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CERTIFICATION PAGE

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In addition, if the applicant institution employs more than fifty persons, the authorized official of the applicant institution is certifying that the institution has implemented a written and enforced conflict of interest policy that is consistent with the provisions of Grant Policy Manual Section 510; that to the best of his/her knowledge, all financial disclosures required by that conflict of interest policy have been made; and that all identified conflicts of interest will have been satisfactorily managed, reduced or eliminated prior to the institution's expenditure of any funds under the award, in accordance with the institution's conflict of interest policy. Conflicts which cannot be satisfactorily managed, reduced or eliminated must be disclosed to NSF.

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By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Drug Free Work Place Certification contained in Appendix C of the Grant Proposal Guide.

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The undersigned certifies, to the best of his or her knowledge and belief, that:

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Project Summary

Katherine Stovel. Hearing About A Job: Networks, Information, and Segregation in Labor Markets. August 2003.

This project addresses how matching processes and structural conditions interact to produce various levels of segregation in labor markets. Empirical evidence reveals that labor markets are often highly segregated with respect to the ascribed attributes of workers. Most of the traditional explanations that have been proposed to account for segregation in labor markets can be classified as either 'supply-side' (worker qualifications or preferences) or 'demand-side' (job requirements or discrimination by employers) accounts. Neither of these accounts addresses the structure of information that links potential workers and employers, or how these actors evaluate the information they do acquire. However, how potential workers hear about vacant jobs, and how employers view referred employees, are crucial parts of the hiring process, and have implications for the level of segregation in a labor market.

The current project has three specific aims: (1) To refine and extend Stovel's existing two-sided matching model of a labor market to incorporate key aspects of labor market institutions and the information structures (including networks) that are relevant for recruiting; (2) to calibrate this model with data describing empirical labor markets; (3) to use this model as an experimental framework to generate testable hypotheses about the relative importance of supply-side, demand-side, and matching based mechanisms that can influence the level of segregation in a labor market.

In addition to straight-forward supply- and demand- based mechanisms, this project will develop two information-based aspects of the matching process explicitly. The first mechanism works via constraints on the information potential employees have about labor markets. If information is not widely spread, but rather flows only through networks linking potential workers, then the structure and composition of those networks will influence who hears about--and is hired into--vacant jobs. Networks that are highly correlated with a particular attribute thus could produce and maintain segregation within jobs or firms, without any discriminatory action on the part of individual employers. The second mechanism draws on the work of Stiglitz and Spence concerning signaling. The logic is that evaluating potential is difficult, and information from trusted employees is more valuable than information from those who are unknown. This may cause employers to prefer workers who are referred from current employees; if the networks through which information about jobs flow are segregated, this mechanism also has the potential to produce and maintain segregation within the labor market.

Previous research has documented some instances where each of these mechanisms plays a role in structuring the level of segregation in employment. However, it is extremely difficult to tease apart the relative impact of each mechanism empirically, particularly because the effect of one mechanism may be contingent on the poorly understood structural features of networks that are maintained for other purposes. By using simulation this project will (1) implement each of these 'mechanisms' as a set of structures and a set of rules in the model; (2) vary the strength of the rules for each; and (3) examine their effect in isolation and in conjunction with other structures/rules, across a range of parameter values. The simulation technique is an ideal way to address this empirically intractable problem, and promises to help us focus subsequent empirical work as well as to recommend strategies that might effectively reduce concentration in the labor market.

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Overview

We propose a framework for simulating the labor market matching process that will enable us to study the impact of various mechanisms that could produce or maintain segregation within a labor market. Our proposed project has three specific aims: (1) To develop a more refined agent-based labor market model that incorporates key aspects of labor market institutions and information structures that are relevant for matching workers with jobs; (2) to calibrate this model with data describing empirical labor markets; (3) to use this model to generate testable hypotheses about the relative importance of, and interaction between, supply-side, demand side, and sorting mechanisms that theoretically affect the amount of segregation in labor markets.

Empirical evidence reveals that labor markets are often highly segregated with respect to the ascribed attributes of workers. Historically, many occupations are sex-typed, while in heterogeneous societies certain fields are often dominated by specific ethnic groups. In the US, one of the fundamental features of the labor market is the concentration of African American workers in the bottom tiers of the labor market. Beyond these aggregate patterns, it has been observed that segregation is most pronounced within jobs (Baron and Bielby 1986), a finding that highlights the extent to which segregation is linked explicitly to employer-specific behavior. All of these forms of segregation are of concern to citizens and policy makers, not least because the existence of segregation appears to be at odds with our cherished political ideals of equality of opportunity and meritocracy.

Many explanations have been proposed to account for segregation in labor markets. On balance, most of these explanations can be classified as essentially ‘supply-side’ or ‘demand-side’ accounts. Supply side-arguments emphasize differences in human capital distributions between groups and link these differences to patterns in labor market outcomes, while demand side-accounts identify employer preferences (either in-group or out-group biases) as the mechanism that segregates labor markets by creating differential demand for different types of workers.

Yet which people are hired into which jobs is not merely a matter of the individual and human capital characteristics of workers or the preferences of employers; it also a function of the complex process by which persons and jobs hear about and are matched with one another (Granovetter 1981; Sørensen and Kalleberg 1981; Marsden and Gorman 2001). Among those interested in labor markets and stratification processes, how workers and employers learn about each other, and how information is evaluated once acquired, are often overlooked aspects of the matching process. This lacunae exists in part because it is extremely difficult to study the matching process empirically, let alone to evaluate the relative role of various information-based mechanisms in the allocation of persons to jobs (cf. Fernandez and Weinberg 1997). Nevertheless, as those who worry about ‘the old boys network’ remind us, there is a lurking suspicion that this aspect of the labor market surely plays a key role in the level of segregation in the labor market. In our research we address these issues by considering two aspects of the matching process explicitly: simple constraints on information, and preferences by employers for workers referred by known sources.

Generating Segregation in Labor Markets

Following recent calls for increased attention to the study of social mechanisms, we identify three classes of mechanisms that may play a role in producing or maintaining segregation in labor markets: supply-side, demand-side, and information/matching-based mechanisms.

Supply-side: Commonly associated with economists (by sociologists, at least), the ideal-typical supply-side model posits that the market mechanism accurately rewards the skill or value of workers. Thus variation in the distribution of skills in a population will be reflected as variation in wages or other rewards associated with jobs. According to this logic, if two (or more) groups have different job-relevant skill profiles (i.e., whites receive, on average, higher levels of education than blacks), the groups will have different labor market experiences. To the extent that occupations or jobs require similar skills, this mechanism may concentrate certain types of workers into certain types of jobs. Thus for this mechanism

to generate segregation, two key elements must exist: (1) there are differences between groups in the distribution of job-related skills; (2) the hiring process evaluates potential candidates exclusively in terms of skill. Empirically testing whether this mechanism explains observed segregation in the labor market is a challenge, largely because it is extremely difficult to observe the hiring process directly. Often researchers work around this by estimating a regression equation predicting wages or occupational prestige as a function of human capital characteristics. The idea is that if the human capital variables fully account for differences between groups in wages or occupation, the hiring process is assumed to be neutral with respect to ‘illegitimate’ characteristics, and any observed labor market segregation is a result of differences in the supply of skill between groups.

