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Social Closure and Gender Gap in Earnings: Evidence from a Multi-level Analysis of Census 2000*

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Using data from the U.S. Census 2000 and other secondary sources, this paper elaborates on social closure mechanisms that restrict access to remunerative occupations and investigates how gender inequality in rewards is conditioned by those closure devices. Hypotheses are tested to see whether social closure devices based on educational credentialing, opportunities for occupation-specific skills training and unionization work in gender-specific manner or not. Hierarchical linear models of regressing gender gap in earnings on social closure variables are estimated. Findings suggest that educational credentialing and unionization work to the advantage of female employees, while skills training dimension of social closure has no significant effect.

Keywords: *Social Closure, Gender Gap, Sex Segregation, Gate-keeping, Rent-Sharing*

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Introduction

Occupational sex segregation and discrimination have long been regarded as determinants of gender gap in earnings, and their role has been confirmed in a wide range of empirical tests (Chang, 2000; Cohen and Huffman, 2003; England, 1992; England, Hermsen and Cotter, 2000; England et al., 1988; Kaufman, 2002; Kelly and Dobbin, 1999; Kilbourne et al., 1994; Kmec, 2005; Nelson and Bridges, 1999). Although there has been much debate on the theoretical mechanisms accounting for these effects, few studies have investigated how social groups and their collective behaviors shape labor market processes through social closure mechanisms and generate gender differentiation in rewards. To the extent that social closure has been considered as a cause of gender earnings difference, previous works have relied almost completely on the percentage or proportion of females in an occupation or job as an indicator of closure. In this paper, an attempt will be made to expand this definition by drawing on recent discussions on social closure theories of labor market inequality and by performing analyses using the most recent representative sample of the U.S. Census.

I will address the following questions: Does social closure capture occupational segregation by gender either through 'gate-keeping' mechanisms or through 'rent-sharing' mechanisms, or perhaps through both? In other words, are female employees worse off because of 'barriers' that prevent them from entering into occupational locations, or are they better off once they get into those positions by virtue of 'exclusionary tactics' against a range of outsiders?

Gender gap in earnings has long been discussed within the context of the U.S. labor market since the late 1960s due to the development of initiatives on equal pay for equal or 'comparable' work and the equal employment opportunity legislation and resultant litigations (Nelson and Bridges, 1999). Studies of the causes or determinants of gender differentials in pay span a wide spectrum from choices made by men and women on human capital investment to society-wide devaluation of feminized work, organizational inequality models, occupational sex segregation and social closure explanations of gender gap in pay (Becker, 1971; England, 1992; Nelson and Bridges, 1999; Tam, 1997; Tomaskovic-Devey and Skaggs, 2002; Weeden, 2002). Among these various streams of research, I focus on the last two theories, paying special attention to how occupational-level social closure yields gender gap in earnings and how occupational sex segregation works to the disadvantage or advantage of female

workers.

In what follows, I review current developments in explaining occupational sex segregation in relation to gender inequality in pay and social closure-based approach to gender gap in rewards. Although these two theories are far from being independent of each other, they do represent distinct dimensions of social mechanisms that generate gender inequality, which is arguably in operation both within and between occupations. In addition, I draw on theoretical conjectures on social closure, which can be defined generally as mechanisms through which dominant social groups exclude subordinate members from access to valuable resources and opportunities that could bring returns in earnings outcomes (Parkin, 1979; Sorensen, 1996; Weber, 1978[1921]). I discuss some recent empirical works based on this notion of social closure to develop a definition of 'occupational social closure.' Then, elaboration and estimation will be made on a series of statistical models that can test hypotheses derived from these theories.

Theoretical Issues

Educational Credentialing as a Dimension of Closure

Students of the labor market and inequality have shown persistent interest in addressing inequality by group membership. Individual attributes, if socially recognized as a signal of status differentiation such as gender, race/ethnicity or citizenship, work as "barriers to access to socially valuable goods" (Parkin, 1979; Weber, 1978[1921]). In the occupational context, educational credentials and licensure are good examples of occupational membership through which returns to closure accrue for those within these terrains (Weeden, 1999, 2002; Zhou, 1993). These two devices are well recognized by the activities of occupational associations or licensing boards, and restrictions in occupational access can be reinforced because they are widely accepted and incorporated with well-established common sense, or scripts of written practices in domains of social activities (Tilly, 1998).

Although neo-Weberian scholars discuss closure effects as a stratifying mechanism that generates inequality in rewards, this line of research has yet to take gender differentiation into account in depth. The works of Weeden (1999; 2002) are among the few studies that extend the social closure proposition to the study of inequality in occupational rewards, dating back to early works of stratification (Collins, 1979; Manza, 1992; Murphy, 1983; Parkin, 1979). In her

analyses, occupational distinctions through educational credentials, certification or representation by professional associations that initially formed nominal boundaries have developed into devices mediated by collective action to bring returns to those who share membership within the 'closed circle.' These mechanisms restrict access to occupational positions such that they yield earnings returns to monopolization of supply of labor in the market. In addition, she asserts that those occupational groups also enhance the demand for their products or services by advertising their 'symbolic currency' in terms of professional ethics and quality of services that distinguish them from those outside the domain (Bourdieu, 1981).

To concretize these arguments, she draws on archival resources that include data on activities of occupational associations, institutions and unions, thereby yielding an elegant array of variables that capture occupational dimensions of earnings determination. Given that her interest lies mainly in transcending investment models of human capital and in articulating 'collective-action-based' models of earnings inequality across occupations, it is no surprise that she just offers a glimpse of the arguably gendered nature of closure effects on earnings. To further direct attention to the gender consequences of closure effects, I would like to briefly comment on some previous studies. In the mid-1970s, Snyder and Hudis (1976) developed a framework to articulate a social closure-oriented explanation of the relationship between occupational composition by gender and income using aggregate census data. Semyonov and Lewin-Epstein (1989) also employed two-wave regression models to decompose explanations on sex segregation and income inequality, finding limited support for segregation explanations of income inequality. What distinguishes their efforts from those in this paper, however, is their focus on a particular dimension of exclusion ('femaleness') rather than on the abstract property of exclusion per se. For example, the occupation of 'cable TV installer' seems to be a mostly male preserve, but the occupation seems to be free of other mechanisms of social closure (i.e., licensing, lofty educational requirements or union membership).

I agree with Weeden's argument that collective agencies at the occupational-level behave as occupational 'gate-keepers' through various devices of social closure, leading earnings benefit to materialize for those inside occupational terrains. However, I turn my attention to the gender dimension of occupational closure effect because I am interested in verifying whether occupational membership benefits male employees while disadvantaging female coworkers, and if so, in quantifying the extent to which these effects vary across occupations. I use educational credentialing as a proxy for the membership dimension of occupational closure below.

Access to Occupation-Specific Skills Training as Another Dimension of Closure

Social closure also operates by restricting individuals' access to training which is required for employment in a specific occupation with regard to gender difference in labor market placement. These processes have been labeled as 'allocative discrimination' (Petersen and Morgan, 1995; Petersen and Saporta, 2004). In other words, the question of whether or not female employees are channeled into different segments of the labor market than their male counterparts is closely related to the issue of whether or not matching of employees to occupations or jobs occurs in a gender-specific manner (Kaufman, 2002; Semyonov and Jones, 1999). The driving forces behind this allocative process are of considerable interest, and I focus on occupational aspects of allocation of skills training as opposed to job-level skills training which has been the primary interest of human capital theories, personnel economics and some sociological works (Lazear and Oyer, 2004; Tam, 1997; Tomaskovic-Devey, 1993; Tomaskovic-Devey and Skaggs, 2002; Tomaskovic-Devey et al., 2006).

While the assertion that occupation membership provides opportunity for access to remunerative positions deserves attention, it only taps one dimension of the issues of concern — that is, how categories of social groups or individuals of particular attributes fill in occupational locations. I have confirmed the social closure theory's argument that occupational hierarchies operate as a stratifying mechanism along boundaries of social groups such as men and women as well as majority and minority groups. Human capital theories posit that allocation of firm-specific skills training results from utility maximizing decisions of both the employer and the employee who take into account the long-term schedules of benefits and costs to each party. And they interpret the whole processes as individual-level decision-making in regard to investments of human capital (Lazear and Oyer, 2004; Mincer, 1997). However, I argue that social groups concerned with organizing skills training interact with each other and influence each other's decisions and, therefore, access to occupational skills training denotes one of the most critical terrains in which various interests among employers, employees and their coworkers are being shaped and put into negotiation for compromise (Burawoy, 1979; Sorensen, 1996).

