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Occupational gender segregation in an equilibrium search model

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Abstract

This paper develops an equilibrium search model to explain gender asymmetry in occupational distribution. Workers' utility depends on salary and working hours, and women have a greater aversion to longer working hours than men. Simulations indicate that women crowd into shorter-hour, lower-paying jobs than men. If employers discriminate against women, offers are tailored more toward the working-hour preferences of men by requiring longer working hours. Similarly, if women have a disutility factor in their utility toward positions with a higher proportion of men, fewer women work at these jobs. In both cases, gender segregation is reinforced.

JEL classification: E24, J16, J64, J71

Keywords: Equilibrium search; Gender preferences; Employer discrimination; Employee discrimination

1 Introduction

Earnings and the number of hours worked are considerably different for men and women in the labor market. Women tend to work in occupations that require shorter hours and pay lower wages, whereas men tend to work in longer-hour, higher-paying jobs.

Pioneered by Bergmann (1974), the overcrowding model shows that women "crowd" into certain occupations, which depresses their wages.[1] Extending Bergmann's model, Johnson and Stafford (1998) provide a simple framework for understanding the factors that affect occupational gender segregation. Their analysis shows that women overcrowd into occupations in which they can find (*i*) a smaller degree of employer discrimination, (*ii*) job characteristics preferred by women, (*iii*) a comparative advantage for their gender, and/or (*iv*) less social pressure. All these models are based on a perfectly competitive labor market, in which the labor supply curve facing an individual firm is perfectly elastic. However, if there are search frictions and workers have imperfect information regarding alternative job opportunities, a reduction in job value will not result in a loss of all employees to employers. Furthermore, empirical studies find that many workers are not perfectly matched to jobs that have their desired working hours and that those who report dissatisfaction with their hours tend to change employers to work in positions that are more in line with their preferred hours (Altonji and Paxson 1988; Kahn and Lang 1991; 1995; 2001).[2]

The purpose of this paper is to present a search model that explains the occupational asymmetries observed between men and women. I present a model based on the heterogeneous-workers, heterogeneous-firms version of the Burdett and Mortensen (1998) and Bontemps et al. (1999) wage-posting games.[3] Relative to these papers, my model differs in the following two dimensions. First, the utility that a worker derives from a job does not necessarily coincide with the salary. It also depends on a nonpecuniary characteristic, which I consider to be the number of hours worked. This setup is similar to Hwang et al. (1998) and Lang and Majumdar (2004) in that it includes a job attribute other than salary.[4] Therefore, instead of a wage-posting game, my model is a job-posting game in which every firm posts a single "tied-salary/hours offer" that workers may accept or reject depending upon their status. The number of hours worked is also an important determinant for the demand side of the labor market because the flow output per employee (labor productivity) is not constant, as modeled in Burdett and Mortensen (1998), but increases along with the total hours worked. Second, there is heterogeneity of workers across gender, which I model by a preference "shifter" in the disutility of work between males and females. Because women tend to spend more time producing household commodities, I specifically assume that women are more reluctant to work longer market hours.[5] This is the main assumption I use to explain the different labor market behaviors of men and women.

The equilibrium of this job-posting game is analyzed numerically. I find the following results:

1. There is a positive correlation between the number of hours worked and salary. Employers that are more productive require longer hours and offer higher salaries. This prediction is in accordance with the compensating differentials theory of Rosen (1974). Hours and salary correlate positively because the utility of the latter compensates for the disamenity of the former. For a given salary level, men experience a smaller disamenity to working, and more productive firms can profit from requiring longer hours. Thus, more productive firms hire more men than women because men require smaller salary compensation for the long hours than women. Therefore, in equilibrium, men sort into longer-hour, higher-paying jobs, and women sort into shorter-hour, lower-paying jobs.
2. If employers experience disutility from hiring women, as in the model of taste-based discrimination à la Becker (1971), gender segregation is reinforced. Employers endogenously choose to post job offers with longer working hours to dissuade women (who are averse to long hours of work) from accepting these jobs. This strategy compensates employers for the utility loss from hiring women.[6]
3. If women experience disutility from working in jobs with a higher proportion of men, (a phenomenon called employee discrimination, which is supported by empirical evidence using the job satisfaction data in Usui (2008)),[7] the implications for gender segregation are the same as in (2). The difference is the channel: because the women experience lower utility in longer-hour jobs, they prefer to either remain unemployed or to work with other women in shorter-hour jobs. In response, employers tailor their job offerings to men to maintain their employment size.

The paper proceeds as follows. Section 2 sets up the model. Section 3 presents the simulation results. The paper concludes in Section 4.

2 The model

Consider a scenario with a large, fixed number of employers and workers (men and women who are equally productive). The measure of men and women in the population is n^m and n^f, respectively, and the measure of employers is normalized to 1. Workers search for jobs while unemployed and employed, and employers offer job opportunities. Workers maximize their expected present value of utility by deciding which jobs to accept, and employers maximize their profits.