Demand-Side: A second class of mechanisms is demand-based, in that it works via employers’ preferences for specific types of workers.¹ Unlike the supply-side mechanism described above, when the demand-side mechanism operates employers are not indifferent to traits other than human capital characteristics. Rather, employers prefer workers of type X (or prefer workers who are ~Y), and potential workers who have the desired characteristic (or who do not have the undesired characteristic) receive preferential treatment in hiring (Becker 1971). If employer-based preferences are strong enough, only those workers with the trait will be hired: if there are no qualified workers with this trait, the job may remain unfilled. This mechanism underlies the idea of a labor queue (Reskin and Roos 1990).

The essential feature of this mechanism is the explicit preference of an employer for (or against) a particular type of workers. Empirically evaluating the content of preferences is notoriously difficult; in the contemporary US setting, few employers would admit to discriminatory preferences. Two types of research dominate: Experimental studies such as those used in housing discrimination studies have been used in an attempt to directly assess employer bias, but these findings are not particularly generalizable. At the aggregate level, researchers often resort to an indirect logic when attempting to reveal this mechanism: after controlling for human capital factors, residual differences in the labor market experiences of groups are interpreted as evidence of discrimination. However, this strategy is well-recognized as inadequate, since many other institutional factors influence the hiring process; further, it is theoretically possible that both (a) groups have different skill profiles and (b) employers have discriminatory preferences, yet this analysis strategy cannot detect the magnitude of these effects or how the two processes interact.

Information-based: The third class of mechanisms is rooted in the way information about labor-markets is disseminated and interpreted. If the labor market is a matching arena, how workers find out about jobs, and how employers find out workers, are crucial links in the chain of employment (Sørensen & Kalleberg 1981). We outline two information-based mechanisms that may play a role in segregating labor markets.

Our first information-based mechanism operates directly through constraints on access to information about jobs. Normally, to get a job one must know about a job. Jobs that are not known about might as well not exist. Thus constraints on the flow of information about open jobs will limit workers’ labor market opportunities. The basic neoclassical model recognizes this: full and perfect information is typically considered a condition for the proper functioning of markets. Deviations from perfect information may result in sub-optimal sorting of sellers and buyers. In the labor market setting, information about potential jobs may flow through a variety of socially structured channels, including organizational or occupational associations, newspapers, headhunters, and word-of-mouth. Each of these channels constrains access to information—both in terms of the number of persons who might hear about vacant jobs, and which particular persons hear about them. One potentially important channel through which information about vacant jobs can flow is the personal contact network of a worker.² If a worker’s

¹ Supply-side accounts can also be conceptualized in terms of employer-preferences, in the sense that employers prefer, and reward, appropriately skilled workers.

² Personal contact networks may work in conjunction with other information channels: for example, organizations may post listings of open jobs on a bulletin board, and employed workers may tell their friends about promising openings.

personal contact network is disproportionately composed of others who share a particular trait, then this worker may disproportionately hear about jobs held by (or known about by) other workers with the same trait. From the employer's perspective, this creates a pool of potential employees that mirrors the (extended) contact network of current employees; selection from this pool will amplify the level of segregation in employment. Thus in and of itself, a constraint on the flow of information—combined with a segregated network structure—could produce and maintain segregation within jobs or firms, without any discriminatory action on the part of individual employers.³

For this mechanism to produce segregation, two conditions must hold: (1) personal contact networks must be an important channel through which information about jobs flows; and (2) networks must tend toward homophily with respect to some attribute. There has been very little systematic investigation of this mechanism to date, perhaps because both of these conditions are difficult to measure on a broad scale. However, it is generally recognized that recruiting through personal networks may have important implications for the diversity of organizations, since homophily in contact networks may be reproduced in the socioeconomic make-up of organizations (Doeringer & Piore 1971, Fernandez, Castilla & Moore 2000). Most of the work on networks and job searching treats Granovetter's finding that weak ties are a good source of information about jobs (1973, 1985) essentially as a sociological truism, despite the fact that Granovetter's original study examined a very restricted sample of skilled professionals who actually found jobs. More progress has been made analytically, most notably Montgomery's (1992, 1994) work showing that those with more extensive networks have access to a richer pool of employment potential, and may end up with higher wages, even if weak ties do not lead them to their ultimate job (see also Boorman 1975). Further complicating research on this aspect of the hiring process is that we know very little about the empirical distribution of the composition and structure of personal contact networks, though some reasonable bounds on these distributions have recently been proposed (e.g., Watts 1999b; Barabási 1999; McPherson, Smith-Lovin & Cook 2001).

A second information-based mechanism is derived from Stiglitz' (1975) and Spence's (1973, 1974) fundamental concerns with screening and signaling. This mechanism captures actors' responses to situations where it is difficult to evaluate information—perhaps because there is too much information (as in a very large number of applicants for a single low-skill position)—or because it is difficult to predict the future from the past (look at all those promising Ph.D.s who flame out at prestigious universities). Under these conditions, employers may weigh information from known sources more heavily than information from unknown sources. Many social processes support this line of reasoning. Burt has argued that those embedded in the same networks will be especially concerned about reputational effects (1992), and therefore will be unlikely to make false recommendations, while Fernandez and his colleagues (1997, 2000) have shown that hiring workers who are tied to current workers may increase the commitment of all to the firm (but beware of bloc defections!). Extending this logic to the macro level, if employers are more likely to hire applicants referred by a current employee, and the networks through which information about jobs flow are biased with respect to some attribute, this mechanism also has the potential to produce and maintain segregation within the labor market.

Our Approach

Previous research has documented that variations on the supply-side, demand-side, and information-based mechanisms all play a role in structuring the level of segregation in employment.

³ It is perhaps worth noting that policies that require public employers to actively and widely disseminate information about all vacancies are designed to counteract the potentially segregating (and individually discriminatory) consequences of this sort of information constraint. These policies, however, increase screening costs, and may provide employers with a great deal of information that is difficult to interpret or evaluate. Therefore, in spite of bureaucratic rules designed to keep an “old boys” network from excessively influencing hiring decisions, applicants with personal referrals may still have an advantage, since employers have more trustworthy information about these workers and may have lower monitoring costs once referrals are hired. This brings us to our second information-based mechanism.

However, it is extremely difficult to tease apart how powerful the mechanisms are, particularly because the effect of one mechanism may be contingent on structural features of the labor market itself, or on the composition of networks that are maintained for other purposes (and are not well understood anyway).