In occupations where occupation-specific skills are organized in a way that allows occupational incumbents to control entry of fellow employees, closure practices should be more predominant than in occupations where allocation of on-the-job training is accomplished by bureaucratic administration of employment relations (Bridges, 1995; Stinchcombe, 1959). The so-called firm-internal labor market theories attribute allocation of firm-specific skills training

to either power relations or to efficiency considerations (Althauser and Kalleberg, 1981). However, occupations constitute distinct labor markets if relevant skills or job titles are well recognized by society-wide norms or customs within their spheres. These segments of occupations constitute occupational-internal labor markets (OILM) in which occupational incumbents have much bargaining power vis-à-vis employers due to higher skills requirements or scarcity in supply of skills in certain circumstances.

Stinchcombe (1959) posits that organization of production depends on the characteristics of skills such that bureaucratic organization of production processes suits the mass production industry well while craft organization is appropriate for the construction industry. In regard to my questions, his proposition denotes how organization of occupational skills that are highly occupation-specific differs from mass production skills which are found in routinized employment settings. Althauser and Kalleberg (1981) also emphasize this type of employment relations, which they labeled as 'occupational-internal labor markets,' where access to occupation-specific skills involves "a greater degree of occupational or professional control" of skills in scarcity. I have not fully taken into account the skills scarcity aspect of occupational training, but I emphasize that allocation of occupation-specific skills relates to occupational social closure in that it keeps those outside occupational boundaries from entering into the occupations based on occupation-specific skills training.

In regard to social closure arguments, I assume these occupations represent occupation-specific skills training dimension of closure given that allocation of occupation-specific skills are controlled by occupational incumbents than by formalized routines within the workplaces. Craft occupations are a clear example of occupational-internal labor markets. I suggest that gender inequality in earnings be conceptualized and measured based on access to occupation-specific skills training as the second mechanism of occupational social closure.

Unionization

The third mechanism that I examine is unionization at the occupation level. Among many aspects of unionization, I focus on the social closure interpretation of unionization, arguing that unions work to restrict access to occupations so that only union members have access, therefore monopolizing labor supply in occupations. Freeman and Medoff (1984) characterize this as the 'monopoly face' of labor unions.[1] The consequences of this mechanism on

[1] Although I mainly discuss the 'monopoly face' of unions in regard to performing closure practices,

wages or earnings are often described as 'union wage' effects. I do not intend to delve into various aspects of unionization on earnings outcome, but rather to measure the unionization effects on gender inequality in earnings through the lens of social closure.

Along with the development of more formalized and bureaucratized personnel systems, labor unions have had a substantial impact on how reward structures change and are shaped across industries or over time. In this regard, labor unions have often been referred to as an alternative source of resolving the concerns of labor allocation that arise within concrete work settings (Burawoy, 1979; Weakliem, 1990). In contrast to the neoclassical notion of wage determination mechanism, the new structuralist approach to social stratification and labor markets focuses on employees' resources that affect how wages are attached to jobs in the context of mutual relations between employers and employees (Baron and Bielby, 1980; Sorensen and Kalleberg, 1981). These theories argue that if common interests exist between the two parties of labor contracts in restricting supply of labor, both parties coalesce into extracting mutual benefits from maintaining such barriers.

This dimension of employment relations indicates the so-called 'composite rents' that only materialize by the 'coordination of interests' between parties participating in social relations (Sorensen, 1996). Labor unions under certain external environments would represent their members with this 'monopoly face' (Freeman and Medoff, 1984), lending credence to the validity of the third mechanism of social closure. The role of unions in shaping closure effects, therefore, can be understood within the framework of 'governance problem' in employment relationship (Bridges and Villemez, 1991). For some occupations where job-relevant skills are socially recognized and are more available in external markets than in specific employing organizations, unions have a much stronger interest in restricting access to positions to those who have relevant 'symbols of affiliation' through membership with unions. Furthermore, unions are more likely to be committed to maintaining their monopolistic market situations in regard to supply of labor.

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unions do affect gender gap in earnings by shaping employment relations via the "voice" aspect of union activities. Therefore, it should not be neglected that unions tend to protect less privileged groups (i.e., female or minority employees), which could be referred to as the 'collective voice/institutional response' face (Freeman and Medoff, 1984).

Synthesis

Based on the discussions described above, I explore three mechanisms of social closure below and develop analytical models to bring them under empirical scrutiny. Although educational credentials function as 'symbolic markers' of individual merits or as signals for occupational gate-keepers of prospective employees who are acceptable for entry into specific occupational locations, the consequences of those closure devices could work in a gender-specific manner in concrete settings. Also, unions are reported to have long favored male workers in recruitment either due to cultural typing or economic benefits associated with exclusionary behaviors (Hartmann, 1976; Milkman, 1987). I, therefore, expect the membership dimension to work to the advantage of male workers. I conjecture that women employees are systemically denied access to occupations that are equipped with a higher degree of closure practices, which in turn prevent them from capitalizing on the earnings returns to closure. However, it is not clear how closure mechanisms are related to the size of gender gap within occupations. That is, women who enter the protected sphere of a relatively closed occupation may be 'more equal' to their male colleagues than other women in less protected occupational environments. I expect that a range of occupations with varying degrees of closure could serve as comparison groups for themselves.

Hypotheses

Based on the theoretical perspectives described above, I tested my hypotheses as follows. I conceptually distinguished between-occupation effects from within-occupation effects of social closure mechanisms so that the following hypotheses would reveal these two distinct processes. To the extent that occupational sex segregation channels female employees into low-paying occupations, it would contribute to an increased gender gap in earnings. I expected the sex composition of occupation to be negatively associated with the level of earnings and gender gap in earnings.[2] However, because previous

[2] Nelson and Bridges (1999) point out the possibility that the existence of job segregation is not a sufficient condition for the gender gap in earnings to occur because there might be a situation where job segregation *per se* is not coupled with male overrepresentation in better paying occupations. They posit, "job segregation *per se* is not sufficient to cause inequality in pay because job segregation

research has produced mixed results (Bayard et al., 1999; Cohen and Huffman, 2003; England, Hermsen, and Cotter, 2000; Kilbourne et al., 1994; Macpherson and Hirsch, 1995; Tam, 1997; Tomaskovic-Devey and Skaggs, 2002), I do not hypothesize that the wage 'penalty' for individual women will be larger in occupations where women are numerically over-represented. First, Hypothesis 1 denotes between-occupation effects of closure mechanisms, while Hypotheses 2 and 3 elaborate within-occupation processes in which occupational closure mechanisms are associated with gender gap in earnings.

> ***Hypothesis 1:*** *Occupational segregation by sex explains a substantial portion of the variation in gender gap in earnings after controlling for human capital and other individual-level determinants of earnings.*

This dimension of gender inequality relates to allocative discrimination (Petersen and Morgan, 1995; Petersen and Saporta, 2004). In the subsequently examined models, I assessed this hypothesis in the following manner: After estimating a model which includes a term for each individual's gender, I added a random intercept term for occupational membership. The reduction in the coefficient for individual gender represents the *maximum* proportion of the overall effect of gender that can be explained by gender segregation. An estimate of the *minimum* contribution of segregation to gender gap can be obtained in my analytic scheme by introducing into the last-mentioned model, a variable representing the proportion female in each occupation. The reduction in the occupation-level variance between these two models captures the overall earnings variation attributable to gender composition. These two different estimates, therefore, bracket the contribution of gender segregation to explaining earnings variation.[3]

Assuming that the entire male-female between-occupation variability in earnings is not attributable to gender composition (see results below), one needs to explore alternate explanations of occupational wage effects. I propose that social closure devices work as an explanation of occupational gender segregation

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must be coupled with an overrepresentation, on average of male workers in better paying jobs. In other words, there is the possibility of a non invidious version of between-job wage differences in which men and women work in different jobs but in which the sex composition of a job is unrelated to its level of earnings (p. 61)."

[3] The reason that the last procedure produces a minimum estimate of the variation attributable to gender segregation is that it only takes into account the linear relationship between proportion of female and earnings. Various non-linear specifications have the potential of explaining a larger fraction of the between-occupation gaps.

to the extent that they keep female employees from entering high-paying occupations either by imposing restrictions via educational credentialing and unionization or by denying access to occupation-specific skills training.

> ***Hypothesis 2a:*** *The coefficient for the sex composition variable will vanish when social closure variables are added to models.*

If this hypothesis holds true, then social closure mechanisms can explain segregation effects because the proportion of women in an occupation is decreased and earnings increased simultaneously.