An employer's job offer to a worker consists of salary S and hours of work H. Because anti-discrimination policies prohibit employers from making gender-specific offers, employers post only a single salary-hours combination that workers must accept unless no production takes place.[8] Output per employee is a concave function of the worker's hours worked, denoted as $\rho_j(H)$ for a type-j job, where $\rho_j(0) = 0$, $\rho_j^{'}(H) > 0$, and $\rho_j^{''}(H) < 0$ for all j. There is a continuous distribution of productivity across employers, and higher-productivity jobs have a larger marginal productivity of hours worked for any given level of hours.

Workers value a job based on its salary and working hours. The utility of a job for a worker whose gender is g (m for men and f for women) is

$$v^g(S, H; \xi^g) = S + \xi^g \phi(H),$$

where $\phi^{'}(H) < 0$, and $\phi^{''}(H) < 0$. For simplicity's sake, it is assumed that S and H enter additively into workers' utility functions and that their marginal (dis)utilities are independent of one another. The parameter ξ^g measures the degree of aversion to hours worked, which is assumed to be $0 < \xi^m < \xi^f$.

Therefore, the marginal disutility of working hours is greater for women than for men.[9] Unemployed workers receive a utility flow b. Its distribution in the population (denoted by K) is identical for men and women and is continuous on its support $(\underline{b}, \bar{b})$.

2.1 Discrimination

Two types of discrimination are incorporated into the model. The first is employer discrimination, modeled as the employer having a distaste d^{ER} for hiring women. In this case, the employer's utility per female worker is $\rho_j(H) - S - d^{ER}$.[10]

The second type is employee discrimination, modeled as women having a disutility factor in their utility toward working with men. Specifically, women incur a disamenity value for working at jobs with a higher proportion of males. Denote $d^{EE}(\theta)$ as the utility loss for women, where θ is the fraction of men working in a job, and $\frac{\partial d^{EE}(\theta)}{\partial \theta} < 0$. Then the women's utility for a job is $S + \xi^f \phi(H) - d^{EE}(\theta)$.

2.2 Steady-state stocks and flows

Workers sample a job offer (at rate λ) from a known distribution while unemployed or employed. The value of a posted contract (S, H) to a man or a woman is determined by the gender-specific utility function $v^g(S, H; \xi^g)$. Thus, this gender-specific utility function transforms the distribution of contracts posted by employers into a gender-specific distribution of offered job-values F^g. The distribution of job values is given by functions F^m for men and F^f for women. Employed workers face job separation with an arrival rate of δ.

The following results, as proposed in Bontemps et al. (1999), are well known for the worker's optimal job acceptance strategy. When unemployed, the optimal strategy is to accept all jobs that have a value greater than or equal to the reservation utility; this is simply b because the arrival rate of job offers is independent of the worker's current state (i.e., employed or unemployed). For someone employed, the optimal strategy is to accept all jobs that have a greater value than the current job.

Let $u^g(x|F^g)$ denote the steady-state measure of unemployed workers whose reservation utility is less than or equal to x, conditional on the utility distribution of offered job-values F^g. Then

$$u^g(x|F^g) = \int_{\underline{b}}^{x} \left(\frac{\delta n^g}{\delta + \lambda[1 - F^g(b)]} \right) dK(b)$$

because the unemployment rate of workers with a utility flow of b is $\frac{\delta}{\delta+\lambda[1-F^g(b)]}$,[11] and the density of these workers is $n^g dK(b)$.

Let G^g be the distribution of job values for employed workers. Then the steady-state measure of employed workers receiving utility no greater than v^g is $G^g(v^g) \times \left\{ n^g - u^g\left(\bar{b}|F^g\right) \right\}$, where $u^g\left(\bar{b}|F^g\right)$ is the total measure of unemployed workers in the economy. The flow of workers leaving jobs offering a utility no greater than v^g (to unemployment or to higher-valued jobs) equals the flow of workers entering such jobs from unemployment in a steady state. It follows that:

$$\{\delta + \lambda[1 - F^g(v^g)]\} G^g(v^g) \left\{ n^g - u^g\left(\bar{b}|F^g\right) \right\} = \lambda \int_{\underline{b}}^{v^g} [F^g(v^g) - F^g(x)] du^g(x|F^g),$$

where $du^g(b|F^g)$ is the measure of unemployed workers with reservation utility b, and $[F^g(v^g) - F^g(b)]$ is the probability that an offer received by a worker with reservation utility b is acceptable and less than or equal to v^g. This result yields

$$\frac{G^g(v^g) \left\{ n^g - u^g\left(\bar{b}|F^g\right) \right\} = \kappa \int_{\underline{b}}^{v^g} [F^g(v^g) - F^g(x)] du^g(x|F^g)}{1 + \kappa[1 - F^g(v^g)],}$$

