Statistical discrimination from composition effects in the market for low-skilled workers.

Adrian Masters[1]

Department of Economics, University at Albany, SUNY

1400 Washington Avenue, Albany, NY 12222

December 5, 2013

[1]e-mail: amasters@albany.edu, Tel: +1-518-437-4418, Fax: +1-518-442-4736

Abstract

In a random search environment with two racial groups each composed of identical numbers of high and low productivity workers, firms use an imperfect screening device (interviews) to control hiring. If inconclusive interviews lead firms to hire majority workers but not minority workers, then the unemployment pool for majority workers is of higher average quality. This can justify the initial hiring choices. Color-blind hiring always eliminates racial disparities but is not necessarily beneficial; in the USA it would improve welfare with only a brief small increase in white unemployment.

Key words: Statistical Discrimination, search, composition effects

JEL Codes: J16, J64

1 Introduction

The unemployment rate among white Americans without a high school diploma has historically been around half of that among similarly educated blacks. And, all of the disparity stems from differences in their matching (rather than separation) rates. This paper shows how such an outcome can arise in a search and matching environment with imperfect screening of workers by prospective employers. Essentially, when firms apply a stricter standard to minority applicants than those from the majority group, fewer low ability minority workers get hired. This makes the average quality of the minority unemployment pool worse than that of the majority. Firms will use the average quality of the pool as a prior as to their applicants' productivity. Imperfect screening means that even after the interview the prior has an effect on the firm's beliefs about the worker's productivity. This justifies the stricter standard being applied to minority workers and leads to worse employment outcomes for that group. The model will be calibrated to data from the USA in order to assess its empirical validity and to address policy implications.

Holzer and LaLonde [2000] analyze worker flows in the low-skilled labor market in the USA using the National Longitudinal Survey of Youth, 1979 cohort (NLSY79). They find that after controlling for observable characteristics whites get jobs much faster than blacks yet their separation rates are not statistically different from each other. Meanwhile Bowlus and Seitz [2000] structurally estimate a variant of the Burdett and Mortensen [1998] model for the USA using the Panel Study of Income Dynamics (PSID). They find that the matching rate for unemployed blacks is much slower than for unemployed whites. To explain measured differences in wages they conclude that there needs to be significant differences in skill levels.[1] The point of their findings for the current paper is that race explains matching and skills explain wages. The subsequent analysis abstracts from differences in skill

[1] This paper will adopt throughout the convention that skill level is observable to the econometrician while productivity is not.

levels to focus on a particular mechanism by which race can affect matching rates.

The continuous time search and matching environment comprises people in two racial groups with similar (low) skills and the same ex ante mix of individual productivities. Each worker's true productivity is his private information. I make a fundamental assumption that makes the environment relevant for the low-skilled workforce: firms do not know the worker's employment history. If firms could observe how long a worker has been looking for a job it would provide a clearer view as to the probability that the worker is high productivity. Low-skilled workers, however, move frequently in and out of the workforce (see Holzer and LaLonde [2000], Krusell et al [2011]) so that even if a firm could find out how long a worker has been jobless, it would not be a strong indicator of how much time he has spent actually looking for work. The idea here is that each firm uses the composition of the whole unemployment pool of the appropriate racial group for its prior as to an applicant's likelihood of being high productivity.

Controlled by a free-entry condition, firms in the model create as many individual vacancies as they like. Unemployed workers encounter the vacancies according to a constant returns to scale matching function. To keep the environment simple, I assume a two point productivity distribution which represents the extreme values of the range of worker productivities who will be in the market. Employed high productivity workers produce more than their non-market output while employed low productivity workers' output is equal to that of their non-market activity. The firm incurs a cost for any worker hired that reflects specific training, administrative and equipment expenditures. Because of this, ex ante gains from trade with low productivity workers are negative. The way to view this is that markets are segmented by skill levels and the model considers the market for one particular skill level. The heterogeneity in productivity here comes from the residual variance in worker output after controlling for skills.

When they meet, the firm interviews the worker. If the worker is revealed to be of high productivity or if the interview is inconclusive but the unemployment pool is of high enough quality, the worker is hired. In the latter case there remains some asymmetry of information. Wage formation is, assumed to be by take-it-or leave-it offer from the firm.[2] All workers then get a wage equal to the value of their non-market activities.[3] Once hired, the firm has no incentive to get rid of the worker.

Simulations are provided to illustrate the workings of the model, to draw out further results beyond those that emerge from the algebra, and to explore policy implications. Parameters are chosen to generate outcomes for black and white over 25 year old high school dropouts in the USA. The presumption is that, due initially to historical factors, the unemployment pools across racial groups are sufficiently different that inconclusive interviews mean white workers get hired while black workers do not. In the Minority Disadvantaged equilibrium of the model, these choices are rational. The fact that some low productivity white workers have been taken out of their unemployment pool means that firms hiring applicants with inconclusive interviews can expect to recoup the hiring costs. Meanwhile, as all of the low productivity black workers remain in their unemployment pool, firms hiring black applicants with inconclusive interviews cannot expect to recoup the hiring costs.

There are three other possible types of equilibrium of the model. There are two types of nondiscriminatory equilibria. In the first, the "Lenient" equilibrium, all workers with inconclusive interviews are hired. In the second, the "Strict" equilibrium no workers with inconclusive interviews are hired. The third alternative equilibrium is the "Majority Disadvantaged" equilibrium in which the numerically larger group (i.e. whites) are the ones for whom an inconclusive interview means they do not get hired.

At the parameter values used here, the Strict and Majority Disadvan-

[2] Giving workers some opportunity to make wage offers (as in Mailath et al [2000]) leads to a signalling game that has a continuum of equilibria. No standard refinement can help in this matter (see Masters [2009]).

[3] Although this mechanism for wage formation is made for tractability purposes, it should be clear that, given the narrow range of productivities within the market, the range of possible wages coming from any other mechanism will be narrow too.

taged equilibria do not exist. Thus the model provides an environment which can help to explain why we typically observe that the numerically smaller group is disadvantaged. When the larger group are disadvantaged, discriminatory hiring has a stronger impact on unemployment. Vacancies are contacted by applicants more frequently which tends to make the firms pickier. But, if the workers to whom they are lenient are sufficiently rare, firms are more inclined to accept workers with inconclusive interviews.