> ***Hypothesis 2b:*** *The coefficient for the sex composition variable will increase when social closure variables are added to models.*

Social closure mechanisms suppress segregation effects because women may be over-represented in occupations that maintain higher exclusionary boundaries. For this to be true, mechanisms of gender segregation would have to be independent of other exclusionary mechanisms so that the two effects can exist at the same time. The hypotheses discussed above are all relevant to between-occupation sources of closure effects on gender earnings gap. However, levels of occupational closure also affect within-occupation sources of earnings variation. I, therefore, turn below to the issues of how closure mechanisms work through within-occupation sources.

> ***Hypothesis 3a:*** *Gender earnings gap is greater in occupations with higher levels of closure if closure devices work to prevent female employees from entering high-paying occupational segments or ranks.*

At the same time, social closure mechanisms may work to exacerbate gender inequality if they are associated with greater within-occupation gender earnings differences. This hypothesis suggests a plausible explanation of the association between gender gap in earnings and the within-occupation sources of the educational credentialing effects. For example, the systems of 'occupational ranks' which operate in the professoriate are related to the closure mechanisms that create privilege for all university faculty — an ideology of expertise, gate-keeping through rituals of acceptability to peers. If this hypothesis holds, then the most 'closed,' or 'credentialed,' occupations are those which are composed of occupational segments that differ widely in their exclusivity.[4]

Table 1. Summary of Closure Mechanisms

Dimensions of Closure	Column A Features of Closure	Column B Between-Occupations Effects (Hypothesis 2a/2b)	Column C Within-Occupation Effects: Underlying Mechanisms (Hypothesis 3a/3b) The 'Gate-keeping' Mechanism or Intra-occupational Segregation	Column D The 'Rent — Sharing' Mechanism
Row 1: Educational Credentialing	Symbolic markers or 'cultural currency'; acceptability of employees to peers or occupational gate-keepers via 'diplomas' or 'degrees'	'Entry barriers' due to high costs and lengthy periods of training	Female employees are excluded from access to remunerative ranks or specialties within a given occupation	Monopoly rents from educational credentialing are shared with female employees
Row 2: Occupation-Specific Skills Training	Occupational incumbents have power or resources to control access to occupation via occupation-specific skills training	'Occupational internal labor markets (OILM); craft occupations control access to occupation specific skills training	*No a priori* explanations	*No a priori* explanations
Row 3: Unionization	The 'monopoly face' of unionization; unions impose barriers to entry through union membership	Unionization keeps non-members from enjoying union wage premiums, therefore, yielding 'monopoly rents.' These become gender-relevant to the extent that women are disproportionately excluded from the occupation	Female employees are excluded from access to remunerative ranks or specialties within a given occupation due to union's realization of 'male interests'	Homogenization of internal differences in earnings; compressed wage distribution between male and female employees

Hypothesis 3b: *However, if occupational social closure actually functions as a 'rent-sharing mechanism,' women employees also benefit from occupational closure in terms of earnings.*

This hypothesis would hold if closure mechanisms function in a 'caste-like' fashion to homogenize internal differences; then closure will have a more positive effect on women's earnings, which would otherwise be low, than they do on men's earnings. The within-occupation gender effects of closure may vary according to the specific closure mechanism under investigation. For example, occupational licensing, on which I have no data, is likely to operate in a homogenizing fashion as specified in Hypothesis 4b. However, for the mechanisms of closure under investigation here — educational credentialing, unionization, and specialized training — it seems unwise to offer any preliminary *a priori* expectations about their outcome. Table 1 describes features of the three dimensions of occupational closure and related hypotheses as suggested above, summarizing how closure effects on gender gap in earnings materialize through both between- and within-occupation mechanisms. I refer to Table 1 below in discussing findings from regression models.

Statistical Analyses

Data

The primary data used here are the 1 Percent Public Use Microdata Sample of Census 2000 (PUMS1-2000). The U.S. Census microdata have often been used in the study of earnings inequality (Cohen and Huffman, 2003), because they provide a large probability sample and represent the overall population of concern. For my purpose, this large sample size is especially important, as I need to generalize my findings about the population of occupations in the United States using the most detailed, three-digit level of analysis available. In addition, because I include some aggregate-level measures in the following statistical models, I should be able to attain precise estimates of those measures, allowing

[4] In a less substantive vein, within-occupation variability of this sort may occur in the data for this paper when occupations are composed of separate and distinct sub-occupations which the Census Bureau does not distinguish. To some extent, this situation occurs within the medical profession where radiology and dermatology constitute something close to separate and distinct occupations with their own journals, meetings and entry requirements.

me to test hypotheses with a higher degree of statistical power.

I also draw on Equal Employment Opportunity Tabulation 2000 to get measures for demographic composition of three-digit occupations (U.S. Dept. of Commerce, 2006). Instead of using estimates from PUMS1-2000, I proceed with EEO file since the latter is known to provide more reliable estimates of population demographics such as proportion female and proportion minority that serve as controls in my models. The EEO file is appropriate for attaining reliable estimates for those groups, since the data were originally designed to yield further information on levels of pay for given demographic composition of organizations and occupations, and to provide estimates as benchmark for wages in the external labor market (National Center for O*NET Development, 2005). Using both PUMS1-2000 and the EEO file, I first constructed PUMS1-2000-EEO for consistent occupation classifications, which serve as level 2 unit throughout my analyses.

For measures of occupation-skills training, I draw on the Occupational Information Network (O*NET hereafter), which was designed as an updated replacement of the Dictionary of Occupational Titles (National Center for O*NET Development, 2005). The latter has long been used in studies of various occupational outcomes, such as earnings inequality, occupational environments, and individuals' occupational choices. Although providing a wide array of measures for occupational attributes, the DOT is known to have been outdated and, therefore, may not accurately reflect the occupational world in the late 1990s, an era that many researchers believe to have undergone structural changes in occupational structure (Cain and Treiman, 1981; Charles, 2003, 2005). Therefore, the O*NET serves better to investigate occupation-level outcomes with up-to-date measures for the occupations in the late 1990s. In addition, no research has yet used the O*NET to perform empirical test of earnings inequality by gender in relation to occupational social closure practices.

Prior to estimating a series of hierarchical linear models, I imposed some restrictions on the data. First of all, I restrict the sample to those who had positive earnings and were between ages 25 to 60 in 1999. Then I excluded observations from the District of Columbia, Puerto Rico and other Islands. Therefore, my sample only contains individuals who worked in the 50 U.S. states in 1999. However, I calculated aggregate measures of occupational characteristics such as the percentage working in the public sector before I imposed age restriction so that those outside the age range can contribute to the aggregate measures. I expect this strategy to be more sensible because occupational characteristics as contextual measures are certainly composed of the entire work force rather than an arbitrarily constrained subset of it.

Variables

Dependent Variable: The dependent variable is the logged annual earnings of individuals who worked in 1999. Annual earnings include all of waged/salaried income and self-employment income. I include the latter earnings because I believe occupational social closure effects are relevant not only for wage earners but also for those who work for themselves. Although some previous researches on earnings inequality use weekly earnings as a dependent variable, I prefer to use annual earnings. The former method is usually done by dividing annual earnings by hours worked for the reference year, but the procedure is likely to bring in measurement errors when the hours or weeks measured are unreliable (Bound et al., 1994; Rodgers, Brown, and Duncan, 1993).

Predictor Variables: Predictor variables of interest are measures for occupational closure mechanisms. Three measures are constructed either by the aggregation of individual observations to the three-digit census occupations or by drawing from secondary data sources. Educational credentialing refers to the extent to which 'educational symbols' function as barriers to entry into occupations. Survey measures regarding the presence of educational credentials by the occupational actors are rarely developed. I use the percentage of employees who worked in occupations in 1999 with a college degree or higher. This measure denotes the extent to which educational credentialing was predominant in occupations in that year. This is more stringent than Weeden (1999, 2002) who used the percentage of employees with some college education or higher as the measure for the extent of educational credentialing. I, therefore, hypothesized that social closure arguments would be strongly supported if significant effects are revealed with this measure.