where $\kappa = \lambda/\delta$ is the ratio of the job-offer arrival rate to the job separation rate. Let $l^g(v^g, F^g)$ represent the steady-state number of workers available to an employer offering v^g given the utility distribution of job offers F^g. Since both $l^g(v^g, F^g) dF^g(v^g)$ and $dG^g(v^g) \left\{ n^g - u^g\left(\bar{b}|F^g\right) \right\}$ correspond to the number of employed workers receiving a job value v^g, it follows that:

$$l^g(v^g, F^g) = \frac{dG^g(v^g)}{dF^g(v^g)} \cdot \left\{ n^g - u^g\left(\bar{b}|F^g\right) \right\}$$

$$= \frac{\kappa n^g K(v^g)}{\{1 + \kappa[1 - F^g(v^g)]\}^2}$$

if F^g is continuous (see Appendix A for derivation), and $l^g(v^g, F^g)$ is increasing on the support of F^g. An employer offers a higher job value to increase firm size in the steady state. The positive correlation between job value and firm size occurs for two reasons, as described in Bontemps et al. (1999). First, a higher utility makes a job more attractive to currently unemployed workers. This phenomenon is known as the Albrecht and Axell (1984) mechanism, in which workers are heterogeneous in their reservation utilities; as a result, a greater number of workers will prefer employment to unemployment when a higher job value is offered. Second, a higher job value attracts currently employed workers, which prevents them from taking another job; this phenomenon is called the Burdett and Mortensen (1998) channel.

2.3 Equilibrium distribution of job offers

Conditional on the job packages offered by all other employers and on the search behaviors of men and women, each employer posts a tied-salary/hours offer that maximizes its steady-state profit (or utility) flow. In the case of employer discrimination, the employer's steady-state utility, given the tied-salary/hours offer, is expressed as: $[\rho_j(H) - S]l^m(v^m, F^m)$ for men, and $[\rho_j(H) - S - d^{ER}]l^f(v^f, F^f)$ for women. The maximization problem is

$$\pi_j = \max_{(S,H)} \left[\rho_j(H) - S\right] l^m(v^m, F^m) + \left[\rho_j(H) - S - d^{ER}\right] l^f\left(v^f, F^f\right) \tag{1}$$

for all jobs.[12]

3 Simulation

I solve for the model described in Section 2 numerically by specifying the functional forms for $\rho_j(H)$ and $v^g(S, H; \xi^g)$ as follows:

$$\rho_j(H) = -a_j(H-T)^2 + a_j T^2, \tag{2}$$

$$v^g(S, H; \xi^g) = S - \frac{\xi^g}{T-H}, \tag{3}$$

where $0 \le H < T$ and technology parameter $a_j > 0$ and ranges from $\underline{a}$ to $\bar{a}$. We use numerical simulations to solve for the model because the equilibrium distribution of job values F^g does not have a closed-form solution, as in Burdett and Mortensen (1998) or Bontemps et al. (1999). The equilibrium distribution of job values F^g is not known a priori because F^g is determined endogenously by the distribution of salaries S and hours H across the population (for which I solve). Because the objective function is unlikely to be globally concave in the two-choice variables, the direct approach to the problem is to perform a grid search, whose computation is extremely expensive. To ease the computation of F^g, I introduce a computationally and economically intuitive algorithm that is a good first guess for the solution. The idea is to take the economically intuitive salary-hour combinations as the starting points and solve for the maxima that converge from these starting points. I present the detailed description of the numerical algorithm used to solve for the distribution of the tied-salary/hours offer in Appendix B.

The parameter values in the simulation are specified as in Table 1. There is an equal number of men and women in the population: $n^m = n^f = 0.5$. Because the preference parameters satisfy $\xi^m = 3000 < \xi^f = 60000$, women are more averse to long work hours than men. The distribution of reservation utility $K(b)$ is normal, with a mean of −1500 and a standard deviation of 1000 for both men and women. Since $\xi^m < \xi^f$ but the distribution of reservation utility $K(b)$ is identical for men and women, for any given job

Table 1 Parameter values

Parameter	Description	Value
n^m	Number of men	0.5
n^f	Number of women	0.5
ξ^m	Men's hours preference	3000
ξ^f	Women's hours preference	60000
b	Reservation utility	N(−1500,1000^2)
a_j	Technology parameter	$0.1 \leq a_j \leq 0.2$
κ	Ratio of job offer arrival rate to job separation rate = λ/δ	3
T	Upper limit on hours worked	70

offer (S, H), the fraction of workers for whom the job value v^g is greater than the reservation utility b is larger for men than women (i.e., $K(v^f) < K(v^m)$). Therefore, it is assumed that, at any given job offer, men are more likely than women to prefer accepting the job offer to being unemployed. The technology parameter a_j is Pareto distributed, and the productivity distribution is plotted in Fig. 1a.[13]

Below, I present simulation results comparing three cases: (1) a baseline case without discrimination, (2) a case of employer discrimination, and (3) a case of employee discrimination.