Two criteria for considering the efficacy of policy are considered: welfare and unemployment. As workers are risk neutral, welfare in the model amounts to aggregate benefits minus aggregate costs. The Lenient equilibrium has higher welfare and lower unemployment for both racial groups than the Minority Disadvantaged equilibrium. Corrective policy in this environment amounts to making sure that firms use color-blind hiring. At the preferred parameter values this sets the economy on a track to the Lenient equilibrium. A potential drawback from this policy is that on impact it reduces vacancy creation and, in the short-term, white unemployment will rise. This could generate political opposition to the measure. However, Figure 1 below shows that the predicted rise is barely perceptible and lasts for no longer than 6 weeks. Convergence to the new steady state takes about 30 months. Coate and Loury [1993] question the implementability of color-blind hiring. They suggest that outcome-based policies are more feasible. Further discussion of this issue is found in Section 4.4.

2 Literature

As the focus of this paper on composition effects that come from hiring decisions, the appropriate modelling environment is one in which the composition of the unemployment pool is endogenous. The search and matching framework is readily adapted for this task and there exists a small literature on its use in understanding discrimination.

Sattinger [1998] provides a model in which different races (or genders) have different ex ante mixes of workers with high and low quit rates. A worker's quit rate is his private information. Statistical discrimination occurs because firms use race as a proxy for quit rates and allow it to influence their hiring strategies. However, different treatment by employers follows entirely from the ex ante difference between races. In the current paper racial groups are ex ante identical.

Lang et al [2005] provide a model of directed search in which the majority group is, ex ante, more productive than the minority group. In such a situation, it is not surprising that an apparently discriminatory outcome occurs. Indeed, if one group is less productive, paying them less is not typically referred to as discrimination. Of interest for antidiscrimination policy then, is only the limiting case in which the groups have the same productivity. To support a discriminatory outcome in this case, firms have to prefer hiring majority over minority workers. That is, in the case of equal productivity, their model relies on taste as in Becker [1971]. If there were free entry of vacancies, the only reason firms with such distaste for minority workers are able remain in the market, is that all firms have the same preferences – nondiscriminatory firms would crowd them out. In this equilibrium, because firms make greater profits from hiring minority workers, minority unemployment is lower than majority unemployment.

Mailath et al [2000] provide a model of discrimination with skill acquisition and complete information. Workers differ in the cost of acquiring the skill but the distribution of those costs is identical across racial groups. Firms prefer to hire skilled workers. If they coordinate their hiring efforts to one group over another, then the preferred group has a higher return to skill acquisition. That group becomes more skilled and faces a lower unemployment rate. A fundamental assumption is that while firms can direct their search toward one racial group over another, they cannot direct their search toward high skilled workers even though skill level is observable. The model presented below assumes completely random search and unobservable productivity levels.

Both the current paper and Mailath et al [2000] generate discriminatory outcomes from search behavior and both have similar implications for the unemployment rates across racial groups. The principal empirical distinction is that in their model higher productivity is acquired and observable while in my model it is unobservable (to the econometrician) and is innate. Their paper is, therefore, more about how the market can differentially encourage skill acquisition while mine is more about the residual differences in unemployment after controlling for skill level.

The possibility of generating discriminatory outcomes by pure composition effects was first suggested in Masters [2009]. That model contains no racial groups and its focus was on the welfare effects of changes in interview technology. For some special parameter values multiple equilibria are possible but the extension to a multiracial economy was not pursued. In the current paper, the interview technology and wage formation are simplified to generate a sharper prediction of the wage and make the existence of multiple equilibria more robust. To provide more realism in terms of labor market flows the current paper also endogenizes the matching rates of workers.

3 Model

3.1 Environment

A continuum of workers live in continuous time. A mass one of workers is born per unit of time and longevity for each is exponentially distributed with parameter δ. The steady state total population of workers is therefore $1/\delta$. There are two racial groups. A share γ of the inflow are in the majority group so that $1-\gamma$ is the population share of the minority.[4] For both groups a share, α, has high productivity (called type h). The remaining $1-\alpha$ of the population have low productivity (type l). A worker's productivity is his private information while his race is not.[5] Workers can be either employed

[4] At this point majority and minority are simply labels and, the subsequent analysis does not require that $\gamma \geq \frac{1}{2}$.

[5] Absent non-contractible choices made by workers (as in Mailath et al [2000]), incomplete information is essential to generate discriminatory behavior. Firms will use race as a proxy for productivity. If productivity is observable race will play no part in the

or unemployed. Workers are risk neutral, discount the future at rate r and, while unemployed, receive a flow utility from non-market activity of b.

There is a continuum of firms that can create any number of jobs. Firms are risk neutral and discount the future at the rate r. Holding open a vacant job incurs a flow advertising cost to the firm of k. A worker of type $t = h, l$ matched to a job produces y_t units of output per unit time. Hiring a worker incurs a one time cost, c, associated with administrative, equipment and training costs. Firms have access to a testing technology: with probability π the firm observes the true productivity of the worker, with probability $1-\pi$ she gets no information from the test. Jobs are subject to a catastrophic technology shock at Poisson arrival rate λ.

Vacancies and unemployed workers find each other according to constant returns to scale matching function. Thus, if v is the mass of vacancies and u the mass of unemployed workers then the flow rate of meetings is $M(u, v)$. The function $M(.,.)$ is assumed to exhibit constant returns to scale, be twice differentiable, increasing in both arguments and concave. The rate at which unemployed workers meet vacancies is then $M(u, v)/u = M(1, \theta)$ where $\theta = v/u$ is called the labor market tightness. It is convenient to define $m(\theta) \equiv M(1, \theta)$ so that $m(.)$ inherits concavity from $M(.,.)$. The rate at which vacancies meet unemployed workers is then $M(u, v)/v = m(\theta)/\theta$. I further assume that $m(0) = 0$, $\lim_{\theta\to 0} m'(\theta) = \infty$ and $\lim_{\theta\to\infty} m'(\theta) = 0$.[6]

The terms of trade are determined by a single take-it-or-leave-it wage offer from the firm to the worker. A game theoretic analysis of the wage setting is provided in Lemma 1 of Masters [2009]. There, it is shown that any equilibrium of the screening game implies that for both high and low productivity workers, $w = (r + \delta)V_u$ where w is the wage and V_u is the worker's value to unemployment. Now if V_w is the value to employment at

allocation.