Access to occupation-specific training is drawn from O*NET Specific Vocational Preparation (SVP) scale, which measures the amount of training time required for occupational incumbents to perform their jobs appropriately. The SVP measure had been included in earlier versions of the Dictionary of Occupational Title and used by many researchers investigating the relations between occupational skill requirements and earnings outcome.[5]

[5] The O*NET measure I use here is JOBZONE, an updated version of SVP that better taps the allocation of occupational skills training within occupational categories. This holds true when I add another control for occupational skills requirements, which directly quantify a wide array of the levels of occupational skills such as substantive complexity and engineering skills. I dichotomize

Table 2. Descriptive Statistics for Variables Used in the Analysis: Men and Women, Ages 25 to 60, 1999 (Unweighted)

Level of Analysis/Variable	Mean	Standard Deviation	Minimum	Maximum
INDIVIDUAL (N=966,677)				
Annual earnings (in 1999 $U.S.)	38599.66	42087.02	4.0000000	680000.00
Annual earnings (logged)	10.2	0.91	1.39	13.43
Female	0.47	0.50	0	1
Race/hispanic origin (Referent: white alone)				
Black	0.09	0.28	0	1
Other races	0.10	0.30	0	1
Hispanic or Latino origin*	0.09	0.29	0	1
Marital status (1=currently married)	0.67	0.47	0	1
Parenthood status (*Referent: having no children under 18 years*)				
Number of own children	0.85	1.12	0	16
Presence of children under 6 years	0.18	0.38	0	1
Presence of children 6 to 17 years old only	0.28	0.45	0	1
Education (Years of education completed)	13.62	2.70	2	20
Potential experience	21.76	9.74	1	52
Potential experience squared	568.2	446.66	1	2704
English speaking ability	3.75	0.70	0	4
Public employment	0.16	0.37	0	1
Lnhours (log of hours worked per week)	3.69	0.35	0	4.6
Lnweeks (log of hours worked per year)	3.84	0.35	0	3.95
Employment status(1=full time, year round employees)	0.72	0.45	0	1
Number of own children	0.85	1.12	0	16
Occupations (N=471)				
Educational credentials (Proportion of employees with education of college or higher)	0.26	0.28	0.01	1
Jobzone 4: Indicator of occupations with higher level of on-the-job training (1=Jobzone>=4)	0.21	0.41	0	1
Jobzone: Level of on-the-job training	2.85	1.06	1	5
Unionization (Proportion covered by union contract)	0.17	0.16	0	0.85
Proportion employed in the public sector	0.17	0.24	0	1
Proportion female	0.37	0.28	0.01	0.98
Proportion minority	0.26	0.11	0.06	0.7
Occupational skills requirements/ Work environments				
Substantive complexity	-0.05	1.01	-3.22	2.47

Table 2. Continued

Level of Analysis/Variable	Mean	Standard Deviation	Minimum	Maximum
Environmental disamenities	-0.06	0.99	-2.62	3.23
Engineering skills	-0.03	0.99	-2.53	3.31

Note: *In U.S. Census 2000, classifications of race and Hispanic origin are not mutually exclusive but crosscut each other. Therefore, the Hispanic dummy variable indicates differences in log annual earnings between employees of Hispanic or Latino origin and those of Non-Hispanic or Latino origin. It may not be compared to the reference group for race, which is non-Hispanic white alone. See U.S. Dept. of Commerce (2003) for details.

Unionization refers to the extent to which occupations are covered by a union contract; the contract serves as a proxy for occupation-level closure in terms of union practices that excludes outsiders from entry into the occupations of concern. However, the U.S. Census 2000 has no variable on union membership or coverage either at the individual- or occupation-level. I instead draw on Current Population Survey estimates, which were compiled by other researchers (Hirsch and MacPherson, 2003). CPS and Census 2000 used different occupational classification schemes until 2003 when CPS converged its occupational classification with those of the Census. I use an occupational crosswalk that allows for consistent estimates of occupational incumbents, ending up with Census 2000 union coverage estimates (U.S. Dept. of Commerce, 2007). Although adding both individual- and occupational-level measures together into the equation would have been ideal, I have no individual-level measures for union coverage from Census 2000. I, however, lend credence to the argument that union coverage as a measure for social closure is better captured at the occupation level and assume that my strategy suffices for current research questions.

Controls: Occupation-level controls include demographic composition of occupations and some measures for occupational characteristics such as skills requirements and work environment. For demographic composition, I include the percentage of minority and percentage of people working in public employment. Minority variables could have been finely classified as in other research, but given my primary interest in gender relations and for the sake of parsimony, I just included one variable to control for minority composition of

occupations with a cutoff point of JOBZONE=4 to simplify interpretations, comparing occupations with higher level of on-the-job training (JOBDUM4=1) to those with lower levels of on-the-job training (JOBDUM4=0).

occupations, i.e., percentage of non-Caucasians in occupations. The percent employed in the government sector is of special interest in that it would test some competing explanations of gender effects of public employment on labor market outcomes such as income inequality, extent of discrimination, and opportunity for promotion or job training (Baron, Mittman, and Newman, 1991; Bridges and Nelson, 1989; Bridges and Villemez, 1991; Gornick and Jacobs, 1998). I also include occupational skills requirements which were constructed by factor analysis of related items from the O*NET (see Appendix A for details). Also included is a measure for environmental disamenities which have been reported to affect occupational rewards in previous studies (England, 1992; Filer, 1985; Jacobs and Steinberg, 1990).

At the individual level, I control for a series of human capital variables which are commonly used as determinants of earnings. Education refers to the number of years of education that occupational incumbents attained as of the survey point. Potential experience is added by deducting the number of years of education and gender from age, and its square term is also included. Other variables include log of hours and weeks worked in 1999, marital status (currently married=1), and its interaction with gender (female=1). A controlled set of race/ethnicity dummy variables indicates respondents who are black, non-white Hispanic and others. Ability to speak English is reverse coded with a range of 1 to 4 so that higher values refer to respondents having a good command of English. Family structure constrains occupational choices of employees, especially those of mothers, so three measures are included to take this aspect of earnings determination into account. Number of own children (NOC) is included as a control. In addition, I constructed two dummies to adjust for parental status: presence of children under 6 years is coded 1 if respondents had children under 6 and presence of children of aged 6 to 17 years is coded 1 if respondents had children 6 to 17 years old only. The reference group is those who had no children under 18 years of age.

Statistical Models

In earlier research on earnings, occupational attributes are often appended to individual observations and treated as individual characteristics. This method, however, violates the classical regression assumption of independent errors because individuals in same occupations are more likely to have occupation-level contextual effects in common (De Ruijter and Huffman, 2003; Hox and Kreft, 1994; Kreft and de Leeuw, 1994). Hierarchical linear models (HLMs) correct for these shortcomings, especially when the purpose of research

is examining the relationship between occupational-level social closure and earnings inequality by gender. I, therefore, use HLMs hereafter, taking into account the dependence of observations within each occupation, verifying whether or not occupational closure effects explain much variance in both individual- and occupation-level of models (Bryk and Raudenbush, 1992).

I first estimate unconditional ordinary least square models and regress individual earnings on a set of human capital and demographic variables as well as a gender dummy (female=1) variable. Then, I allow the intercept and gender coefficients at the individual-level models to vary across occupations and to be explained by occupation-level social closure variables and other controls such as skill requirements and demographic composition (proportion female and proportion minority in occupations). At the individual level (Level-1), my model is defined as follows:

$$\text{Equation (1): } Y_{ij} = \beta_{0j} + \beta_{1j}(Female_{ij}) + \sum_{2}^{k} \beta_{kj}(X_{kij} - \overline{X}_{k..}) + \varepsilon_{ij}$$

Here, Y_{ij} is the log annual earnings of person i in occupation j, and β_{0j} is the intercept for occupations holding all other covariates constant at their means. β_{1j} is the coefficient of primary interest, which denotes individual gender effects on earnings. In other words, this coefficient taps the extent to which gender earnings inequality exists within occupation j. β_{kj} denotes coefficients for individual-level covariates and X_{kij} refers to the corresponding individual-level controls. Before estimating models, I centered all individual-level covariates except gender dummy variables on their grand means. This centering procedure makes coefficient estimates more interpretable and makes maximum likelihood estimation to easily converge (see Bryk and Raudenbush, 1992, Chapter 2 for discussion). Finally, ε_{ij} is the error term at the individual level, and it is assumed to have normal distribution with equal variance of ε^2 for all observations.