3.1 Baseline case without discrimination

The equilibrium solutions are represented by the solid lines in Fig. 1b-f. As illustrated by the solid line in Fig. 1, men place greater value on higher-productivity jobs that pay greater salaries and require longer working hours. Conversely, women place lower value on these types of jobs because they are more averse to long working hours. Twenty-six percent of women never work (i.e., never participate in the labor force) because their reservation utility is greater than the utility derived from all jobs.[14]

Because of the presence of search frictions, jobs are not completely segregated by gender. The fraction of men working in jobs increases with job productivity from $\theta =$ 0.0783 to 0.9846. Men quit and move to more productive jobs, and few women work in these jobs. The labor supply elasticity $\frac{\partial l^g/l^g}{\partial S/S}$ is positive and is greater for men than for women in these higher-productivity jobs. This finding implies that (*i*) when the salary changes in the higher-productivity jobs, the change in hours worked is greater for men than women, and (*ii*) for these higher-productivity jobs, employers tailor their offers to men's preferences for longer working hours.[15] Consequently, not only do women quit to obtain jobs with shorter working-hours, but a high proportion of women (75.5%) prefer to remain unemployed rather than accept higher-productivity jobs. In contrast, in lower-productivity jobs, the labor supply elasticity is greater for women than for men, and the changes in hours worked is greater for women than men when the salary changes in the low-productivity jobs. Thus, for these low-productivity jobs, employers' offers are tailored toward women's preferences for shorter working hours.

To understand how segregation interacts with search frictions, I examine the equilibrium job offers when the amount of frictions is smaller (i.e., when the job offer arrival rate λ is increased.) Specifically, I increase $\kappa = \lambda/\delta$ from 3 to 5. The results when $\kappa = 5$

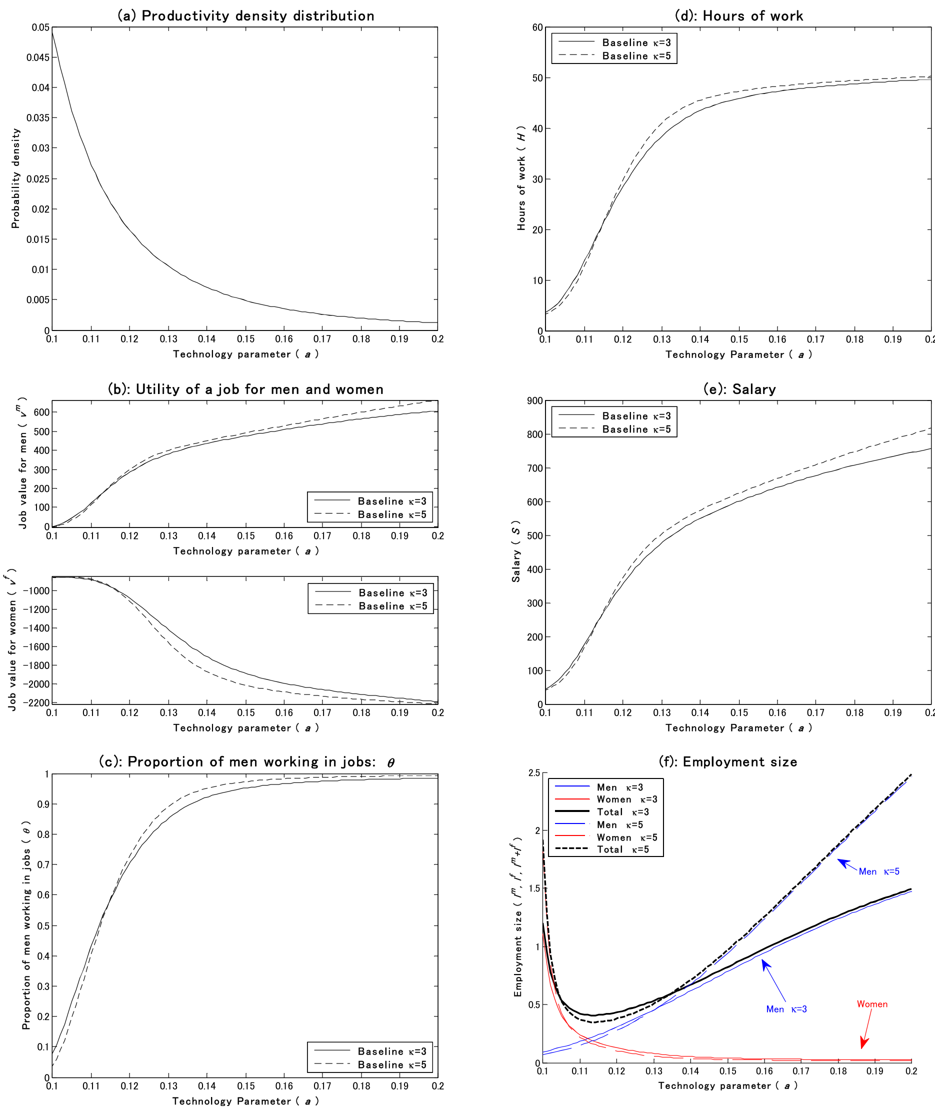

Fig. 1 Baseline case

are presented in dotted lines in Fig. 1b-f. When κ increases, more men and women work in jobs that they prefer. In higher-productivity jobs, employers tailor their offers more to men's preferences by requiring longer hours, while in lower-productivity jobs, employers tailor their offers more to women's preferences by requiring fewer hours. As a result, the fraction of men in a job is larger in higher-productivity jobs and smaller in lower-productivity jobs; in this way, segregation by gender is enforced.

