Networks and Mobility in the Workplace," *Amer. Soc. Rev.* 62:5, pp. 673-93.
- Portes, Alejandro. 1998. "Social Capital: Its Origins and Applications in Modern Sociology," *Ann. Rev. Soc.* 24, pp. 1-24.
- Ports, Michelle. 1993. "Trends in Job Search Methods: 1970-1992," *Monthly Lab. Rev.* Oct. pp. 63-67.
- Putnam, Robert D. 2000. *Bowling Alone*. NY: Simon & Schuster.
- Rees, Albert. 1966. "Information Networks in Labor Markets," *Amer. Econ. Rev. Pap. Proceed.* 56:2, pp. 559-66.
- Reid, Graham. "Job Search and the Effectiveness of Job-Finding Methods," *Ind. Lab. Rel. Rev.* 25, pp. 479-95.
- Rosenbaum, J.E.; S. DeLuca, S.R. Miller and K. Roy. 1999. "Pathways into Work: Short- and Long-Term Effects of Personal and Institutional Ties," *Sociol. Ed.* 72:3, pp. 179-96.
- Schelling, Thomas C. 1971. "Dynamic Models of Segregation," *J. Math. Soc.* 1, pp. 143-86.
- . 1978. *Micromotives and Macrobehavior*. NY: Norton.
- Simon, Curtis and Warner, John. 1992. "Matchmaker, Matchmaker: The Effect of Old-Boy Networks on Job Match Quality, Earnings, and Tenure," *J. Lab. Econ.* 10:3, pp. 306-30.
- Smith, Sandra. 2000. "Mobilizing Social Resources: Race, Ethnic, and Gender Differences in Social Capital and Persisting Wage Inequalities," *Sociol. Quart.* 41 4: pp. 509-37.
- Staiger, Doug. 1990. "The Effects of Connections on the Wages and Mobility of Young Workers," work. pap. Harvard U. Kennedy School Govt.
- Stigler, George J. 1961. "The Economics of Information," *J. Polit. Econ.* 69:5, pp. 213-25.
- . 1962. "Information in the Labor Market," *J. Polit. Econ.* 70:5, pp. 94-105.
- Strand, Jon. 1983. "Equilibrium Wage Distributions with Word-of-Mouth Worker Communication," U. Oslo mimeo.
- Topa, Georgio. 2001. "Social Interactions, Local Spillovers and Unemployment," *Rev. Econ. Stud.* 68, pp. 261-95.
- Tassier, Troy and Filippo Menczer. 2002. "Social Network Structure, Equality and Segregation in a Labor Market with Referral Hiring," work. pap. U. Iowa econ. dept.
- van den Berg, Gerard and Jan van Ours. 1996. "Unemployment and Duration Dependence," *J. Lab. Econ.* 14:1, pp. 100-25.
- Waldinger, Roger D. 1996. *Still the Promised City?* Cambridge MA: Harvard U. Press.
- Wasmer, Etienne and Yves Zenou. 1997. "Equilibrium Urban Unemployment," LSE Centre Econ. Perform. DP 368.
- Wasserman, Stanley and Katherine Faust. 1994. *Social Network Analysis: Methods and Applications*. Cambridge and NY: Cambridge U. Press.
- Wasserman, Stanley and Garry Robins. 2001. "An Introduction to Random Graphs, Dependence Graphs, and p\*, forthcoming in *Models and Methods in Social Networks Analysis*. Peter

- Carrington, John Scott and Stanley Wasserman, eds. Cambridge and NY: Cambridge U. Press.
- Watts, Alison. 2001. "A Dynamic Model of Network Formation," *Games Econ. Behav.* 34, pp. 331–41.
- Weinberg, Bruce A.; Patricia B. Reagan and Jeffrey J. Yankow. 2000. "Do Neighborhoods Affect Work Behavior? Evidence from the NLSY79," forthcoming, *J. Lab. Econ.*
- White, Harrison C. 1995. "Network Switchings and Bayesian Forks: Reconstructing the Social and Behavioral Sciences," *Soc. Res.* 62:4, pp. 1035–63.
- Young, H. Peyton. 1993. "The Evolution of Conventions," *Econometrica* 61:1, pp. 57–84.
- . 1998. *Individual Strategy and Social Structure*. Princeton, NJ: Princeton University Press.
- Zuckerman, Ezra W. 2003. "On *Networks and Markets* by Rauch and Casella, eds," *J. Econ. Lit.* 41:3, pp. 545–65.