Level-1 coefficients predicting the log of earnings at the individual level are treated as either random or fixed effects at the occupation level (Level-2). I allow the intercept β_{0j} and the gender coefficients β_{1j} to vary across occupations, treating them as random effects, while other coefficients are held to be constant across occupations, treating them as fixed effects. For Level-2 models, I also centered all variables on their grand means. My Level-2 models are as follows:

$$\text{Equation (2-1): } \beta_{0j} = \gamma_{00} + \gamma_{01}(PF_{sj} - \overline{PF_{..}} + \sum_{s=2}^{4} \gamma_{0s}(SC_{sj} - \overline{SC_{..}} \sum_{s=5}^{k} \gamma_{0s}(W_{sj} - \overline{W}_{..}) + \nu_{0j}$$

Equation (2-2): $\beta_{1j} = \gamma_{10} + \gamma_{11}(PF_{sj} - \overline{PF}_{..} + \sum_{s=2}^{4} \gamma_{1s}(SC_{sj} - \overline{SC}_{..} \sum_{s=5}^{k} \gamma_{0s}(W_{sj} - \overline{W}_{..}) + \nu_{0j}$

γ_{00} and γ_{10} refer to the grand means for Level-1 coefficients of the intercept and the gender dummy variable, respectively. PF denotes proportion female in occupations and γ_{01} and γ_{11} are coefficients for that variable in Level-2 equations. γ_{02}, γ_{03} and are γ_{04} the effects of social closure mechanisms (educational credentialing, access to occupational skills training and unionization, respectively) on the occupation average male earnings, adjusting for individual-level covariates. γ_{12}, γ_{13} and γ_{14} are the effects of social closure on gender gap in earnings in each occupation, which are of particular interest in the following analysis. These coefficients are, in other words, estimates for the effects of cross-level interactions between the female dummy and each of the three social closure mechanisms. SC_{sj} refers to the three social closure measures all centered around their grand means. W_{sj} is a set of occupation-level covariates, the coefficients of which are γ_{04} through γ_{0k} in the model for the Level-1 intercept. The Level-2 error terms for the intercept and gender dummy models are ν_{0j} and ν_{1j} , which are assumed to have means of 0 and variance-covariance of T.

Results

Prior to testing the hypotheses suggested above, I laid the groundwork for discussion on the relationship between occupational gender segregation and other social processes, including social closure mechanisms, that exert between-occupation influences on earnings determination. For this to be accomplished, I report two kinds of estimates for the gender effects: total and within estimates. The former denotes the 'total' gender effect on earnings gap, while the latter captures the 'within' component of gender differentials in earnings, which conceptually partial out gender gap that results from between-occupation processes. In Table 3, Model 1 and Model 2 reveal the adjusted and unadjusted gender gaps, respectively, while Model 3 through Model 5 provide within-estimates of the gender effect.

Model 1 shows that the overall gender gap without adjusting for individual-level variables equals 39.71% (=100*[1 – $e^{-.506}$]), revealing that female employees only made about 60% of what male employees earned in the labor market. Because I added controls for individual-level determinants of earnings, the gender gap narrows to 25.47% (=100*[1 – $e^{-.294}$]). I subsequently refer to this as the 'adjusted' gender gap in earnings. The decrease in the

Table 3. Effect of Individual-Level Gender and Occupational Gender Composition on Individual Earnings, PUMS 2000*

Variables	Total estimates		Within estimates		
	Model 1	Model 2	Model 3	Model 4	Model 5
	(Unconditional Model, OLS)	(Including Individual-Level Controls, OLS)	(Including Individual-Level Controls, Occupation Fixed Effects, OLS)	(Including Individual-Level Controls, Occupation Random Effects, HLM)	(Including Individual-Level Controls, Occupation Random Effects, HLM)
Intercept (b_{0j})					
Intercept (γ_{00})	10.435	10.337	10.168	10.318	10.318
Proportion Female (γ_{01})					-.142
Gender (Female = 1) (b_{10})	-.506	-.294	-.251	-.251	-.251
Variance Component					
(τ_{00}) (Intercept)	N.A.	N.A.	N.A.	.070	.068
(σ^2) (Residual)	.763	.442	.383	.384	.384

Note: * All coefficients significant p<.05.

Statistical significance is determined by robust standard errors of each coefficient.

Sample size: Individual N=966,677; occupation n=471.sn

coefficient for the gender dummy (female=1) is 41.89% of the total gender effect shown in Model 1.

Next, I estimate the between-occupation portion of the adjusted gender gap. Model 3 and Model 4 show the potential segregation effects on gender earnings gap. I first run a fixed-effects model that adjusts for between-occupation effects, therefore yielding a coefficient estimate for the within-occupation gender effect now equaling -.251. Comparing this coefficient to that from Model 2, I noticed that the effect of occupational membership amounts to 14.62% [=100*{–.294–(–.251)}/(–.294)] of the adjusted gender gap. Therefore, I postulate that the *maximum* amount of gender earnings gap that could be explained by occupational segregation is about 15%. This is smaller than the magnitudes reported by previous studies which analyzed job-level data (Baron and Newman, 1990; Bayard et al., 2003; Nelson and Bridges, 1999; Petersen and Morgan, 1995; Reskin and Roos, 1990). However, given that my focus is on occupation-level social processes, I consider this to be substantial. I also estimate a random-effects model that allows the overall level of earnings to vary across occupations, finding almost identical results in Model 4. The coefficients for the gender effect after Model 3 are now the 'within estimates' in that between-occupation variation in earnings has been taken out prior to estimating the female coefficients of interest.

In Model 5, I added proportion female in occupation to see whether the gender composition of occupations is significantly associated with gender gap in earnings. I report reduction in variance in the intercept as a measure of contribution of sex composition effects. Once this estimate is obtained, I can bracket the contribution of occupational segregation by gender, controlling for individual-level covariates. As seen in Table 3, adding a sex composition variable to Model 3 explains some variability around the intercept estimate, .02 (= .70 – .68), which equals 2.85% of the overall variance in the intercept coefficient. Therefore, I have shown that the overall contribution of between-occupation gender segregation effects is approximately between 3% and 15%. Thus, there is some support for the role of occupational segregation by gender in explaining between-occupation variation in earnings.

Given these results, I found that controls for the individual-level variables had major effects on the size of the individual gender coefficient. As expected, in comparing Model 4 and Model 5, some parts of the overall effect of 'occupation' are attributable to gender composition, but the effect is rather small. This finding suggests that other occupational characteristics, including closure, need to be taken into account both as main effects and as potential sources of statistical interaction with the occupational sex composition variable.

Table 4. Hierarchical Linear Regression Coefficients for Annual Earnings: Men and Women, Ages 25 to 60, 1999

Variable	Model 5 (Random Intercept + Sex Composition)	Model 6 (Model 5 + Sex Composition by Female Dummy)	Model 7 (Model 6+ Social Closure)	Model 8 (Model 7 + Occupation-Level Controls)
Intercept (b_{0j})				
Intercept (γ_{00})	10.318**	10.310**	10.310**	10.311**
Proportion Female in Occupation (γ_{01})	-.142**	-.174**	-.233**	-.188**
Educational Credentialing (γ_{02})			.587**	.497**
Specific Vocational Preparation (γ_{03})			.090**	.064**
Proportion Covered by Union Contract (γ_{04})			.267**	.351**
Proportion Minority in Occupation (γ_{05})				-.474**
Proportion Employed in the Public Sector (γ_{06})				-.104**
Cognitive Skills (γ_{07})				.025**
Environmental Disamenities (γ_{08})				-.014
Engineering Skills (γ_{09})				.018+
Female (b_{0j})				
Intercept (γ_{10})	-.251**	-.228**	-.250**	-.252**
Proportion Female in Occupation (γ_{11})		-.007	.017	.018
Educational Credentialing (γ_{02})			.079**	.101**
Specific Vocational Preparation (γ_{13})			.001	.006
Proportion Covered by Union Contract (γ_{14})			.247**	.075
Proportion Minority in Occupation (γ_{15})				.305**

Table 4. Continued

Variable	Model 5 (Random Intercept + Sex Composition)	Model 6 (Model 5 + Sex Composition by Female Dummy)	Model 7 (Model 6+ Social Closure)	Model 8 (Model 7 + Occupation-Level Controls)
Proportion Employed in the Public Sector (γ_{16})				.134**
Cognitive Skills (γ_{17})				.007
Environmental Disamenities (γ_{18})				.015+
Engineering Skills (γ_{19})				.009
Level-1 Control	Yes	Yes	Yes	Yes
Variance Components				
τ_{00} (Intercept)	.068	.065	.032	.028
τ_{11} (Female Slope)		.009	.008	.007
σ^2 (Residual)	.384	.384	.382	.382
Total	.452	.458	.422	.417

Note: Individual-level controls include years of education, potential experience and its square, race and Hispanic origin, public sector employment, English speaking ability, marital status (1 = currently married), number of own children and two dummies for parenthood status, log of hours and weeks worked in 1999, indicator for full-time and year-round employees.

1) Statistical significance is determined by robust standard errors of each coefficient.

2) Sample size: Individual N = 966,677; occupation n = 471.