3.2 The case of employer discrimination

To study discrimination in an environment that has gender asymmetries in working-hour preferences, I use the parameter values in the baseline case ($\kappa = 3$) and set the discrimination parameter as $d^{ER} = 20$. The results are represented by the dotted lines in Fig. 2a-d.

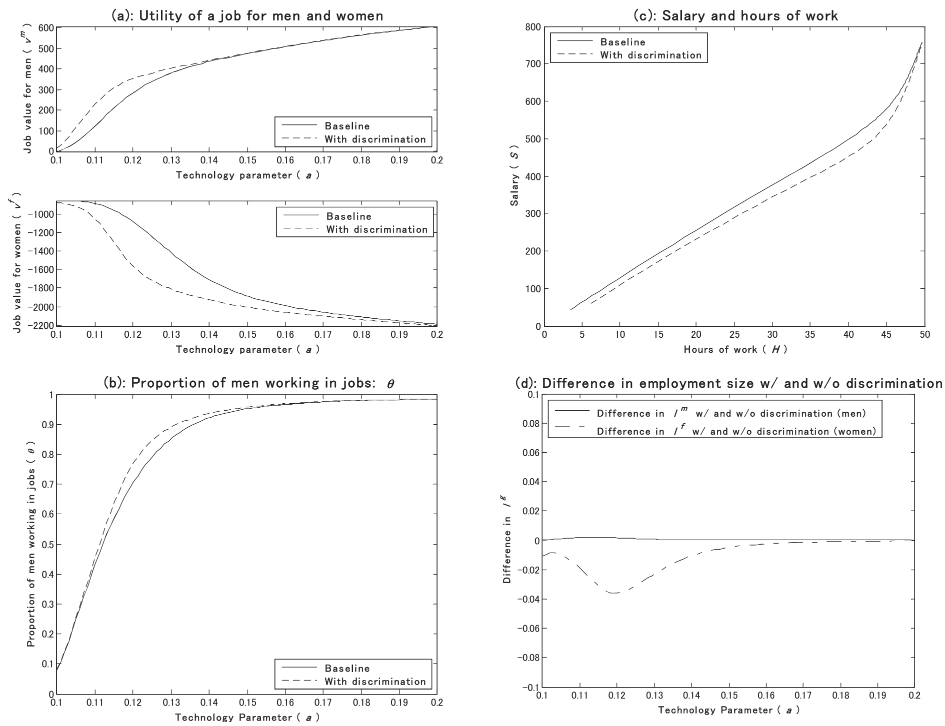

Fig. 2 Comparison between the baseline case and the case of employer discrimination

Employers suffer a loss in utility of d^{ER} by hiring women. Constrained to post only one offer for both men and women, employers make their offers unappealing to women by requiring more working hours while not significantly increasing the salary. As the job value for women declines, women with a higher reservation utility prefer to remain unemployed rather than work in these types of jobs. Therefore, the number of females employed at that job declines. Men, in contrast, seldom leave their jobs. As a result, the fraction of men working at that job increases. This increase is modest, however, because the job offers have already been tailored toward the working-hour preferences of men in the baseline case without discrimination.

3.3 The case of employee discrimination

Finally, I consider a case where women incur a disutility from working in jobs with more men but derive a positive utility from working in jobs with more women. The discrimination parameter is set as $d^{EE}(\theta) = 500(\theta - 1/2)$, and all other parameter values are taken from the baseline case ($\kappa = 3$). The equilibrium solutions are represented by the dotted lines in Fig. 3a-d.

As illustrated in Fig. 3 (dotted line), women suffer a utility loss from working in higher-productivity jobs with high hours required and a large proportion of men. Some women choose to be unemployed rather than work in these types of jobs. The number of women employed in these jobs drops, and the fraction of men thus employed increases. Compared with the baseline case, these employers realize less profit because attractive job packages must be offered to maintain employee numbers.