Given these substantial limitations, our approach rests on a developing a dynamic agent-based model that is flexible enough to incorporate various preferences and structures consistent with specific abstract descriptions of labor-market behavior. In adopting this approach we build on computational advances and our own previous work using a similar framework that emphasizes the two-sided nature of a matching problem. In Stovel and Fountain (2003) we examine how socially structured access to information about jobs can influence macro-level characteristics of the labor market such as unemployment rates, mobility, and turnover. By modifying this framework, and using it to simulate artificial labor markets, we will be able to (1) implement each of these 'mechanisms' as a set of structures and a set of rules in the model; (2) vary the strength of the rules for each; and (3) examine their effect in isolation and in conjunction with other structures/rules, across a range of parameter values. The simulation technique is an ideal way to address this empirically intractable problem, and helps us to focus subsequent empirical work as well as to develop strategies that might effectively reduce concentration in the labor market.

Theoretical Background: Modeling Labor Markets as Matching Arenas

The essential elements of a labor market are a supply of workers, a supply of jobs (controlled by employers), and some process for matching workers with appropriate jobs (or jobs with appropriate workers). Since information plays a key role in three of the four segregation-generating mechanisms outlined above, we consider the structure of information and its implications for the matching of persons with jobs.

In most circumstances, those with jobs to be filled and those looking for jobs do not have perfect information about one another's existence. To the extent that access to information is restricted, workers and employers are forced to choose from a set of possibilities that are incomplete and potentially biased. That is, if a worker does not hear about a job for which she would be an attractive candidate, that job will not be member of the set of offers she chooses from. And of course, the same applies to employers searching for qualified workers. Beyond being incomplete, the channels through which information flows are rarely random or uniform; rather, access to information about employment opportunities is typically structured by a variety of factors such as geography, social and familial relationships, professional and occupational relationships, and access to media and information technology. This focus on information availability highlights the importance of strategies that employers use for advertising vacant positions to potential workers, and how these strategies influence the matching process in different institutional environments.

Finding information and Finding Jobs

Both employers and job-seekers use a variety of different strategies to learn about labor market opportunities, including classified advertisements, social and business contacts, vacancies announcements in school or professional registers, job fairs or employment agencies, headhunters; an increasing number use internet bulletin boards and job search services (Fountain 2003). Each of these methods requires different amount of investment on the part of the searcher, and offers a different mixture of breadth and depth as a reward.

Although the economics literature provides little empirical evidence about the cost of searching for and screening information, there are several useful theoretical models of economics of information in job searching. A key assumption of the so-called 'economics of information' is that labor market information is heterogeneous and often of uncertain value, so that search costs are composed not only of the costs of acquisition (searching) but also the interpretation and evaluation of information (screening).

The simplest versions of neo-classical theory suggest that broadcasting information about a vacant position as widely as possibly results in the best job-match, because this brings in the largest

number of applicants from which an employer could choose. With more information and the concomitant reduction in mismatch, productivity should rise, along with wages, and workers and jobs will have less reason to separate. Thus, as search costs are reduced benefits to individuals and to society should accrue as workers are hired for jobs for which they are better matched (McCall 1970). In labor market settings that approximate a spot labor market--as when an employer has many jobs with low or variable skill levels--it may in fact be efficient to place classified ads or post openings on the web. In part this efficiency comes because since there is little pay-off to worrying about finding the 'best' worker. Such widespread recruitment strategies are common among large firms seeking entry level workers in many divisions, temporary help or business services/contractor firms that require a constant stream of new recruits at all skill levels, and in industries-- such as the fast food industry--where jobs have very high turnover and low skill requirement.

Signaling models incorporate the insight that workers are rarely able to pick and choose from a set of job offers without first making their productivity and availability known to employers. Workers need to gather information about vacant jobs, and to signal their qualifications and availability to employers (Spence 1973, 1974). This information can take the form of "signals" of productivity such as level of education and past work history, social relationships with trusted acquaintances, as well as ascriptive characteristics like race and sex (Spence 1973, Stiglitz 1975).⁴ Simultaneously, employers must gather information about potential hires and use employees' signals to screen the qualified applicants from the available pool (Stiglitz 1975), both costly endeavors. Severe information asymmetries concerning the reliability of workers' signals about productivity may create a classic "lemon" market (Akerlof 1970); avoiding this trap may involve investing extensively in screening, hiring, training, and evaluating prospects (Spence 1973, 1974).

In settings where an employer is willing to invest in determining which applicants are best qualified, she might prefer to choose from among a smaller group of qualified employees than a large group with more variance in qualification level. Such refined pools can be more easily obtained through organizational or occupational associations or through personal networks than via broadcast recruiting. Fernandez, Castilla & Moore (2000) show that in a large bank, recruiting through existing employees' contact networks resulted in a pool of applicants who were better qualified than those who come in without a referral. This suggests that different recruiting strategies employed by firms might result in a different set of applicants for vacant positions, as well as a different set of job opportunities for workers. Further, the structure of the recruitment process may trigger different evaluation mechanisms on the part of employers.

Regardless of what employers do, workers employ a variety of strategies to find jobs. Table 1 provides some recent data from the CPS reporting search methods used by unemployed workers in 2002. Despite limitations in the way these questions are asked, these data show that most categories of workers employ a variety of strategies, and that both formal and informal methods are frequently incorporated into the job-search process.

Table 1: Unemployed jobseekers, reason for unemployment, and active job-search methods used among workers 16 years or older, 2002 CPS

Reason Unemployed	Methods used as a percent of total jobseekers							Ave. # of Methods
	Contact Employer Directly	Sent Resume or App'l.	Placed/ Answer Ads	Friends/ Relatives	Public Agency	Private Agency	Other	
Total	62.9	54.4	16.7	17.2	20.3	8.5	11.8	1.92
Lost job ¹	65.4	54.6	19.9	20.7	26.1	11.4	13.9	2.12
Left job	64.7	57.2	18.5	15.9	19.5	7.7	10	1.94

⁴ Although signaling will not be explicitly modeled in this study, it is implicit in the assumption that an employer does not have information about a worker unless that worker knows about the job.

Reentrants	59.7	52.9	12.7	13.3	14.8	5.7	10.5	1.7
New entrants	57.9	54.9	11.2	13.7	8.8	3	6.9	1.57

¹Data on the number of jobseekers and the job-search methods used exclude persons on temporary layoff.

NOTE: The percent using each method will always total more than 100 because many jobseekers use more than one method.

Social Networks and Job Searching

Among the informal job-searching methods, the use of social networks has garnered by far the most attention from sociologists. Granovetter’s ground-breaking work (1973, 1995) showed that individuals with many “weak” ties might have an advantage in the labor market, since these acquaintances give them access to more diverse information than if they had to rely on close friends and family. He has also subsequently argued that those who find jobs via their networks are more likely to earn higher wages and be more satisfied with their jobs. Building from Granovetter, Montgomery (1992) argued that researchers’ proper focus should be the overall structure of a worker’s network--not just the actual source of the information that led to a successful job match. Using an analytic model, he also showed that the level of weak versus strong ties in a population’s social network has important implications for both employment level and wage inequality. Lin, Ensel & Vaughn (1981), however, warn that the advantages associated with using a social network for job-searching are not uniformly distributed. Clearly, if personal contact networks are important channels through which people find jobs, the structure and composition of these networks matters a great deal for who ends up with which job.