**p< = .05; + p < = .10 (two-tailed tests).

In Table 4 below, I report results from a series of hierarchical linear models.[6] I replicated Model 5 as in Table 4, which serves as a benchmark against which following models are compared. Model 6 allows gender effect to be interacted with the sex composition of occupations to see whether there are significant gender differences in the effects of occupational gender composition. There are few differences in the coefficient estimates and in the variance in the Level-1 intercepts among occupations.

In Table 4, female coefficients denote the extent to which female employees are paid less than their male colleagues *within* the same occupation. This interpretation holds due to the fact that occupation-specific random effects for Level-1 intercept and the female coefficient are simultaneously controlled. Therefore, gender coefficients denote within-occupation inequality in earnings adjusting for individual- and occupation-level covariates. Social closure coefficients associated with the Level-1 intercept denote the extent to which social closure effects vary for male employees among occupations, while the sum of those effects and the corresponding coefficients associated with the female dummy variable is the between-occupation social closure effect for women.

Thus far, I have addressed the between-occupation components of variation in gender earnings gap in somewhat indirect ways. The reason is because few direct measures are available from the U.S. Census, so adjusting for random effects for the model intercept would reveal the proportional contribution of between-occupation effects on the 'gross' gender gap in earnings. When I compared the female coefficients estimates from the conditional OLS model (Model 2) with those from the conditional HLM (Model 4), the female coefficients drop from -.294 to -.251, a decline of about 15% of the gross gender gap in earnings. Therefore, I conclude that occupational segregation, which is arguably measured by the decline in the female coefficients after adjusting for random effects for occupations included in the analysis, is a significant determinant of the gender gap in earnings at the national occupation level.[7]

In Model 6, I added aggregate proportion female variable to test whether the sex composition of occupations helps explain gender gap in earnings across occupations. Consistent with previous literature, higher female concentration

[6] In Model 1-2 in Appendix A, a random intercept model with no predictors at either the individual or the occupation level is estimated, which allows me to partition variance in earnings into two components: individual and occupation levels. About 25% of variance in earnings is attributable to occupation-level phenomenon while 75% of it results from individual-level characteristics.

[7] See Appendix A for variance explained statistics.

lowers levels of earnings, but it has no effect on gender gap in earnings. In addition, it helps little in explaining between-occupation variance in either the overall earnings or in gender inequality in earnings (see variance explained statistics in Appendix A).

Model 7 to Model 8 show that female concentration lowers the rewards for occupations in general but does not penalize female employees to a greater extent when compared with their male coworkers. These are interesting findings, given that in earlier census periods most of the previous studies investigating the relationship between aggregate proportion female and gender gap in pay have, consistently but with varying degrees, reported a greater penalty for females working in female-dominated occupations (Cohen and Huffman, 2003; England, 1992; England, Hermsen, and Cotter, 2000; Kilbourne et al., 1994; Reskin, 1993; Rosenfeld and Kalleberg, 1991; Sorensen, 1990). I am not able to propose a specific explanation for this with data at hand, but I suspect there have been changes in the late 1990s that provide equivalent rewards for female employees to those of male coworkers in the occupation of same- sex composition.

The coefficients for sex composition on the levels of earnings decrease and those for gender gap increase slightly when I added social closure variables to Model 6. Results favor Hypothesis 2b over Hypothesis 2a, showing that the absolute values of coefficients increased when social closures variables are plugged in. The coefficient for the gender composition on the levels of earnings actually increase by -.059 [=-.233-(-.174)] (γ_{01}) in Model 7 compared to that in Model 6, and the coefficients for the gender composition of the female dummy become positive, although they remain statistically insignificant. These findings lead me to conclude that social closure mechanisms suppress the effects of occupational concentration by female employees on gender inequality in earnings.

Model 7 and Model 8 show that the within-occupation gender inequality is inversely associated with all three closure mechanisms, among which the effects of educational credentialing are most noticeable and remain consistent. Occupations that are highly 'credentialed' evidenced more equal earnings outcomes for female employees. This refutes Hypothesis 3a that predicted closure devices would work to prevent female employees from entering high-paying occupational segments or ranks within the given census occupations. Positive coefficient of credentialing, however, does reveal that occupational closure functions to 'homogenize internal differences'; therefore, female employees are better off in occupations with higher levels of closure than elsewhere. This serves as an empirical support for the argument of closure as

'rent-sharing' mechanisms as suggested earlier in this paper.

For the occupation-specific skills dimension of closure, I found no support for either 'gate-keeping' or 'rent-sharing' mechanisms as assumed in Hypotheses 3a or 3b. Unionization also helps explain the 'rent-sharing' mechanism, through which closure contributes to the reduction of gender gap in earnings. In Model 7, I noticed that women are paid more if they work in occupations that are highly covered by union contracts than in occupations with less union protection. Therefore, I can argue that women enjoy higher earnings when their occupational reward structure is more homogenized by unionization than otherwise. However, this is a tentative proposition because the effects of unionization vanish once I added other occupational covariates. I propose some possible explanations later in the discussion section of the paper.

In Model 8, I replicated Model 7 with occupational-level covariates and verified whether closure mechanisms are shaped by or operate through other occupation-level covariates. I included occupational composition measures which have been reported to have effects on gender gap in earnings. Proportion minority in occupations decreases the average levels of earnings for men while it actually works in favor of female employees, decreasing gender gap in earnings (γ_{15} = .305). Public employment decreases average earnings for men while it narrows the gender differences (γ_{16} = .134); this supports the argument of institutionalist theories in that public employment encounters normal pressure that serves to decrease earnings inequality in general (Dobbin et al., 1993; Edelman, 1992). Controls for occupational skill requirements provide general pictures of occupational skill effects on earnings and on gender gap. Occupations with higher levels of substantive complexity and of engineering skills do yield earnings returns. The need for environmental disamenities actually decreases the level of mean earnings for men. However, the latter two effects do not hold any significance. There are no gender-specific difference in the effects of these three skills and work-context-related measures for earnings outcome.

Estimating Model 8 provides more stringent tests of social closure effects both on the overall levels of earnings and on gender earnings gaps. Signs of the social closure effects on average male earnings remain unchanged at large although their sizes changed to a lesser or greater degree. The coefficients for educational credentialing decreased and unionization increased. And the coefficient for specific vocational training decreased by a third, from .092 (Model 7) to .064 (Model 8). This is not surprising because occupational skill requirements were controlled with three additional measures, which attenuate the effects of occupation-specific skills training (SVP) on earnings. The

coefficients associated with the female dummy variable also changed. Educational credentialing effects on gender gap increased slightly, and unionization effects on the female coefficient became insignificant. This seems to have occurred when I included the percentage employed in the public sector (γ_{16}), which has been found to be highly unionized and beneficial for female employees. Given these results, some of the social closure effects on male earnings and gender gap in earnings remain significant even when occupational composition and other occupational covariates are controlled.[8]

Although coefficient estimates from regression models reveal the overall magnitude of the social closure effects on gender gap in earnings, there may

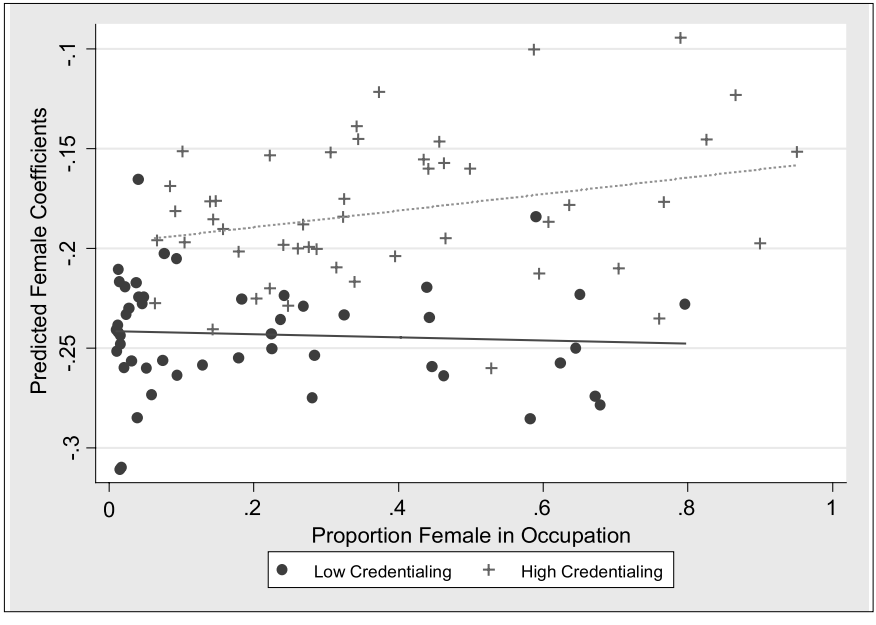

Figure 1. Gender Gap in Earnings by Proportion Female in Occupation Conditional on the Levels of Educational Credentialing.