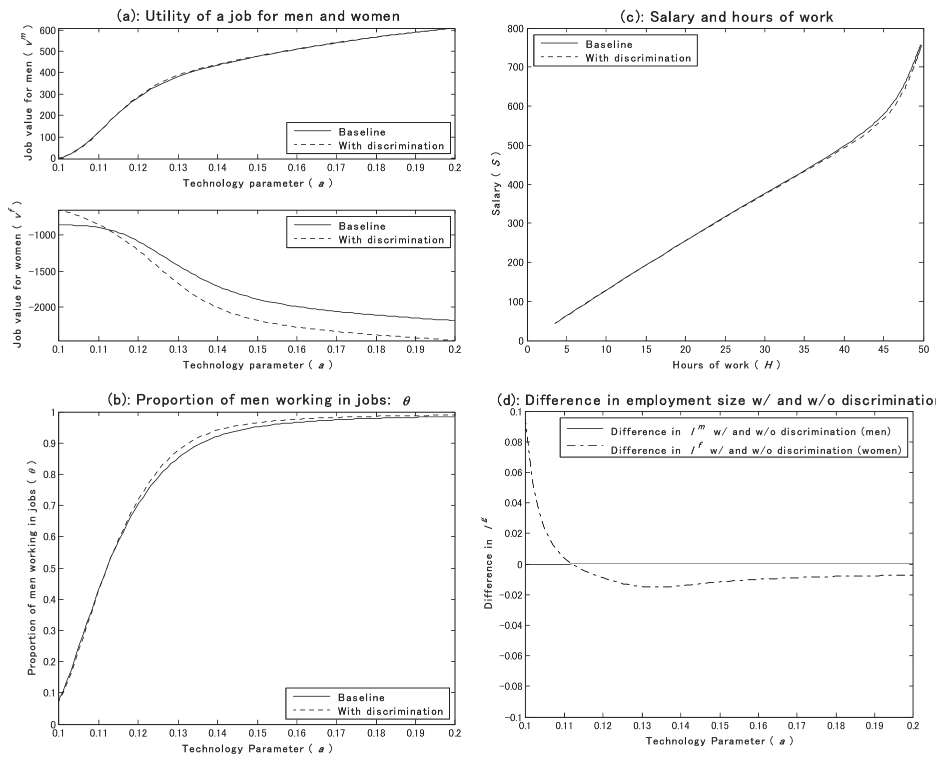

Fig. 3 Comparison between the baseline case and the case of employee discrimination

Meanwhile, the utility of work for women increases in lower-productivity jobs. Women prefer reduced working hours and the presence of more women in the working environment. The fraction of men decreases slightly. Employers obtain a higher profit compared with the baseline case because women attain a higher utility without incurring further costs. Specifically, in the least productive jobs (where the technology parameter is $a_j = 0.1$), the utility that women derive from only the tied-salary/hours package is −858.06 ($= S + \xi^f \phi(H)$) (which is almost equivalent to the utility women derive in the baseline case, −858.08), but the actual utility that women receive is higher because $v^f = S + \xi^f \phi(H) - d^{EE}(\theta) = -664.32$.

4 Conclusion

In this paper, I analyze an equilibrium search model in which salary and working hours are job attributes, and men and women differ in their working-hour preferences. In particular, women are more averse to longer working hours than are men. Every employer posts a single menu of salaries and working hours, which workers may accept or reject depending on their employment status. Because the equilibrium of this model does not admit closed-form solutions, I propose an algorithm to numerically solve for the equilibrium. The qualitative features of the equilibrium are studied via simulations.

The simulations indicate that employers with a larger marginal productivity of hours require more working hours. Women, who are more averse to longer working hours than men, predominate in less productive jobs, which offer fewer working hours and lower pay. If employers discriminate against women, these employers will require more working hours. This discrimination effectively excludes women from those jobs. Employers can control the gender of workers they hire by choosing to offer certain job amenities because different genders of workers tend to have different job amenity preferences.

If employee discrimination against women increases with the proportion of men working in the job, employers tailor their offers to the group from which they can hire more workers. Women place a smaller value on higher-productivity jobs because of the greater working-hour requirements and the disutility from the higher concentration of men. Conversely, women place a greater value on lower-productivity jobs because of the shorter hours and the amenity from the higher fraction of females. Consequently, higher-productivity jobs are tailored more toward the working-hour preferences of men, and lower-productivity jobs are tailored more toward those of women. Therefore, segregation is reinforced.

Because the model yields empirical predictions regarding discrimination and gender differences in preferences, future researchers may calibrate the search model by using labor market survey data. It would be a challenging exercise to identify the discrimination and preference parameters, but this examination would enable us to answer the question of whether it is employers, employees, or neither group that discriminates in the labor market.

Endnotes

[1]See Altonji and Blank (1999) for a comprehensive survey of the theoretical and empirical literature on occupational gender segregation.

[2]Altonji and Paxson (1986) and Senesky (2005) find that the variance of the change in hours worked is much higher for job movers than for job stayers. This finding implies that employers place significant constraints on their employees' choice of hours worked and that job movers are less constrained in their choice of hours worked than job stayers.

[3]The wage-posting model explains a number of stylized facts. For instance, wages are dispersed, and larger firms offer higher wages.