Although few sources of nationally representative social network data exist, the available evidence reveals that there is substantial support for the idea that people’s social contact networks are disproportionately composed of others like themselves. This has important implications for the flow of labor market information through these networks, as sociodemographic characteristics structure the availability of information. In general, individuals’ social networks tend to be quite dense, as well as homogenous with respect to many demographic characteristics (Marsden 1987). Race and ethnicity tend to be the most salient characteristic on which social networks are structured, followed by age, religion, education, occupation, and gender (in approximate order of importance) (McPherson, Smith-Lovin & Cook 2001).

There is little evidence that persons choose their social ties because they share traits; rather, people are likely to know and interact socially with others who live near them, go to school, work, or church with them, or are related to them in some way. Thus social relations are conditioned by geographic propinquity; work, religious, academic, and other organizational contexts; and family arrangements. These social factors play a key role in producing relatively homogenous social networks.⁵ In addition, there is evidence that non-homophilous ties are more likely to dissolve, and that cross-race and cross-sex ties are more likely to be dropped in an otherwise homogenous group of friends (Hallinan & Williams 1989, Tuma & Hallinan 1979). Thus, people tend to be embedded in social networks with others who are like themselves in many ways, and as organizational affiliations such as employment relationships are influenced by social ties, this pattern intensifies.

Although social networks are vital in understanding the information available to workers and employers, and the employment segregation that may result, there is little solid empirical evidence about the global structure of those networks. Nevertheless, some valuable attempts have been made to model them theoretically. Duncan Watts has developed a series of theoretical models designed to produce networks with specific characteristics common to observed social networks: high overall connectivity (short average path length) and high local clustering (most of the people you know also know each other)

⁵ In our proposed work we do not model the processes that yield differentiation in skills or homophily in networks, though clearly the level of each of these independent structures will affect whether particular mechanisms are in play. Our aim in this project is to explore the consequences of the various mechanisms, given different patterns of social interaction.

(Watts 1999a, 1999b). The models are based on a simple principle – that most people’s social networks are locally dense with a few quasi-random bridge ties. His basic alpha model allocates ties such that a tie is most likely to go to an actor with whom one already shares ties, mimicking the process through which people often make friends with those known by their current friends. Subsequent models refine these basic principles. Watts has been able to show that many networks share the characteristics of the networks created by his models; however, validation is plagued by the paucity of data. The combination of high local clustering with random bridge ties dovetails nicely with the sociological research of Granovetter and others on weak ties versus strong ties. Another similar modeling strategy comes from Albert-László Barabási and his colleagues, who use a related preferential-attachment model but base it on different assumptions for the distribution of ties (Barabasi & Albert 1999). Although neither of these theoretic models of social networks are based explicitly on principles of homophily, the preferential attachment mechanism for allocating ties is compatible with a model of social network homophily, provided that the model is seeded with ties to those who share attributes.

This research team has extensive experience with social network data and models: Stovel (PI) has worked with large-scale network data from the National Longitudinal Study of Adolescent Health and regularly holds workshops on social network analysis; and Moody (Consultant) is an expert in analyzing empirical social networks and simulating networks for modeling purposes.

Additional labor market institutions

Another important feature of labor markets that affects how matches between workers are made is the way in which the labor market is organized. From the literature on labor market institutions, we draw two stylized types of institutionalized labor markets: neoclassical spot markets for labor, and highly structured markets dominated by competition over vacancies. Since these provide crucial institutional context in which hiring and segregation occur, we briefly describe the key features of each these labor market institutions.

Spot markets for labor: In the neoclassical free market for labor, workers compete amongst themselves for the highest wage level at a certain skill level (thus keeping the price of labor at the point of marginal productivity). Free markets for labor (often termed spot-markets) are “open” labor markets, since there is no expectation by either employer or employee that the worker should continue to hold a job. The logic is that as long as workers cannot restrict access to their jobs, wage competition results and employers hire workers on a daily basis at the market rate. In pure spot markets for labor, there are no returns to tenure and no firm-specific capital; thus all qualified workers are essentially interchangeable from the employer’s perspective. Further, opportunity is not constrained by the activities of other workers because every job is “up for grabs” in every iteration, whether or not it contains an incumbent. Although these markets are empirically rare (Kalleberg & Sørensen 1979), they are theoretically important for economic analysis of labor markets and useful as a point of reference for more structured markets.

Vacancy competition Regimes: More common empirically are structured labor markets. Following Sørensen and Kalleberg (1981) and Sørensen (1977), we focus on vacancy competition regimes, a labor market structure in which access to jobs is restricted, usually via a contract between employer and employee. Of central importance in such “closed” systems is the fact that workers can only fill jobs that are not currently held by another worker: thus workers are competing for vacant jobs. Jobs are more or less attractive because they are associated with certain wages and other benefits, so it is the particular *job* a worker holds that determines wages, rather than the specific productivity of the worker (as is assumed in a spot market). In a vacancy competition regime, only vacant jobs create opportunities for mobility, so a worker’s career prospects are directly determined by the mobility of other workers, whose prospects are similarly dependent on the mobility of other workers. In this way, worker mobility creates a vacancy chain that moves in the opposite direction of workers’ movement (White 1970).

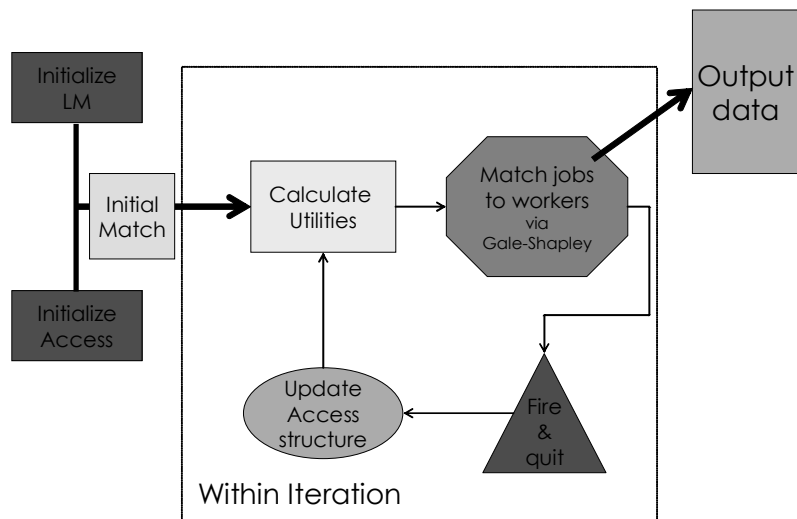
A Computer Simulation of Labor Market Environments