Note: Female Coefficient Estimates are from Model 8 in Table 4; n (occupation) = 99.

'Low credentialing' refers to occupations that rank in the 10th percentile or below in the distribution of educational credentialing variable, and 'high credentialing' occupations that rank in the 90th percentile or above in the distribution of educational credentialing variable.

[8] Model 9 in Appendix A explains about 56% of the variations in the average levels of earnings estimated in the baseline of Model 4 by adjusting for occupational-level determinants of earnings, including closure and other covariates.

exist different relations between the levels of gender inequality and gender composition in occupations, conditional on the extent of closure practices. To illustrate this possibility, I present some plots, which show these conditioning effects of closure mechanisms. I selected occupations with a lower extent of closure practices and those with a higher extent as well. For the former, I selected occupations that rank in the 10th percentile or below in the distribution of closure variables, and I selected occupations that rank in the 90th percentile or above for the latter in the distribution of closure variables: educational credentialing and unionization, respectively. I plot-predicted female coefficient estimates from Model 8 in Table 4 against proportion female in occupations by the two occupational groups for closure practices.

Figure 1 shows that the wage penalty faced by female employees diminishes as they work in female-dominated occupations in which educational credentialing is highly visible. However, female employees do not benefit much

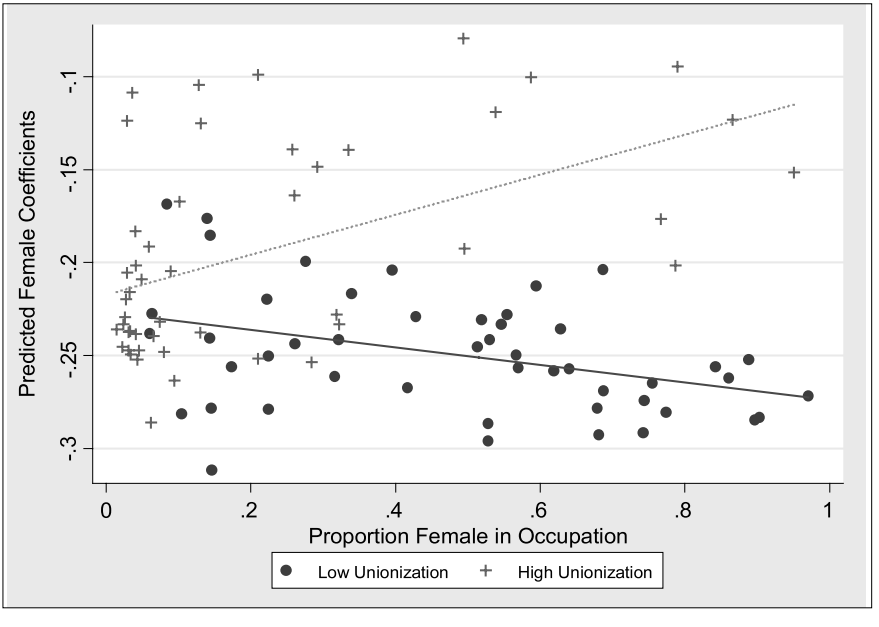

Figure 2. Gender Gap in Earnings by Proportion Female in Occupation Conditional on the Levels of Unionization.

Note: Female Coefficient Estimates are from Model 8 in Table 4; n (occupation) = 96.

'Low credentialing' refers to occupations that rank in the 10th percentile or below in the distribution of the unionization variable, and 'high credentialing' occupations that rank in the 90th percentile or above in the distribution of the unionization variable.

from working in highly feminized occupations where few entry barriers exist in terms of educational credentialing. I interpret this as corroborating the 'rent?sharing' effects of closure, because women take advantage of 'exclusionary' practices of credentialing as more female employees pass through the boundaries set up by educational credentials. In lower credentialed occupations, women do not fare well enough to catch up to their male colleagues in terms of earnings.

For the unionization dimension of closure, even more striking is the opposite relation occurring between the extent of gender gap and female representation in occupations. As Figure 2 shows, female representation increases male-female differences in pay in lower unionized occupations, while female employees make more earnings while working in highly female-dominated occupations in which unionization is prevalent. As is the case with educational credentialing, I interpret these patterns as revealing the 'rent-sharing' aspect of closure mechanisms, through which female employees are better off with increasing representation of employees of their own gender. Therefore, I emphasize that there exists differing effects of occupational sex composition on gender gap in pay and that they are conditional on the overall tendency for occupations to be 'exclusive' via closure mechanisms such as educational credentials and unionization.

Conclusion and Discussion

In this paper, I delineated distinct mechanisms of social closure at the occupation level by occupational membership that works through educational credentialing and unionization and by allocation of opportunity for occupation-specific training. I found that these two dimensions contribute to shaping gender outcomes in earnings. As an alternate explanation of an approach based on sex composition to occupational gender inequality, social closure mechanisms function as both within- and between-occupation sources of variation in levels of earnings and in gender differentials.

I also stress that occupational sex composition, which has been regarded as a major determinant of gender inequality in earnings, has no additional impact on gender inequality even in models with no occupation-level covariates, suggesting that the late 1990s saw significant changes in the structuring of gender inequality in the U.S. labor market. I call for a different explanation of the processes by which earnings inequality by gender is generated, and propose explanations based on occupational closure which explains a substantial

proportion of variations in between-occupation gender inequality.[9] The latter relates to within-occupation effects, adding to an explanation of gendered features of rewards in the labor market.

I have deferred possible explanations of the directions in which social closure affects gender inequality given that no previous literature has proposed theoretical propositions regarding whether closure should work for or against female employees, net of labor market qualifications and occupation-level predictors of earnings such as skill requirements and demographic composition. It is not surprising because social closure explanations at the occupation level aim at examining between-occupation differences in earnings (Weeden, 1999, 2002), while job-level analysis of social closure implicitly assumes employer discrimination to be coterminous to any sorts of exclusionary practices at concrete workplace settings. (Tomaskovic-Devey, 1993; Tomaskovic-Devey and Skaggs, 2002). As a compromise between the two previous approaches, I emphasized structural properties of social closure mechanisms which exclude the subordinate gender group from remunerative positions within occupational hierarchies, and their impact on gender inequality in earnings was investigated. The outcome seems rather paradoxical in a sense in that 'exclusionary mechanisms' that are assumed to bring a higher degree of gender inequality contribute to narrowing the net difference in earnings between male and female employees. I discuss possible explanations of these outcomes in detail below.

It is plausible that educational credentialing can either increase or decrease gender differentials in earnings. Educational credentials work as closure at the occupation level if they restrict access to remunerative positions in the occupational hierarchy based on the educational marker of degrees and diplomas, which may not be strongly related to occupational skills (Row 1/Column B). For occupations with higher composition of the highly educated, employers or coworkers would seek to set up entry barriers to generate additional earnings premium, which is regarded as rents from monopoly of labor. This can result in female employees being disproportionately channeled into distinct occupational positions. In short, if educational credentials prevent females from entering high-paying segments of occupations, these should work as a gate-keeping mechanism, yielding a greater earnings penalty for women (Row 1/Column C). However, the opposite was the case with my data. My

[9] In Appendix A, Model 3 illustrates variation in the average levels of earnings and in gender gap in earnings that have been explained by social closure and occupational covariates in comparison to the baseline adjusted model (Model 4). The full model (Model 9) explains about 52% of the intercept variance τ_{00} and 22% of the gender variance τ_{11} among occupations.

explanation would be that educational credentials work to generate an earnings premium for female employees who have already passed entry barriers and bestowed on them greater amount of returns; female employees take greater advantage of these returns than do their male counterparts. Therefore, formal educational credentialing shows a clear example of how gender gap in earnings is attenuated by means of rent mechanisms that operate through 'exclusionary' tactics of occupational incumbents (Row 1/Column D).

In a similar manner, unionization as closure affects earnings determination by excluding non-union members from entering union spheres of occupations, therefore contributing to between-occupation gap in earnings. This reflects the rent mechanism which allows union members to entertain an earnings premium and becomes gender-relevant to the extent of disproportionately excluding women from the occupations of concern (Row 3/Column C). Contrarily, unionization may lead female employees to achieve higher rewards by compressing earnings structure or by 'setting pay equity policies' (Elvira and Saporta, 2001: 473), an equity-enhancing effects of unionization in regard to the earnings gap between male and female employees (Row 3/Column D).[10] In the final model, the effects of unionization vanish when occupation-level controls are added. I propose that the level of public employment in occupation would explain these unionization effects. This corroborates the beneficial effects of public employment for female employees as reported in previous studies (Baron, Mittman, and Newman, 1991; Blau and Kahn, 1992; Gornick and Jacobs, 1998).