[6] These conditions rule out corner solutions.

wage w then

$$\begin{aligned} rV_u &= b + \mu(V_w - V_u) - \delta V_u \\ rV_w &= w + \lambda(V_u - V_w) - \delta V_w \end{aligned}$$

where μ is any matching rate. Setting $w = (r + \delta)V_w$ now implies that $w = b$. Due to the search frictions there is a strictly positive match surplus. As the firms get all of the bargaining power, workers are driven down to the monopsony wage.[7] Firms cannot demand a hiring fee from workers. This restriction is quite common in the search and matching literature (e.g. Millard and Mortensen [1997], Blanchard and Diamond [1994]) and is usually justified by the workers being liquidity constrained or by the firms being unable to commit not to renegotiate wages.

It is also assumed that a worker's employment history is his private information. While, say, the time since the end of a worker's last employment spell should be available to a prospective employer, how much of that time is actually spent looking for work is unobservable. That the whole of the worker's employment history is his private information represents an alternative benchmark to that history being common knowledge.[8] The implication is that firms cannot use a job applicant's employment history to ascertain his true productivity. Rather, firms use the current composition of the whole unemployment pool. Again, such an assumption seems more reasonable in a low-skilled labor market where people are known to move in and out of the labor force with some frequency.[9]

The parameters satisfy the following restrictions:

$$y_h > y_l = b \tag{R1}$$

$$\frac{\alpha\,(y_h - b)}{r + \delta + \lambda} - c > 0 \tag{R2}$$

[7] This result extends the Diamond Paradox to the case with asymmetric information.

[8] Other papers that make this assumption include Akin and Platt [2012], Masters [2009] and Sattinger [1998].

[9] See Krusell et al [2011].

Restriction (R1) implies that once hired there are non-negative gains from trade between firms and both types of worker. The idea is that the market comprises of workers whose productivities lie in the range between b and y_h. I consider the simplest distribution of that type with mass points at y_h and b. Restriction (R1) also means that for low productivity workers, because of the hiring cost, there are no ex ante gains from trade. Restriction (R2) implies that there are expected gains with the inflow population. This means that no matter how bad the interview technology (i.e. even with $\pi = 0$) there is some incentive to create vacancies in the first place.

3.2 Equilibrium

Definition 1 *A hiring strategy for a firm is a mapping from the set of post interview possible beliefs as to the probability that the worker is of high productivity* $[0, 1]$ *into a hiring decision in* $\{0, 1\}$.

If the interview is conclusive (that occurs with probability π) the belief as to the worker's productivity is either 0 or 1. If the interview is inconclusive the firm uses its prior belief as to the worker's productivity which comes from the composition of the unemployment pool for the appropriate group of workers.

Definition 2 *A workforce composition is an allocation of workers by type and group into unemployment and employment.*

Definition 3 *An equilibrium is a workforce composition and a hiring strategy for each firm, such that, given the workforce composition, each firm follows an optimal hiring strategy and that when all firms follow their optimal strategy the implied population flows are consistent with the workforce composition.*

I seek pure strategy symmetric equilibria. Pure strategy here means that firms do not randomize over hiring decisions. Symmetry means that all firms follow the same strategy in equilibrium. This means that any two firms have the same propensity to hire, say, a minority worker whose interview is inconclusive. It does not prevent differences in their propensity to hire minority workers versus majority workers.

Three types of such equilibria are possible. In a discriminatory equilibrium whenever an interview is inconclusive, members of one group, do not get hired whereas members of the other group will get hired. I will call the group who do not get hired after an inconclusive interview the "disadvantaged" group so that the other group will be called the "advantaged" group. For a given value of γ there are potentially two subtypes of discriminatory equilibria. One in which the minority are disadvantaged, henceforth called a "Minority Disadvantaged" equilibrium, and one in which the majority are disadvantaged, henceforth called the "Majority Disadvantaged" equilibrium. The other two equilibrium types are nondiscriminatory. In a "Lenient" equilibrium, regardless of their racial group, workers with inconclusive interviews get hired and in a "Strict" equilibrium they do not.

3.3 Characterization

The objective here is to construct a Minority Disadvantaged equilibrium. To do so we first posit its existence and then obtain any restrictions that specify circumstances under which the equilibrium does exist. That the wage is equal to the flow value of the workers' non-market activity, b, trivializes the worker's side of the economy. Firms, however, have a non-trivial problem to solve. They have to decide how many vacancies to create and whom to hire based on the interviews they conduct. Taking the current population stocks as given, this subsection obtains an implicit expression for the implied level of labor market tightness, θ, such that firms are indifferent between creating an additional vacancy and not doing so.

Notationally, superscripts will refer to group membership, $g = a, i$ (majority or minority group respectively) and subscripts will refer to type, $t = h, l$ (high and low). Let V_t^g be the present discounted value to a firm who employs a type t worker from group g and let V_v be the value to holding open a vacancy. Then, allowing a dot over a variable to denote its time derivative,

$$\begin{aligned}(r+\lambda)V_v - \dot{V}_v &= \frac{m(\theta)}{\theta}\left[\psi\phi^a\pi(V_h^a - V_v - c)\right. \\ &\quad +\psi(1-\pi)\phi^a(V_h^a - V_v - c) \\ &\quad +\psi(1-\pi)(1-\phi^a)(V_l^a - V_v - c) \\ &\quad \left.+(1-\psi)\phi^i\pi(V_h^i - V_v - c)\right] - k. \qquad (1)\end{aligned}$$

where ψ is the share of majority group workers in the unemployment pool and ϕ^g is the share of group g unemployed workers who are high productivity. The first term in the square brackets says that with probability $\psi\phi^a\pi$ the worker is of group a, is high productivity and has a conclusive interview. So, the firm experiences the capital gain associated with hiring a group a type h worker. The second term says that with probability $\psi(1-\pi)\phi^a$ the worker is group a, is high productivity but has an inconclusive interview. So, the firm experiences the capital gain associated with hiring a group a type h worker. The third term says that with probability $\psi(1-\pi)(1-\phi^a)$ the worker is group a, is low productivity and has an inconclusive interview. So, the firm experiences the capital gain associated with hiring a group a type l worker. The final term says that with probability $(1-\psi)\phi^i\pi$ the worker is of group i, type h and has a conclusive interview. So, the firm experiences the capital gain associated with hiring a group i type h worker. No other types of worker are hired in the Minority Disadvantaged equilibrium.