Understanding how workers are segregated through employment relations requires considering multiple complex social processes simultaneously. Most theories address small pieces of this puzzle, and data constraints often limit scholars to either describing aggregate phenomena or studying small delimited cases intensively. We adopt a different approach: we create an artificial environment in which simulated actors interact according to highly specified rules. At the heart of our model are two sets of actors: a set of workers choosing from a set of jobs (controlled by employers), and a set of jobs choosing from the set of workers. Workers have characteristics (human capital, attributes) and preferences (for types of jobs), as do jobs/employers. In our framework, the actual matching of workers-to-jobs is conceptualized as an iterative process in which workers and jobs evaluate their utility for one another based on their preference structure and time-specific characteristics of the labor market structure. Specific utility values of workers for jobs and jobs for workers, constrained by the available information about opportunities, drive the matching process. Particular labor market arrangements and matching mechanisms can be operationalized as structured parameter sets and rules in the model, and can be systematically varied (or held constant) in order to disentangle the effects of the complex labor market processes that are our substantive focus. The main advantage of this modeling framework is its flexibility: once the basic simulation structures are complete, we can explicitly control characteristics of the labor supply, the supply of jobs, the way information about jobs flows between workers and employers, how information about jobs and workers is evaluated once acquired, and the way in which matches are made. By varying the parameter sets of the model, we will be able to generate simulated labor market data consistent with theoretically described mechanisms, and thus better understand precisely how various preference structures and information structures affect labor market segregation in different institutional environments.

Technical Details

Three broad families of parameters govern our labor market environment: characteristics of the labor force and the supply of jobs, a preference structure, and an information structure. These are linked via the matching algorithm, which allocates workers to jobs according to a slightly modified version of a commonly-used two-sided matching algorithm described by Gale & Shapley (1962). We implement the model as a stochastic dynamic simulation, as shown in Figure 1. Below, we describe the central components of the model.

Figure 1: Flow Control for Model



Setting the Supply of Workers and Supply of Jobs: The model has two types of agents: workers and jobs, with the size of the worker population initially set at w and number of jobs initially set at j . Members of each type of agent can be assigned attributes, depending on what characteristics are theoretically relevant for a particular experiment.⁶ In the simplest version of the environment, workers are given two attributes, skill and race, while jobs are allocated into groups that can be thought of as roughly analogous to occupations or type of work (but can alternatively be thought of as levels of human capital), and each job is assigned to a firm. Firms can contain homogeneous or heterogeneous assortments of jobs.⁷

Within dimensions of differentiation, groups are qualitatively different from one another, and can be treated as ordered or unordered. Workers and jobs are assigned to their attribute categories by an ordered vector of probabilities that is exogenous to the model. In more complex implementations, the number of attributes, or the number of categories within an attribute, can be altered to represent specific labor market characteristics, such as markets for workers with and without college degrees, or high, medium and low-skill workers. The environment allows us to control the level of correlation between workers' attributes. (The correlation of worker attribute with job position is a product of the matching process, and provides one measure of segregation.) In addition, each worker is also assigned an inertia score (drawn from a normal distribution, $\mu = 0$) to reflect individual heterogeneity in propensity to change jobs. Scores that represents a worker's base reservation wage, and the cost of a job remaining vacant are also included; these are used to calculate utilities for remaining unemployed or vacant, respectively.

Preference Structure and Utility Calculation: We assume rational actors who seek to maximize the utility of their match. Utilities of workers for specific jobs are a weighted linear function of worker characteristics (such as employment status, utility for current job, worker inertia), job characteristics (class, vacancy), and worker-job pair characteristics (tenure, mismatch). Utilities of jobs for specific workers are a weighted linear function of job characteristics, worker characteristics, and job-worker pair characteristics. In each iteration of the dynamic model, utilities are calculated for each job-worker and worker-job pair. Utilities are recalculated for each iteration because individual and job-related characteristics vary over time.

In the most general form, each worker i 's utility for job j can be described as:

$$U_{ij} = \alpha x_{ij} + \epsilon_i$$

where x_{ij} includes a variety of worker and job characteristics and ϵ_i is a random term for individual variation in preferences. Parameters in α represent preferences for particular characteristics. These values can be adjusted according to empirical data or to reflect theoretical expectation. For example, we would model a strong worker preference for a job that worker's own occupational class with a high α parameter associated with $k_i=k_j$. The utility for unemployment (U_{i0}) will be nonzero for many workers, which means that some workers will choose unemployment over some available options.⁸

Similarly, each job j has a utility for each worker i , given by:

$$V_{ji} = \beta x_{ji} + \epsilon_j$$

where x_{ji} includes job and worker characteristics and ϵ_j is a random term for job-specific variation in preferences. The parameters in β represent preferences for particular characteristics. For example, an employer's preference for workers with a particular attribute would be represented with a high β parameter for that worker attribute. V_{ji} can equal zero if the employer would prefer to have the job

⁶ Distributions of these population characteristics are drawn from empirical data sources so as to make the populations representative of workers and jobs in national, regional, or sectoral labor markets. See appendix.

⁷ Future versions of this model will assign jobs to firms according to empirically observed distributions of jobs by firm size. See appendix for data sources that will inform this distribution.

⁸ In this sense, U_{ij} for unemployment is analogous to a reservation wage, where the value of welfare, unemployment insurance, leisure time, or not having to pay for child care is greater than the value of all jobs from which a worker can choose.

remain empty rather than fill it with i , or if the job does not know about worker i because of information constraints or employment status.

Information-access related structures: Access to information about specific jobs or workers is structured by various *information regimes*, each of which determines whether a particular worker will hear of a particular job or vacancy. Conceptually we represent an information regime with a $n_w \times n_j$ matrix A , where n_w is the number of workers in the system and n_j is the number of active jobs; and the cell values denote whether or not the worker and job know about one another. By convention, all access ties are symmetric, so that if worker i is aware of job j , then job j is aware of worker i . The matrix A is then used to adjust the utilities U_{ij} and $V_{j,i}$ such that if $A_{ij} = 0$ then $U_{ij} = 0$ and if $A_{j,i} = 0$ then $V_{j,i} = 0$.

The baseline information regime is the *full information regime*, in which every worker and every job know about each other, and $A_{i,j} = 1$ for all workers i and jobs j . All the remaining information regimes introduce an information constraint; this allows us to explore how variation in the structure of information flow across nodes affects the level of segregation in the labor market over time. While the total amount of information flowing in the labor market under a given information regime is a tunable parameter δ , we hold this constant in our comparison of regimes (excluding comparisons to the full information regime).

The least structured of our incomplete information regimes are the *random incomplete regimes*. For a given value of δ , access information is distributed randomly across workers and jobs independent of their characteristics, with the caveat that all workers know about the job they currently hold. All information flows are re-assigned at the start of each iteration.

In the *firm* information regime, workers know only about jobs in their own firm. If a worker quits or is fired, she no longer has access to information about any new jobs, and therefore stays unemployed for the remainder of the simulation. Since there is no mechanism for movement between firms in this regime, the unemployment/vacancy level tends to rise with each iteration; absent market-level population dynamics, the labor market will eventually fail. By itself, this regime is a poor descriptor of real labor markets, but because it captures key features of strict firm-internal labor markets, it is an interesting comparison to with other information regimes.