In this paper, I have explored the social mechanisms that exclude certain employees from achieving higher occupational success in regard to earnings. I focused on occupation-level devices which are measured by levels of educational credentialing, access to occupation-specific skills training and unionization. Given that my focus is on occupation-level closure than job-level one, I have limited ranges of options to choose from. Data availability and generalizability also kept me from delving into whatever effects employers may have had on gender gap in earnings across labor market.

I explored how educational credentials as markers of appropriateness of prospective employees to occupational gate-keepers operate to generate gendered outcomes in earnings. There is no *a priori* reason for occupational

[10] Zero-order correlation between unionization and wage dispersion (ratio of 90^{th} percentile to 10^{th} percentile earnings for occupations) reveals a negative and statistically significant relationship (Pearson correlation coefficient = -.24; $p < .001$), lending support for the latter proposition. Note that when added into the HLMs, unionization actually decreases gender gap in earnings ($\gamma_{14} = .247$ in Model 7).

gate-keepers to exclude female employees from entry into the occupations of concern. The results presented above are, however, somewhat the opposite of assumptions in previous literature. In occupations where educational credentialing is highly prevalent, female employees are better off in earnings attainment than they would have been, resulting in narrowing the gender gap in earnings.

At the onset of this paper, I elaborated on three closure mechanisms through which male and female employees are channeled into different locations in the occupational structure of the U.S. labor market. This approach is somewhat distinct from those of previous researchers who focus on either job-level segregation or employer-level discrimination. My analyses are limited in both respects: on the one hand, I have no such detailed data in regard to segregation-based approaches to delve into 'specific' job-level social processes where decisions of labor allocation and payment schemes are determined by both the market and organizational processes. Given the fact that few national survey data suffice in this aspect, my analyses are hampered by the lack of job-level information that could have enabled me to uncover micro-level labor market processes. However, I have paid attention to closure mechanisms which are intrinsically more occupation-based phenomenon than job-based ones. Therefore, my research design sheds light on social mechanisms that shape gender inequality in earnings across national occupations.

Although this paper examines closure effects with the latest U.S. census data, caution is advised in interpreting the effects of social closure on gender gap in earnings because they may reflect benefits of economic rents for female employees who have successfully entered the remunerative occupations with a higher level of social closure practices than 'exclusionary' effects of social closure *per se*. Because I have no data allowing me to delineate the 'rent — sharing' effects for the subordinate group from the 'gate-keeping' effects, my conclusions may be tentative. Further research is recommended to explore relevant data and to develop models to address these questions.

Appendix A. Variance Estimates across Models

Models Estimated	Within-Occupation Variance (σ^2)	Between-Occupation Variance in the Intercept (τ_{00})	Between-Occupation Variance in the Female Slope (τ_{11})
Model 1-1[1)]: Unconditional Random Intercept Model	.606	.202	N.A.
Model 1-2[1)]: Unadjusted Random Slope Model	.576	.163	.021
Model 4: Model 1-2 + Individual Level Controls	.382	.067	.009
Model 6: Model 5 + Occupational Sex Composition	.382	.065	.009
Model 8: Model 4 + Social Closure Variables	.382	.032	.008
Model 9: Model 5 + Occupational Level Controls	.382	.028	.007
Model Contrasts (Components Added into the Models)			
1. Model 4 vs. Model 1-2 (Individual-Level Controls)	33.68%	60.73%	57.14%
2. Model 8 vs. Model 4 (Sex Composition and Social Closure Variables)	N.A.	52.23%	11.11%
3. Model 9 vs. Model 4 (Sex Composition, Social Closure Variables, and Occupational Controls)	N.A.	58.20%	22.22%

Note: 1) Model 1-1 and Model 1-2 were not reported in Table 3, but included here for comparison.

* All statistics are significant at the p-value of .01. Sample size: Individual N = 966,677; occupation n = 471.

Appendix B. Factor Analysis of Skill Measures from the Occupational Information Network (O*NET 9.0)

The Occupational Information Network (O*NET) consists of a series of datasets that contain detailed items on occupational characteristics. Among them are abilities, interests, education, training and experience, job zone, knowledge, skill, work context, work activities, work values and work styles. These datasets allow one to construct detailed measures for occupational skill requirements and work conditions, which may confound the causal relationship between social closure, gender composition and gender inequality in earnings. Before proceeding to regression-based analysis, I derive a set of theoretical constructs that adjust for these compounding factors.

Previous research on gender segregation and gender inequality have drawn on the Dictionary of Occupational Title (DOT), ending up with a few measures of occupational skill requirements and work conditions (England et al., 1988;

Kilbourne et al., 1994; Sorensen, 1990; Tam, 1997; Tomaskovic-Devey and Skaggs, 2002; Weeden, 2002). These studies have constructed occupational-related characteristics based on the DOT and add these to their analyses as controls, although details of measures vary depending on model specifications. However, the use of the DOT as a source of occupational-level control has been criticized for its items being obsolete, given tremendous changes in occupational structure (Cain and Treiman, 1981). In addition, the original design of the DOT was tailored to the occupational structure in the industrial economy since World War II. However, its application for recent data is doubtful, given empirical evidence that the U.S. economy has moved toward an arguably de-industrialized, service-dominant system especially since the last decade.

A careful development of a new data source for representing this changing occupational structure is necessary, an end that the O*NET attempts to satisfy in a better manner (Borman, 1996; National Center for O*NET Development, 2005; Peterson et al., 2001). I combined three sub-datasets of the O*NET, that is, knowledge, skills, and work context datasets to yield an updated, but comparable, set of measures for the new occupational structure of the late 1990s. The knowledge dataset contains a total of 33 items on different kinds of knowledge that occupational incumbents are required to attain. And the skill datasets have 35 items on skills necessary for each occupation. Although the above two datasets of knowledge and skill are quite exhaustive, controls for work conditions are warranted. As well known, occupational distributions by gender and their consequences for earnings outcome have often been explained in the logic of compensating differential theories of wages (Filer, 1985; Jacobs and Steinberg, 1990), which attribute observed low level of earnings for female employees to individual preference for non-pecuniary utilities such as flexible work schedules or physical amenities. To exclude this sort of competing explanations, one needs to add controls for these sources of occupational differentiation by gender. The work context dataset of the O*NET contains 55 items on work environments which may shape occupational preferences for occupational choice by individuals and denote workplace settings.

Combining items from three datasets, I have a very detailed array of 123 items on occupational skills, knowledge and work environments. I then performed principal component analysis using the PROC FACTOR command in SAS with varimax as an option for factor rotation. In order to maintain reasonable degree of explanatory power and to make derived factors interpretable, I retained the first three factors, which explain 58.76% of the total variance (See Appendix C). I labeled three factors by examining items that highly load on each factor and named each of them "Substantive Complexity,"

"Engineering Skills" and "Environmental Disamenities," respectively. Due to incomparability between the O*NET occupational classifications and those of the U.S. Census, missing data are generated for 151 of 471 EEO-PUMS1 occupations. For those occupations, factor scores are imputed using PROC MI command in SAS based on occupational demographic composition (percent minority/percent female employed and average hourly wages for occupations. Details are available from the authors upon request). Although less comprehensive than the previously proposed items from the DOT by other researchers, I believe these three factors capture occupational skills that represent the new structure of occupational division of labor in the American labor market. See Appendix C for details of factors and items that load high on each factor.

Appendix C. Principal Component Analysis of Skills and Work Context Measures and Items with Highest Loadings for a Three-Factor Solution

Factor and Items	Loadings
Substantive complexity (36.69%)	
Social perceptiveness	.925
Coordinate or lead others	.921
Negotiation	.916
Contact with others	.914
Persuasion	.911
Time management	.903
Service orientation	.900
Environmental disamenities (14.81%)	
Outdoors exposed to weather	.886
Very hot or cold temperatures	.823
Outdoors under cover	.811
Extremely bright or inadequate lighting	.810
Exposed to whole body vibration	.746
Engineering skills (7.26%)	
Troubleshooting	.854
Installation	.831
Quality control analysis	.792
Technology design	.771
Equipment selection	.763
Repairing	.757
Equipment maintenance	.747

Note: Data Source: O*NET 9.0. Total variance explained is 58.76% for 123 items used in the analysis.

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