The left-hand-side (LHS) of equation (1) represents the flow value to creating a vacancy adjusted for its rate of change. The right hand side (RHS) is a breakdown of the components that contribute to it. The ratio $m(\theta)/\theta$ is the expected rate at which the vacancy will meet workers. So, predicated on meeting a worker contributions to V_v come from the possibility of meeting a majority group worker who tests positive (the first term), a majority worker whose test is inconclusive (the second and third terms), and a minority group worker who tests positive (fourth term). From the positive contributions to vacancy holding that come from meeting workers it is then necessary to subtract the flow cost, k, of maintaining the vacancy.

Now

$$rV_t^g - \dot{V}_t^g = y_t - b + \delta(V_v - V_t^g) - \lambda V_t^g, \quad g = a, i \quad t = h, l. \tag{2}$$

The firm pays the wage, equal to b, out of the match output. The match is subject to the worker leaving the workforce at rate δ that leaves the job intact. The job is subject to a catastrophic technology shock at arrival rate λ that puts the worker back into the unemployment pool. The LHS of equation (2) is the flow value to being matched to a type t worker from group g adjusted for dynamics in V_t^g. The components of the RHS comprise the flow profits from the match, $y_t - b$, the possibility that the worker might die, and the possibility that the job might get destroyed. It should be clear from equation (2) that $V_t^a = V_t^i$ for $t = h, l$ so that in the sequel, without ambiguity, I will drop the superscripts from V_t.

As firms can create as many vacancies as they like, they will continue to do so whenever $V_v > 0$. At every instant in time, therefore, we have $V_v = 0$ and equation (1) reduces to

$$k = \frac{m(\theta)}{\theta} \left\{ \psi \left[\phi^a (V_h - c) + (1 - \phi^a)(1 - \pi)(V_l - c) \right] + (1 - \psi)\pi\phi^i (V_h - c) \right\}. \tag{3}$$

Then from equation (2), as there is no other source of dynamics,[10]

$$V_t = \frac{y_t - b}{r + \delta + \lambda} \quad t = h, l. \tag{4}$$

This means that although we have not imposed any steady state, the firms' value functions are constant over time. Free entry implies that V_v is always 0, V_t is simply the present value of a constant profit flow regardless of what happens outside the match. Any dynamics in the model will be restricted to the population flows.

Now, as $y_l = b$ and $V_l = 0$, equation (3) reduces to

$$k = \frac{m(\theta)}{\theta} \left\{ \psi \left[\phi^a (V_h - c) - (1 - \phi^a)(1 - \pi)c \right] + (1 - \psi)\pi\phi^i (V_h - c) \right\}. \tag{5}$$

[10] There is a possibility of a bubble component but as long as V_t remains finite we can rule that out.

As is common to models with the Pissarides free entry condition, the cost of holding a vacancy is equal to the present expected flow profits from matching. Unlike the standard Diamond-Mortensen-Pissarides framework, however, equation (5) does not imply a constant value for the market tightness, θ. As ψ, ϕ^a, and ϕ^i vary over time so will θ. As V_h is a simple combination of the model parameters, for notational brevity the remainder of the analysis will treat it too as a parameter.

3.4 Population flows

The values of ψ, ϕ^a and ϕ^i come from consideration of the population flows. Clearly, the total population, P, is $1/\delta$, and there are always $P^a = \gamma P$ majority workers and $P^i = (1-\gamma)P$ minority workers in the workforce. If u_t^g and e_t^g are respectively the measures of unemployed and employed workers from group $g = a, i$ and type $t = h, l$ then for the high productivity majority group workers

$$\dot{u}_h^a = \alpha\gamma + \lambda e_h^a - [\delta + m(\theta)]u_h^a. \tag{6}$$

The first two terms on the right hand side of equation (6) are the flows into unemployment, the last term is the flow out. In the Minority Disadvantaged equilibrium, these workers always get hired so π does not show up in this equation. Now, e_h^a can be obtained from subtraction from the total population:

$$e_h^a = \frac{\alpha\gamma}{\delta} - u_h^a.$$

Low productivity majority group members only get hired when the interview is inconclusive. So, by the same token,

$$\dot{u}_l^a = (1-\alpha)\gamma + \lambda e_l^a - [\delta + (1-\pi)m(\theta)]u_l^a \tag{7}$$

where

$$e_l^a = \frac{(1-\alpha)\gamma}{\delta} - u_l^a.$$

Minority group high productivity workers only get hired when the interview is conclusive. So,

$$\dot{u}_h^i = \alpha(1-\gamma) + \lambda e_h^i - [\delta + \pi m(\theta)]u_h^i \tag{8}$$

where

$$e_h^i = \frac{\alpha(1-\gamma)}{\delta} - u_h^i.$$

Minority group low productivity workers never get hired so

$$u_l^i = \frac{(1-\alpha)(1-\gamma)}{\delta} \tag{9}$$

Then, if $u^g = u_h^g + u_l^g$, for $g = a, i$ and $u = u^a + u^i$, we have

$$\phi^g = u_h^g / u^g \quad \text{for} \quad g = a, i \quad \text{and} \quad \psi = u^a / u. \tag{10}$$

3.5 Existence and dynamic stability of steady state equilibria

A characterization of the Minority Disadvantaged equilibrium is a list $\{\theta, \phi^a, \phi^i, \psi\}$ such that the market tightness, θ, solves equation (5) where ϕ^a, ϕ^i and ψ come from population flows as described in Section 3.4 and firms hire majority group workers whose interview is inconclusive (i.e. $\phi^a V_h \geq c$) while they do not hire minority group workers whose interview is inconclusive (i.e. $\phi^i V_h < c$).