The *occupational information* regime structures information by worker-job classification. In its pure form, this regime prohibits movement between classes, essentially forming k distinct labor markets in which all job turnover is within a particular worker-job sector. Theoretically, this regime approximates a strict caste system or a guild, where assignments to jobs are made through an occupational organization. As with the firm-based regime, the occupational regime is less interesting in itself, but can be combined with other information dissemination structures.

Finally, we use a class of information regimes that are structured by workers' *social networks*. As a baseline, we will hold network structure constant by generating networks with a high degree of local clustering and high overall connectivity (Watts 1999a, 1999b). This "small-world" structure is common among human actors, and has been shown to have high potential for diffusion of information. In these networks, actors tend to have ties to actors with whom they share alters, but a tunable proportion (controlled by the parameter α) of ties are random. We implement two variants of a small-world structure: one in which clustered ties are independent of worker characteristics, and one in which workers tend to know other workers of their type. Since social networks are ties between workers, we use firms to connect workers to jobs. Under the social network regimes, a worker knows about a job if he or she is socially tied to someone who works in the same firm as that job. This means that access to information about jobs is limited by actors' social networks so that workers who know many people, or people in large firms, have more job opportunities.

Matching algorithm: After iteration-specific utilities are calculated and the information constraints imposed, valid pair-specific utilities are transformed into a rank-ordered sets of preferred options for each actor. Then workers and jobs are matched to one another using a variation on the Gale-Shapley algorithm for two-sided markets (Gale & Shapley 1962). The Gale-Shapley procedure has many

advantages, not the least being that it has been frequently used in two-sided matching models, and its properties are fairly well understood. The basic logic of Gale-Shapley is a deferred acceptance model. Given a set of rank orders for all potential actors in the system, a job is randomly selected to propose a match to its most preferred worker. The worker provisionally accepts the job if it is in the worker's ranked set and is more preferred than the offer they are currently holding. If a worker has already provisionally accepted a job but receives an offer from a more preferred job, the second offer is provisionally accepted and the first job is returned to the pool of vacant jobs. The matching proceeds in this fashion until all jobs have made offers to all the workers they prefer to remaining vacant. All workers need not have received offers, and some jobs may remain vacant. It has been shown that given a fixed set of preferences, the conventional G-S matching algorithm produces a stable, optimal (but not necessarily unique) match (see Roth and Van de Vate 1990).

We have made two modifications to the Gale-Shapley algorithm. First, and most importantly, we limit the set of actors who can be matched in any given iteration to those pairs of jobs and workers who have access to information about one another. Technically, this means that if $A_{ij} = 0$ then $U_{ij} = V_{ji} = 0$. Second, the utility inputs have a stochastic component, which means that neither utilities nor the actors available to be matched are necessarily stable between iterations. This produces the dynamic nature of the system that is crucial for simulating a labor market. Thus, mobility can be more explicitly vacancy-driven than is possible in the conventional Gale-Shapley where the matching proceeds among all actors in the system.

A related modification is used when the environment describes a vacancy competition regime. In addition to limiting the pool of potential matches to those the actors know about, the pool is further reduced so that only unemployed or looking workers, and vacant jobs are available to be matched. Unemployed workers can only be matched to vacant jobs (preserving the focus on job vacancies as the engine of opportunity), and looking workers can only be matched to vacant jobs or to the job in which they are currently employed. On the other side, vacant jobs can only make offers to unemployed workers; jobs that are filled remain with the same incumbent unless the fires/quits or population dynamics routines affect the match. Under the open labor market institutional regime, all workers and jobs are available to be matched to one another (given their preference structures and available information); in the closed vacancy competition regime only unemployed, vacant, and 'looking' actors are matched.

Additional components: We will also include two modules that will control various demographic and institutional aspects of the labor market. The population dynamics module removes and adds workers and jobs to the labor market, according to 'death' and 'birth' rates. These rates can either be fixed, or be a function of recent labor market conditions. The labor market dynamics module contains a routine that fires or resigns a small proportion of workers, and identifies a subset of workers who are employed but 'looking' for new jobs. Firing, resignation, and 'looking' are modeled as stochastic functions of tenure and occupational classification, and worker-job mismatch. This module is implemented only in the simulations of vacancy competition labor markets: it is skipped under the spot market regime, since all active actors are available to be matched, regardless of their employment status.

Simulated Data: Once a stable matching is achieved, the access structure is updated to reflect the new population and employment arrangements, and the iteration ends. Each trial consists of a specified number of iterations; at the conclusion of each trial, detailed data describing time-varying characteristics of workers and jobs and the state of the labor market at each iteration are saved to a file for analysis. Labor market statistics can be calculated from the simulated data, and the relationship between various parameters and the time-varying level of segregation can be modeled using standard statistical techniques.

Pilot Work

With support from a seed grant from the Center for Statistics in the Social Sciences at the University of Washington, we developed a small pilot version of this labor market framework. The pilot model

incorporated many of the basic features proposed here—including the fundamentals of matching, some rudimentary worker-and job-characteristics, and various information regimes. Agents in our pilot model had no characteristics other than occupational training, so we could not explore the effects of differences in network composition on labor market outcomes. This early work does, however, demonstrate the basic feasibility of our approach,

Substantively, we used the pilot model to assess the impact of differential information structures on macro-level labor market performance. We used the model to simulate small (100 x 100) labor markets, running 15 trials for each set of initial parameter values and letting each trial run for 1000 iterations. Data generated from trials of different information regimes were used to examine macro- and individual-level labor market outcomes, including employment level and stability, transitions into and out of employment and unemployment, quality of matches, efficiency of matching process, and employment segregation. Preliminary analyses of these data suggest that this is a promising strategy for analyzing the impact of access to information on both individuals and the labor market as a whole.

Overall, our model highlights that when information is limited in any way, two key measures of efficiency--mobility and turnover--decrease. This is consistent with the familiar idea that limits on information limit opportunity for actors in labor markets. However, the pattern evident in data simulated from our pilot model is that the distribution of number of jobs held during a career does not differ greatly between social network and full information regimes, while a constrained but unstructured information regime reduces both the mean and variance substantially. This implies that if there are any real penalties associated with frequent job changes, either in terms of search costs or rewards to tenure, full information may not produce optimal outcomes. Thus in key respects, spreading information through social networks produces macro-level and individual-level outcomes quite similar to those observed in the full information regime, although with lower mobility rates. In contrast, limited yet unstructured information regimes produce more egalitarian outcomes than either full information or social networks, by giving workers equally bad opportunities.

Operationalizing Segregation Mechanisms

The primary intellectual activity associated with this proposal involves carefully operationalizing the four segregation-generating mechanisms described above. Here we outline how each can be reflected in our labor market framework.