[4]Hwang et al. (1998) present a Burdett-Mortensen model in which heterogeneous employers who differ in the production technology of job amenities post a tied-salary/amenity offer to homogeneous workers. In contrast, Lang and Majumdar (2004) consider a nonsequential model in which homogeneous employers make a take-it-or-leave-it tied-salary/hours offer and trade off the salary/hours package against the possibility that the offer may be rejected.

[5]Using the U.S. Panel Study of Income Dynamics, I find that the probability of reporting overemployment is higher for women than for men (Usui, 2009). Following Ham (1982, 1986), Altonji and Paxson (1988), and Kahn and Lang (1991, 1995, 2001), I create the overemployment measure by utilizing variables that indicate constraints against workers' hours on the job.

[6]Holden and Rosén (2014) analyze an equilibrium search model in which it is costly for the firm to lay off a worker and where the workers have identical preferences and productivity characteristics. They show that there exists a discriminatory

equilibrium in which one type of worker (e.g., immigrants) is hired only when the employers receive a high signal that corresponds to the probability that the match is of high quality, while the other type of worker (e.g., nonimmigrants) is hired regardless of the signal. This is because it is more costly for employers to hire workers from the former group, since the expected duration of a bad match is longer for this group as a result of their having worse outside employment opportunities. They also show that profit-maximizing employers without discriminatory preferences will nevertheless practice discriminatory hiring, which is in contrast to Becker's (1971) discrimination model.

[7]There is empirical evidence that women care about the fraction of their co-workers who are female. According to job satisfaction data from the U.S. National Longitudinal Survey of Youth, women who move to jobs with more men report that co-workers are less friendly and that their physical surroundings are less pleasant, whereas men who move to jobs with more men report that coworkers are more friendly and their surroundings more pleasant (Usui 2008).

[8]In Usui (2002), I present an alternative equilibrium search model in which employers can condition job offers by gender. This model is a simple extension of Hwang et al. (1998) because profit-maximizing employers post separate offers for men and women. Consequently, there is no need for employers to consider the difference in gender preferences or the mix of men and women who choose their jobs.

[9]Alternatively, H can represent the effort that an employee puts into the job. Effort increases productivity, and effort is more costly for female employees than for male employees. Gneezy et al. (2003) provide experimental evidence that men exert more effort than women in high-stakes situations.

[10]Employer discrimination in the framework of search models has been studied by Black (1995), Bowlus and Eckstein (2002), and Flabbi (2010).

[11]The unemployment rate is derived from the equality of the flow of workers into employment and the flow from employment to unemployment.

[12]For the case without discrimination, eliminate the disamenity value d^{ER} in Equation (1). For the case of employee discrimination, subtract the term $d^{EE}(\theta)$ from the female utility.

[13]The probability density function of the technology parameter is $\frac{2.8 \times 3000^{2.8}}{3000+\left(a_j-0.1\right)\times 50000}$, which is defined over the interval $a_j \geq 0.1$. In the simulation, one hundred jobs are chosen at regular intervals along the segment $a_j = [0.1, 0.2]$, and the equilibrium job offer is derived for each of these jobs.

[14]The corresponding number for men is 1.75 %.

[15]Higher-productivity jobs offer a higher hourly wage ($= S/H$). This positive relationship between productivity and hourly wage is due to search frictions, in that higher-productivity jobs are more generous in regard to salary than in regard to hours of work.

5 Appendix A

Derivation of $l^g(v^g, F^g)$

$$l^g(v^g,F^g)=\frac{dG^g(v^g)\{n^g-u^g(\bar{b}|F^g)\}}{dF^g(v^g)}=\frac{dG^g(v^g)\{n^g-u^g(\bar{b}|F^g)\}}{dv^g}\frac{dv^g}{dF^g(v^g)}$$

$$=\frac{dv^g}{dF^g(v^g)}\times\left[\frac{\kappa\int_{\underline{b}}^{v^g}\frac{dF^g(v^g)}{dv^g}du^g(x|F^g)\{1+\kappa[1-F^g(v^g)]\}}{\{1+\kappa[1-F^g(v^g)]\}^2}\right.$$

$$\left.+\frac{\kappa^2\frac{dF^g(v^g)}{dv^g}\int_{\underline{b}}^{v^g}[F^g(v^g)-F^g(x)]du^g(x|F^g)}{\{1+\kappa[1-F^g(v^g)]\}^2}\right]$$

$$=\frac{\kappa\int_{\underline{b}}^{v^g}\{1+\kappa[1-F^g(x)]\}du^g(x|F^g)}{\{1+\kappa[1-F^g(v^g)]\}^2}.$$

Use $\{1+\kappa[1-F^g(x)]\}du^g(x|F^g)=n^g dK(x)$, which is derived from the first steady-state condition. Then $l^g(v^g,F^g)$ is simplified to

$$l^g(v^g,F^g)=\frac{\kappa\int_{\underline{b}}^{v^g}n^g dK(x)}{\{1+\kappa[1-F^g(v^g)]\}^2}=\frac{\kappa n^g K(v^g)}{\{1+\kappa[1-F^g(v^g)]\}^2}.$$

6 Appendix B

I propose a two-step algorithm for solving for the distribution of the tied-salary/hours offer. In the first step, I compute economically intuitive salary-hour combinations. Then, in the second step, I compute the optimal salary-hour combinations starting from the values determined in the first step.