While the dynamic response of the population flows to policy changes will be provided in the simulations below, the analysis here will focus on steady states. In steady state the population variables are constant over time. Steady state values of population variables will carry a bar. For example the steady state value of u_h^i is $\bar{u}_h^i$.

Proposition 1 *For any $c \in (0, [\alpha(1-\pi)/(1-\alpha\pi)]\, V_h]$ there exists a value $\hat{k} > 0$ of the vacancy advertising cost, k, such that for any $k \in (0, \hat{k}]$ a steady state Minority Disadvantaged equilibrium exists. If γ, the share of majority group workers in the economy, is 0 or 1, the equilibrium is unique.*

Proof. See Appendix. ■

Proposition 1 establishes existence of the Minority Disadvantaged equilibrium for a wide range of the parameter space. It also indicates how, in principle, to construct an equilibrium: given any values for r, α, γ, δ, λ, π and any matching function, $m(.)$, that satisfies the requirements stated earlier, pick a value for c in the specified range and then pick a value for k. Part of the proof establishes that a solution to equation (5) exists and that $\phi^a V_h \geq c$. Use the implied value of ϕ^i to see if $\phi^i V_h < c$, if not, pick a lower value for k. Proposition 1 also establishes the existence and uniqueness of the Lenient and Strict equilibria. This is because the Minority Disadvantaged equilibrium in which $\gamma = 0$ is observationally equivalent to the Strict equilibrium and the Minority Disadvantaged equilibrium in which $\gamma = 1$ is observationally equivalent to the Lenient equilibrium. Symmetry also implies that a Majority Disadvantaged equilibrium in which the majority group is disadvantaged can be constructed in a similar fashion.

Notice, though, that the foregoing does not establish coexistence of these equilibrium types. Given all of the other parameter values, the value of $\hat{k}$ typically differs by the type of equilibrium sought. Indeed, at the parameter values chosen for the simulations below, neither the Strict nor any Majority Disadvantaged equilibrium exists. What should be clear, though, is that for any k below the smallest of those values for $\hat{k}$, all 4 steady state equilibria will exist. When all 4 equilibrium types do exist, the choice of which group is disadvantaged is arbitrary. The presumption here is that for historical reasons (e.g. government sanctioned, or taste-based discrimination), one group has suffered worse labor market outcomes than the rest of the population. Ultimately, when we look at the data, the issue is moot. In the case of the US it is the Black, smaller, population that experiences the higher unemployment rate and that guides the selection of equilibrium for policy analysis.

Generically, the conditions on populations required to sustain equilibria of any type will be satisfied with strict inequalities. Thus for the Minority Disadvantaged equilibrium $\phi^a V_h > c$ and $\phi^i V_h < c$. This means that a deviation by a positive measure of firms away from equilibrium behavior even for a strictly positive amount of time will not necessarily affect populations enough to set the economy moving toward a different steady state.[11] As a

[11] By the same token, the set of equilibria will be robust to small enough changes in the parameters. This means that, for example, the Discriminatory equilibrium will, generi-

consequence, the Minority Disadvantaged, Majority Disadvantaged, Lenient and Strict equilibria (when they exist) are dynamically stable. As equilibria in these kinds of model generically come in odd numbers, there will in fact be mixed strategy symmetric steady state equilibria in which firms are indifferent between hiring and not hiring workers of one or both groups when their interview is inconclusive. In those steady states, any deviation by a positive measure of firms will immediately set the workforce on a path away from the precise composition required to sustain the firms' indifference. Such steady state equilibria will be dynamically unstable.

4 Simulations

This paper represents an attempt to understand how outcomes can differ so greatly across racial groups even after controlling for skills. Consistent with Holzer and LaLonde [2000] and Bowlus and Seitz [2000], all of the action in the model is in hiring. Still, it is not clear from the preceding analysis that the composition effects identified here are of any quantitative significance. For example, Hornstein et al [2011] show that while the sequential search model is capable of supporting wage dispersion, they also show that under realistic parameters the extent of that dispersion is small relative to that found in the data. Here, I demonstrate that the model is capable of generating the kinds of outcomes observed in real labor markets. Specifically the model will be calibrated to the market for black and white high school drop-outs in the USA. The implied parameter values will then be used to address the potential efficacy of policy initiatives.

4.1 Functional forms and parameters

k	α	π	γ	r	δ	λ	m	η	y_h	b	c
0.183	0.905	0.92	0.85	0.04	0.05	0.6	12	0.5	1	0.956	0.02

Table 1: Parameter Values

cally, continue to exist for a small enough increase in the share of minority workers who are high productivity.

Table 1 contains the parameters for the leading example. The parameters are chosen based on a time unit of 1 year. The matching function is chosen to be Cobb-Douglas so that $m(\theta) = m\theta^{\eta}$. Blanchard and Diamond [1989] and Pissarides and Petrongolo [2001] discuss matching function parameters. From there I set $m = 12$ and $\eta = 0.5$. As is common in the real business cycle literature, the discount rate, r, is set to 0.04. The parameter γ, the proportion of majority group workers, was chosen to match data from the 2000 US census.[12]

Holzer and LaLonde [2000] calculate transition rates for low-skilled workers from employment to non-employment from the NLSY79. After controlling for location and other factors they found that race plays no part in the exit rate from employment. In the raw numbers they found an average rate of around 1.9% per week for low-skilled workers. This translates into an annualized figure for $\delta + \lambda$ of 0.65. The rate of labor force exit, δ was set to 0.05. This corresponds to an expected duration of 20 years which would be the average expected remaining length of participation of workers with 40 year working lives.