The basic *supply-side mechanism* will be implemented through a related set of parameter distributions and utility preference structures. The logic of supply-side models of segregation require that (1) employers evaluate potential workers and choose the most skilled or productive; and (2) skills, productivity, qualifications are correlated with another attribute, such as race or sex. Thus, the model will begin with a set of workers that are stochastically assigned “skill points”⁹ that are correlated with another qualitative attribute, such as race. Employers execute their desire for skilled workers by ranking preferred candidates according to a utility calculation depending solely on skills and a stochastic component to reflect bounded rationality. Thus, if workers prefer “better” jobs, and jobs prefer better workers, then segregation along an attribute should occur as a result of the preference for skill (in the utility calculation) and the correlation of skill with that attribute (from the population distributions). Experiments with the level of correlation of the attribute with the skill distribution will allow us to establish the amount of employment segregation that is likely to occur with this mechanism alone, and what level of correlation is required to produce observed levels of segregation (and conversely, how much segregation should be expected to observe given observed levels of correlation between ascribed attributes and job qualifications).

Demand side-mechanisms rely on similar combinations of population characteristics and preference structures. If employers prefer workers with a certain attribute, then we should observe

⁹ “Skill points” are a stylized substitute for productivity. These can be obtained through a composite score of education and experience, or similar characteristics, from empirical labor market data such as the Current Population Survey. See Appendix.

segregation along that attribute regardless of whether it signals anything about the workers' productivity. For this model, we can begin with zero correlation between the attribute and the skill level. The main variables here are the parameters controlling employers' preferences for skill versus a particular attribute. If employers strongly prefer to have workers with (or without) an ascribed attribute, then they will have higher utilities for workers with that attribute and we should expect to see high segregation. If employers have only a weak preference for the attribute relative to their preference for the skill (and the two characteristics are uncorrelated) then we should see less segregation. Extending this logic, if employers have strong preferences for both skill and an attribute, then we might expect to see the set of workers with both highly in demand. Explorations of the range of the parameter space for these two preference values can help us to distinguish the level of segregation that can be generated by levels of in-group (or out-group) bias in hiring decisions alone or in conjunction with the desire for skilled workers.

Information mechanisms include two distinct processes. The first depends solely on the availability of information in the labor market, while the second depends on the preference by employers for referred workers. For both mechanisms, we assume that information is not perfect, nor is it randomly distributed in the population without respect to attributes. Information is socially structured, by social networks, professional associations, geography, and so on. Furthermore, people's social networks and other affiliations may be (more or less) correlated with a particular attribute. A strong tendency toward homophily means we are more likely to know others with the same salient attribute; if job information is passed through social networks, access to information might be similarly biased. For the first mechanism, we assume that employers prefer appropriately skilled workers, and that skill is uncorrelated with the attribute. However, if workers hear about jobs primarily through their social networks, and the social networks are biased toward homophily on a particular attribute, we should expect hired workers to disproportionately share the attribute with the current work force even without an overt bias in the hiring decision. This mechanism can be operationalized through the creation of social networks where ties are more likely between agents sharing an attribute (or lack thereof). Distributions of skills and attributes can be uncorrelated in the population, and employers' preference parameter for skills is high, with zero preference for the relevant attribute. One interesting application of this mechanism would be to experiment with adjusting the employer's attribute preferences to reflect out-bias with respect to the attributes of the current work force. In other words, this can help us to determine how much affirmative action might be necessary to counteract the segregating effects of biased social networks on recruiting.

This mechanism is operationalized by adding a preference parameter for social network information over other types of information. Again, the prediction is that segregation should be higher with a stronger "nepotism" parameter, yet this should be even higher than under the first mechanism, since we have both the access and the referral bias effects acting on this. Analyses of both informational mechanisms in conjunction with one another should allow us to assess the relative impact of each of these.

Work Plan

Our plan for developing our labor market environment consists of three phases: expansion of pilot model into a useable research tool: calibration of parameter values with data drawn from empirically observed distributions, and experimental simulation of labor markets under various mechanisms that may play a role in segregating the labor force. Throughout, we will conduct sensitivity analyses and assess the validity of the model.

Model refinement and expansion: The pilot model was developed using the programming language R, which constrained us to unreasonably small labor markets. In order to use the framework to simulate larger and more complex artificial labor markets, we must translate the framework into C++, a much more powerful computing environment. After consultation with several experienced C++ programmers, we are confident that the model's basic architecture will be retained; thus, a great deal of

our effort will be devoted to creating a user-friendly and flexible research environment that will enable researchers to model a variety of labor market practices.

Calibration with Empirical Data: Since the model has a high degree of complexity, we are committed to using empirical data to establish standard values (or at least reasonable bounds) on many of the parameters. This will allow us to focus systematically on the effect of variation in the structures and mechanisms of theoretical interest. For example, although the model structure requires that jobs be assigned to firms, the impact of firm size on outcomes is not of key substantive interest. Therefore, we will draw our distribution of firm size from existing data, so that this can be held constant in the background of trials while other research questions can be addressed. Similarly, although the level at which workers and jobs prefer to remain unemployed or vacant rather than be matched with any available alternatives plays an important role in the matching process, and has a big impact on employment level, we do not intend to model reservation wages. Rather, we will assign this parameter a value that seems reasonable given available empirical evidence, and keep this variable in the background of our simulation. We have conducted a review of data sources that seem especially appropriate for these tasks: a table summarizing key model concepts/parameters and relevant available data appears as an appendix to this proposal.

Similarly, we will continue to consult data describing the behavior of labor-markets (in terms of turnover, unemployment, separations, and so in) as evaluate the extent to which our model offers a reasonable description of social process. Though we know that empirical labor markets are composed of complex mixes of matching functions and labor and job supplies, as long as our baseline model does not produce wildly high levels of unemployment (for example), we gain a bit of confidence in its utility as a tool for theorizing. We are very encouraged by the performance of our pilot model in this regard: fundamental features of the labor market are well within empirically observed ranges. This suggests that we will be able to use our simulated data to better understand how specific aspects of the hiring process may relate to segregation.

Experimental Design: Our purpose in developing this research framework is to help us better understand the conditions under which social structures and preferences will produce segregation in labor markets. Using an experimental design, we will simulate data with the dynamic model, implementing sets of various parameter values consistent with each of these mechanisms separately and in conjunction with one another. Key factors that we will vary include: the correlation of skill with attribute; the correlation between attribute and social network composition; employers' preference for workers with particular attributes; employers' preference for workers hired via specific information channels. The simulation framework is promising because it will allow us to explore, under highly controlled conditions, questions like: how segregated must informal structures be in order to generate segregated labor markets? And, what types of social structures can over-ride discriminatory preferences? This endeavor should therefore provide an important foundation for subsequent empirical analysis of the complex interplay between social distributions and micro-level preferences in producing segregation in labor markets.