Step 1: Initialization Points. Because men and women have different preferences concerning hours, profit- (or utility-) maximizing employers post a salary-hour combination that considers the differences in gender preferences and the mix of men and women who would typically choose their jobs. Therefore, hours of work are first determined such that the marginal productivity of an hour equals the weighted average of the marginal disutility of an hour for men and women, where the weights reflect the gender composition of the particular job type in equilibrium. Let θ_j^* be the fraction of men working in a type-j job in equilibrium. Then H_j solves as follows:

$$\rho_j'(H)+\left[\theta_j^*\xi^m\phi'(H)+\left(1-\theta_j^*\right)\xi^f\phi'(H)\right]=0.$$

Using the functional forms for $v^g(S,H;\xi^g)$ and $\rho_j(H)$ that are given in Equations (2) and (3), the hours are determined as

$$H_j^*=T-\left(\frac{\theta_j^*\xi^m+\left(1-\theta_j^*\right)\xi^f}{2a_j}\right)^{1/3}. \quad (4)$$

Next, the salary is chosen to maximize the steady-state profit (or utility) flow, given H_j^* and θ_j^*:

$$\pi_j = \max_{(S)}\left[\rho_j\left(H_j^*\right)-S\right]l^m\left(S+\xi^m\phi\left(H_j^*\right),F^m\right) + \left[\rho_j\left(H_j^*\right)-S-d^{ER}\right]l^f\left(S+\xi^f\phi\left(H_j^*\right),F^f\right). \quad (5)$$

The algorithm I use to solve for the distribution of (S, H) is as follows: First, I make initial guesses for S^0 and θ^0 and then compute the hours H^0 using Equation (4). Given the distributions of S^0 and H^0, I derive the distributions of the job values $F^g(v^g)$ and the fraction of men working in jobs θ^1. I then obtain salary S^1, using the first-order condition of Equation (5). Given the updated distributions of (S^1, θ^1), I again compute the hours H^1 by using Equation (4). I continue this procedure until (S, H, F^g) converges.

Step 2: Newton Method. In determining the hours in Equation (4), I did not consider the difference in turnover behavior between men and women, even though employers are likely to place greater value on workers who remain in the job longer. The solution derived in Step 1 may therefore not be optimal.

The second step of the algorithm performs a Newton method on the H variable. Starting from the salary-hour combinations derived in Step 1, I solve for the salary-hour combinations that satisfy (*i*) the first-order conditions for local maxima in Equation (1):

$\frac{\partial \pi_j}{\partial S} = 0$ and $\frac{\partial \pi_j}{\partial H} = 0$ for all j;

and (*ii*) the second-order condition that implies that the Hessian matrix is a negative definite:

$$\frac{\partial^2 \pi_j}{\partial S^2} < 0,\ \frac{\partial^2 \pi_j}{\partial H^2} < 0,$$

$$\text{and}\ \frac{\partial^2 \pi_j}{\partial S^2}\frac{\partial^2 \pi_j}{\partial H^2} - \left[\frac{\partial^2 \pi_j}{\partial S \partial H}\right]^2 > 0\ \text{ for all } j.$$

In particular, I first update the hours by $H^{k+1} = H^k + \psi\partial\pi/\partial H^k$, where ψ is the negative of the inverse of the second-order derivative. Given the salary and the updated hours, I solve for the distributions of the job values $F^g(v^g)$ and employment size $l^g(v^g, F^g)$. Then salary S is derived using the first-order condition with respect to S in Equation (1). The hours are again updated by $H^{k+1} = H^k + \psi\partial\pi/\partial H^k$. This procedure is repeated until (S, H, F^g) converges and all jobs satisfy the first- and second-order conditions for Equation (1).

To examine whether the solution derived with this two-step algorithm is the best one, I take various initialization points and use the Newton method in Step 2 to solve for (S, H). In cases in which (*i*) the initial hours and salary distributions are chosen to increase with job productivity and (*ii*) the second-order derivative with respect to hours remains negative during the iteration process, the salary-hours bundles converge to the same solutions as the two-step algorithm does. However, others do not converge to satisfy the profit (or utility) maximization conditions of Equation (1). Therefore, the advantage of using the two-step algorithm is that the algorithm produces optimal solutions in a short amount of time.

Competing interests
The IZA Journal of Labor Economics is committed to the IZA Guiding Principles of Research Integrity. The author declares that she has observed these principles.

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