Setting y_h to 1 is a normalization. The value of b was chosen to deliver a similar share of match productivity to the firms as emerges in the calibration of the Mortensen and Pissarides [1994] model by Hagedorn and Manovskii [2008]. They set the value of leisure to 95.5% of the worker's productivity and the bargaining power of the firm to 0.95. This means the firm gets 4.2% of the match productivity. Although the focus of their paper is on the time series behavior of unemployment, what leads the Hagedorn and Manovskii [2008] calibration to this conclusion is the low cost of vacancy creation that they obtain from cross-sectional analysis. Given such a cost of vacancy creation, only a small fraction of match output can go to the firm. Otherwise, a counterfactually large number of vacancies would be created. Here, the wage, that is b, is set to 95.6% of the high productivity worker's output. This means the employed workers get 95.8% of their mean

[12] Grieco and Cassidy [2001] report that 12.3% of the census respondents considered them selves to be black. Another 2.4% are mixed race.

productivity as in Hagedorn and Manovskii [2008]. The immediate costs of hiring a worker include the expenses associated with specific job training, administration, equipment and uniforms. The value of c was chosen to be equivalent to about 1 week's match output. Clearly if $c = 0$, there could not be a discriminatory equilibrium - firms would hire everyone without any interview. Larger values of c are easily accommodated in the model.

The remaining parameters, k, the advertising cost, α, the population share of high productivity workers, and π, the probability of a conclusive interview, were chosen to match the following features of the labor market for over 25 year old high school dropouts from the Current Population Survey (CPS) between 2000 and 2007: average monthly unemployment, 7.9%; average monthly unemployment for whites, 6.9%; average monthly unemployment for blacks, 13.4%.

4.2 Welfare

As everyone in the economy is risk neutral, welfare, W, amounts to aggregate benefits minus aggregate costs. So,

$$W = e_h^a y_h + e_l^a y_l + e_h^i y_h + e_l^i y_l + ub - u\theta k - \text{flow hiring costs.} \quad (11)$$

As who gets hired depends on the firms' hiring strategies, hiring costs are contingent on those strategies. Table 2 contains the flow hiring costs for each of the strategies considered.[13]

Strategy	**Flow hiring cost**
Lenient	$m(\theta)\left[u_h^a + u_h^i + (1-\pi)(u_l^a + u_l^i)\right] c$
Minority Disadvantaged	$m(\theta)\left[u_h^a + (1-\pi)u_l^a + \pi u_h^i\right] c$
Majority Disadvantaged	$m(\theta)\left[u_h^i + (1-\pi)u_l^i + \pi u_h^a\right] c$
Strict	$m(\theta)\pi\left[u_h^a + u_h^i\right] c$

Table 2: Flow hiring costs

[13] A hiring strategy associated with a particular equilibrium type is the one that firms follow in that equilibrium.

The resulting value of welfare can be compared to the benchmark value associated with no job creation at all, $\bar{W} = b/\delta$, and the constrained efficient level of steady state welfare, W_P. Using the calibrated parameters, $\bar{W} = 19.12$ and $W_P = 19.52$.

4.3 Results

Table 3 presents the outcomes for various economies based on the calibrated parameters of Table 1. "Disc" is the Minority Disadvantaged equilibrium. "Lenient" is the equilibrium in which everyone is treated like an advantaged group member. At these parameter values neither the Strict nor the Majority Disadvantaged steady state equilibrium exists. That is, at the workforce composition implied by either of these steady states, firms would accept all workers with inconclusive interviews. In the language of Proposition 1, the calibrated value of k is larger than the value of $\hat{k}$ associated with the existence of either of those equilibria.

The result is more general than specific parameters used here though and speaks to why we typically see the numerically smaller ethnic group being disadvantaged. When the larger group are disadvantaged, discriminatory hiring has a stronger impact on vacancy creation. Unemployment is higher so that employers find applicants faster which tends to make them pickier. But, if the workers to whom they are lenient are sufficiently rare, firms are more inclined to accept workers with inconclusive interviews.

The column headed "$\pi = 1$" refers to a perfect interviewing economy - everyone's true productivity is obvious when they apply for the job. The column headed "$\pi = 0$" refers to an economy in which there are no interviews.

Economy → Outcome ↓	Disc	Lenient	$\pi = 1$	$\pi = 0$
ψ	0.744	0.850	0.850	0.850
ϕ^a	0.527	0.519	0.336	0.905
ϕ^i	0.292	0.519	0.336	0.905
% Aggregate unemployment rate	7.85	6.32	14.32	2.14
% Majority unemployment rate	6.87	6.32	14.32	2.14
% Minority unemployment rate	13.42	6.32	14.32	2.14
$(W - \bar{W})/(W_P - \bar{W})$ %	9.41	11.05	10.86	11.22

Table 3: Results

The rows of Table 3 refer to the main outcomes of interest. Recall that ψ is the share of the majority group workers in the unemployment pool. It should be compared with the share of majority workers in the population, $\gamma = 0.85$. Then ϕ^g is the share of high productivity workers in the unemployment pool of group $g = a, i$. These should be compared with the share of high productivity workers in the population, $\alpha = 0.905$. The aggregate, majority and minority unemployment rates are self-explanatory. Finally, $(W - \bar{W})/(W_P - \bar{W})$ is the extent to which the current equilibrium allocation provides an improvement in welfare above the benchmark of no job creation.

In the Minority Disadvantaged equilibrium, the racial composition of unemployment does not look a lot different from the population at large. About a quarter of the unemployed are minority workers compared to about one sixth of the general population. But only 52.7% of the white unemployed and 29.2% of the black unemployed are high productivity compared to 90.5% in the general population. This reflects the importance of interviewing in shaping the composition of the workforce.

As long as policy can be used to eliminate discrimination (see Section

4.4), the model predicts that the economy will eventually move to the Lenient equilibrium. The outcomes associated with that equilibrium are included to demonstrate the possible benefits that emerge from policy action. Specifically, the model predicts that in the long-run welfare would be higher and unemployment would be lower for everyone with the elimination of discrimination.

The columns of Table 3 headed $\pi = 1$ and $\pi = 0$ are included to provide context to the Minority Disadvantaged and Lenient equilibria and to help demonstrate the the working of the model. Under those parameter restrictions, discriminatory equilibria are impossible. In the case of $\pi = 1$, this should be obvious as there are no applicants for whom the interview is inconclusive. In the case of $\pi = 0$, discrimination cannot occur because there is no basis for the composition effects that cause the discriminatory behavior in the first place.