Appendix: Overview of parameters to be calibrated empirically and description of potential data sources

Concept	Model Parameter or Function	Data Source(s)
<u><i>Labor Market Characteristics</i></u>		
Growth rates	Worker and job birth and death (retirement) rates	Current Population Survey household survey (CPS) Current Employment Statistics establishment survey (CES) Economic Census (EC) BLS/CPS data
Unemployment level	Initial employment level Unemployment as an outcome	BLS/CPS data
Worker-job mismatch and risk of separation	Fires, quits, looking functions	CPS Mobility and Tenure Supplements
Tenure and separation risk	Fires, quits, looking functions	CPS Tenure and Turnover Supplement
<u><i>Worker heterogeneity</i></u>		
Worker skills and qualifications	Worker class Worker Productivity	CPS occupation, education, experience, and wages
Tendency to leave or stay in jobs	Inertia	CPS mobility & turnover PSID (Panel Study of Income Dynamics) Risk Tolerance Supplement TBD
Value of leisure time, value of being unemployed	Reservation Wage	Unemployment Insurance payments? CPS Basic Monthly
Job Search strategies used by unemployed workers	Mixed information regimes	
Social Network characteristics	Number & distribution of ties Homophily/In-group bias Assortative characteristics Tie type and strength	(GSS) 1985 General Social Survey
<u><i>Job Heterogeneity</i></u>		
Firm size	Distribution of firm sizes from which assignments are drawn	(CEW) Covered Employment and Wages (EC) Economic Census <i>CES (Current Employment Statistics)</i> (OES) Occupational Employment Statistics
Job type	Job class	JOLTS (Job Outcome and Labor Turnover Survey) TBD
Cost of maintaining a vacancy	Vacancy cost	JOLTS (Job Outcome and Labor Turnover Survey) TBD
Recruitment strategies	Distribution of strategies Preference for known workers	
Vacancies	Number of vacancies Length of Spells	JOLTS
<u><i>Outcomes</i></u>		
Turnover	Turnover rates (for jobs)	JOLTS CPS Tenure and Turnover Supplement
Mobility	Mobility rates (for workers) Career mobility	CPS Mobility & Turnover NLSY (National Longitudinal Survey [of Youth]) CPS Labor Market data
Job Segregation/Inequality	Matching of workers to jobs by some characteristic	
Search Costs	Size and variation in pool of available alternatives?	TBD
Career trajectories	Sequence of jobs and unemployment spells	<i>NLS/NLSY</i> PSID
Opportunity structure	Vacancy chains	<i>TBD</i>

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Biographical Sketch
Katherine W. Stovel
August 2003

Professional Preparation

A.B. Stanford University (Political Science) 1988.

M.A. University of North Carolina, Chapel Hill (Sociology) 1994.

Ph.D. University of North Carolina, Chapel Hill (Sociology) 1999.

Appointments

1999-present, Assistant Professor, Department of Sociology, University of Washington.

Faculty Affiliate of the Center for Statistics and the Social Sciences (Seminar Director) and the Center for Studies in Demography and Ecology.

1997-1999, Acting Assistant Professor, Department of Sociology, University of Washington

1989-1991, Social Science Research Assistant II, Departments of Psychiatry and HSR&D program, Stanford University and Palo Alto VA Medical Centers

Related Publications

Stovel, Katherine and Michael Savage. "Mergers and Mobility: The Origins of Career Migration at Lloyds Bank." Resubmitted to the *American Journal of Sociology* 8/03.

Bearman, Peter, James Moody, and Katherine Stovel. "Chains of Affection: The Structure of Adolescent Romantic and Sexual Networks." Resubmitted to the *American Journal of Sociology* 7/03.

Stovel, Katherine and Christine Fountain. "Hearing About a Job: A Simulation Model of Differential Information Flow and Job Matching." Under review (5/03). Also available as CSSS Working Paper no. 30, www.csss.washington.edu/Papers/wp30.pdf

Savage, Michael, Katherine Stovel, and Peter Bearman. 2001. "Class Formation and Localism in an Emerging Bureaucracy: British Bank Workers, 1880-1960." *International Journal of Urban and Regional Research* 25:284-300.

Stovel, Katherine, Michael Savage, and Peter Bearman. 1996. "Ascription into Achievement: Models of Career Systems at Lloyds Bank, 1890-1970." *American Journal of Sociology*, 102:358-399.

Other Publications

Stovel, Katherine and Marc Bolan. Forthcoming. "Residential Trajectories: The Use of Sequence Analysis in the Study of Residential Mobility." *Sociological Methods and Research*.

Stovel, Katherine. 2001. "Local Sequential Patterns: The Structure of Lynching in the Deep South, 1882-1930." *Social Forces* 79:843-880.

Bearman, Peter, James Moody, Katherine Stovel, and Lisa Thalji. Forthcoming. "Social and Sexual Networks: The National Longitudinal Study of Adolescent Health" *Partnership Networks and the Spread of Infection*. Martina Morris, editor. Oxford University Press.

Bearman, Peter and Katherine Stovel. 2000. "Becoming a Nazi: A Model for Narrative Networks." *Poetics* 27:69-90.

Timko, Christine, Katherine W. Stovel, Martha Baumgartner, and Rudolf H. Moos. 1995. "Acute and chronic stressors, social resources, and functioning among adolescents with juvenile rheumatic disease." *Journal of Research on Adolescents* 5:361-385.

Synergistic Activities

1. As part of an earlier research project I developed an algorithm for calculating a variation of the Leventshein distance that can be used with large numbers of pairs of sequences. Similar algorithms had been developed for social science applications, but none that are as flexible as this or that could handle large data sets. I have since implemented this algorithm in a variety of widely used programming languages, including SAS and R; these versions are now used by researchers across the world
2. I regularly hold workshops on social network analysis for a variety of audiences, including NIH, participants in the Center for Spatially Integrated Social Science summer workshop, and at a ISSUP conference on HIV.
3. Locally, this past year I helped conceptualize and organize a national conference (co-sponsored by the Center for Statistics and Social Sciences and the Political Science Department) on computational modeling in the social sciences, which brought over 50 scientists using or interested in using computational methods to the UW for a two-day conference.
4. I have developed and now regularly teach a large and highly regarded introductory course designed to present undergraduates with a set of integrated principles and analytic models that are foundational to sociology. The course makes extensive use of technology and peer-based learning, and is a lot of fun.

Collaborators and Other Affiliations

a) Current or Recent Collaborators

King K. Holmes, Department of Medicine, University of Washington
Peter Bearman, Department of Sociology, Columbia University
Michael Savage, Department of Sociology, Manchester University
Taraneh Shafii, Department of Pediatrics, University of Washington
James Moody, Department of Sociology, Ohio State University
Marc Bolan, Organizational Research Institute, Seattle, WA

b) Graduate Advisor

Peter Bearman, Chair, Department of Sociology, Columbia University

c) Ph.D. Thesis Advisor

- o Justin Baer, Research Associate, American Research Institute, Washington, DC.
- o Christine Fountain (in progress)

In addition, I serve or have served on the Ph.D. thesis committees of April Linton (post-doc at OPR, Princeton), Kim Korinek (post-doc at CPC, UNC-Chapel Hill), Tanya Pergola (co-founder, Terrat), Susan Rachel Gragg (ASA Congressional Liaison), Shawn Bauldry, Julie Elizabeth Jackson, Josh Kane, and Adria Scharf.