4.4 Anti-discriminatory policy

An obvious question here is what could affirmative action achieve in this economy? In the Minority Disadvantaged equilibrium, both racial groups earn the same wages but minority workers are hired at a lower rate. Ideally, antidiscrimination policy will entail having firms interview in a way that the employer cannot detect the applicant's group membership (color-blind hiring). Their propensity to hire members of either group will now depend on the proportion, ϕ, of high productivity workers in the combined population of the unemployed. Thus

$$\phi = \frac{u_h^i + u_h^a}{u}.$$

If $\phi V_h > c$ firms will hire everyone one whose interview is inconclusive leading eventually to the Lenient steady state equilibrium. If $\phi V_h < c$ firms will hire no one whose interview is inconclusive leading to the Strict steady state equilibrium. At the calibrated parameter values, however, we know that the Strict equilibrium does not exist so that color-blind hiring will work to move the economy to the Lenient equilibrium with the concomitant long run

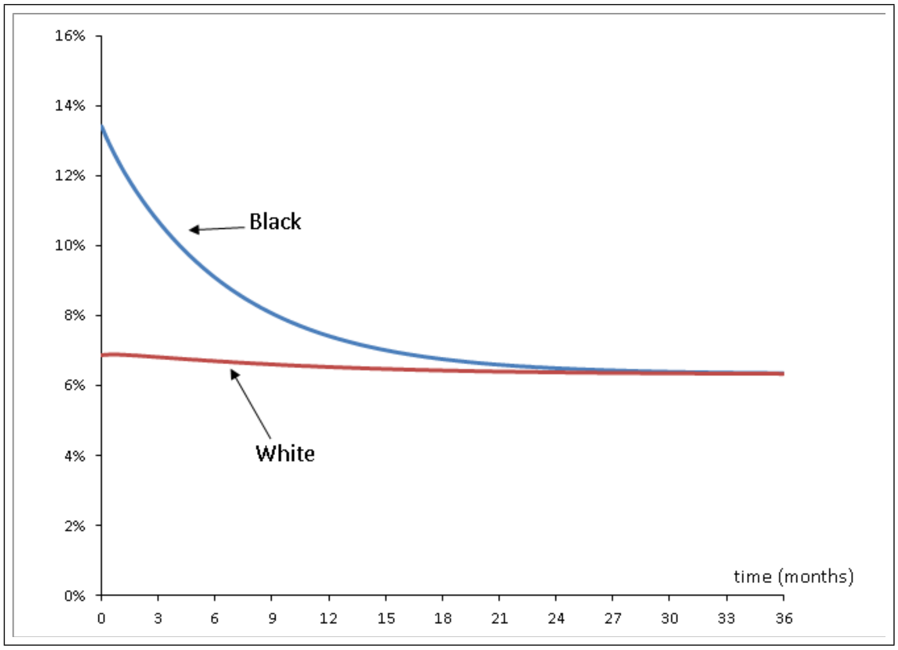

Figure 1: Predicted transition paths of unemployment rates for black and white high school drop-outs under color-blind hiring.

welfare and employment gains.

A concern here, though, is that when the policy is first brought in, firms are being forced to hire in a way that is not in their immediate interest. Vacancy creation will fall initially leading to higher unemployment among whites in the short term.

Figure 1 plots the value of u^g/P^g, $g = i, a$ over the transition following enactment of color-blind hiring. The short term increase in white unemployment is barely perceptible. It rises by less than one hundredth of a percentage point and returns to its pre-policy value within 6 weeks. Convergence to the long run level of unemployment takes around 27 months. The present discounted value of welfare over the transition converted to the measure used in Table 3 is 10.98%.

But, how practical is color-blind hiring? Goldin and Rouse [2000] looked at the practice of orchestral auditions held behind a screen. They find that it increased the success rate of women by 50%. Coate and Loury [1993] on the other hand, argue that such "process" control is not feasible in the general labor market and suggest that policy analysis should focus on "outcome" control. In the context of the current model this would mean that firms should be required to hire black workers at the same rate as white workers. Under the above parameterization this would mean firms initially having to hire blacks that were known to be low productivity. This would cause a more severe drop in vacancy creation and a sharper increase in white unemployment than occurs under color-blind hiring. To the extent, however, that outcome control is more feasible it would equally be possible to enforce the outcomes associated with color-blind hiring and allow firms to decide who to take under that constraint.

5 Extensions

5.1 Costly interviews

In reality, assessing the ability of applicants is costly. Thus far the paper has abstracted from this cost and consequently avoided the extent to which the interview is a choice of the firm. Let κ represent the cost of interviewing the worker. Clearly, for κ large enough, no firms will interview anyone and the outcome would be the same as with $\pi = 0$. Table 3 indicates that as a policy initiative, punitively expensive interviewing would, at least in the long run, be Pareto improving. Despite this, in all of the equilibria discussed above, the private return to interviewing for firms is strictly positive. This means that there is a positive value of κ small enough that its introduction will not change anything.

Of greater interest, then, are the intermediate values where κ lies between the private value to interviewing when no one else does and the value when everyone else does. Consider first the environment with out races, $\gamma = 1$ or 0. This amounts to comparing the value to interviewing in the Lenient equilibrium to the private value of conducting an interview with accuracy $\pi = 0.92$ when no one else has access to the interview technology (i.e. for $\pi = 0$). The values are 44.2 and 8.7 percent respectively of the hiring cost, c. So, under the parameters adopted here, the return to interviewing is higher when everyone else does it than when no one does. For values of κ between these figures no one will interview as long as nobody else does - ignorance is privately optimal. But if everyone else interviews, then I will have to interview too.

Now with $\gamma = 0.85$, the value to interviewing everyone in the Minority Disadvantaged equilibrium is 49.2% of c. But, it differs by race. Being able to interview whites is worth 43.5% while being able to interview blacks is worth 65.7%. A cost of interviewing between these values would lead, in the short run, to a discriminatory interviewing process. In the long run though, as whites would all be getting hired, this would bring down the value to interviewing for both races. As long as the return to interviewing minority workers continues to exceed that of interviewing majority workers it can be in a firm's interest to implement a discriminatory interview policy.

5.2 Interview technology investment

Here I suppose instead, that individual interviews are costless but that firms must invest ex ante in their interview technology. The cost of the initial job creation would be $f(\pi)$ where $f' > 0$, $f'' > 0$, $f(0) = f'(0) = 0$ and $\lim_{\pi \to 1} f(\pi) = \infty$. Again the propensity to invest in this way will depend on the value to interviewing which depends in turn on the propensity for others to invest. From the foregoing it should be clear that $\pi = 0$ will not be an equilibrium. It is privately in every firm's interest to acquire the technology even though they would all be better off without it. What this means is that there will be overinvestment in interviewing. As individual interviews are costless firms would never be inclined to follow a discriminatory interview policy. Whether the technology will sustain discriminatory hiring would depend on parameters.

6 Conclusion

This paper provides a simple model of statistical discrimination based on composition effects. Imperfect interviewing means that hiring firms make mistakes. If they hire all workers for whom the interview is inconclusive they end up hiring some low quality workers. Consequently, there are relatively few low quality workers in the unemployment pool that can then justify hiring the workers with the inconclusive interviews. If firms do not hire any workers for whom the interview is inconclusive, it leaves all of the low quality workers in the unemployment pool. The implied composition can then justify the unwillingness to hire the workers with inconclusive interviews. These outcomes can be supported as multiple equilibria in a model without racial groups. The model with racial groups can then be used to understand why one racial group might experience high unemployment while operating in the same labor market as another racial group that has low unemployment. The idea is that firms identify individuals as being a member of a racial group for whom the unemployment pool has a known composition. If the quality of the worker's unemployment pool is high, the worker is hired. If it is low, the worker is rejected.

A major point of this paper is that these composition effects are not merely a theoretical possibility but that they can plausibly cause the kinds of differences in outcomes that we observe in real labor markets. For this reason, the model was calibrated to the US labor market for high school dropouts and shown to be consistent with the observed differences in unemployment between whites and blacks. In the model, as in the data, whites and blacks are equally likely to loose their jobs – all of the action is in hiring.

Corrective policy here is mandatory color-blind hiring. The predicted transition path shows that concerns as to the impact of this policy on white unemployment are unfounded. Aggregate welfare gains are small but positive.

7 Appendix

7.1 Proof of Proposition 1.

7.1.1 Step 1: Properties of $\bar{\phi}^a$ and $\bar{\phi}^i$

From (10) we obtain

$$\bar{\phi}^a = \frac{\alpha\left[\delta+\lambda+m(\theta)(1-\pi)\right]}{\alpha\left[\delta+\lambda+m(\theta)(1-\pi)\right]+(1-\alpha)(\delta+\lambda+m(\theta))} \tag{12}$$

and

$$\bar{\phi}^i = \frac{\alpha(\delta+\lambda)}{\alpha(\delta+\lambda)+(1-\alpha)(\delta+\lambda+\pi m(\theta))}. \tag{13}$$

Straightforward algebra establishes that both $\bar{\phi}^a$ and $\bar{\phi}^i$ are strictly decreasing in θ and for all $\theta > 0$, $\bar{\phi}^a > \bar{\phi}^i$. For low values of θ, $m(\theta)$ is small compared to the parameters δ, and λ so that as $\theta \to 0$, $\bar{\phi}^a \to \alpha$ and $\bar{\phi}^i \to \alpha$. Now as θ approaches ∞, $m(\theta)$ becomes large and

$$\bar{\phi}^a \to \frac{\alpha(1-\pi)}{\alpha(1-\pi)+(1-\alpha)} < \alpha \tag{14}$$

while $\bar{\phi}^i \to 0$.

7.1.2 Step 2: Solution to equation (5)

Consider the contents of the curly brackets in (5),

$$\Gamma \equiv \bar{\psi}\left[\bar{\phi}^a(V_h-c)-(1-\bar{\phi}^a)(1-\pi)c\right]+(1-\bar{\psi})\pi\bar{\phi}^i(V_h-c).$$

Given the properties of $\bar{\phi}^a$ and $\bar{\phi}^i$ the only possibility for Γ to become negative is if the contents of the square brackets become negative. The lowest possible value of that occurs for the lowest value of $\bar{\phi}^a$. Substituting from (14) implies

$$\bar{\phi}^a(V_h-c)-(1-\bar{\phi}^a)(1-\pi)c \geq \frac{(1-\pi)\left[\alpha\left(V_h-c\right)-(1-\alpha)c\right]}{\alpha(1-\pi)+(1-\alpha)}$$

which is positive as long as $\alpha V_h - c > 0$. This is implied by the hypothesis.

Now consider the Lenient outcome in which all workers with inconclusive interviews are hired. This is equivalent to setting $\gamma = 1$ and the majority being the advantaged group. Without any minorities in the economy, $\bar{\psi} = 1$ too. Equation (5) reduces to

$$k = \frac{m(\theta)}{\theta} \left\{ \bar{\phi}^a (V_h - c) - (1 - \bar{\phi}^a)(1 - \pi) c \right\} \tag{15}$$

It is immediate that RHS of (15) is negatively sloped in θ and from the properties of the matching function it limits to infinity as θ approaches 0 and limits to 0 as θ approaches infinity. There is always a unique value of θ that solves (15).

Now consider the Strict nondiscriminatory outcome in which only those known to be of type h are hired. This is equivalent to everyone being treated like a minority group worker in the Minority Disadvantaged equilibrium. With $\gamma = 0$, $\bar{\psi} = 0$ too and

$$k = \frac{m(\theta)}{\theta} \pi \bar{\phi}^i (V_h - c). \tag{16}$$

There is, clearly, always a unique value of θ that solves (16).

Now consider the general case of solving equation (5), $\bar{\phi}^a$ and $\bar{\phi}^i$ are given by (12) and (13) but $\bar{\psi} = \bar{u}^a / \left(\bar{u}^a + \bar{u}^i \right)$ now enters the system. From Section 3.4 we obtain

$$\bar{u}^a = \frac{\gamma(\delta + \lambda) \left\{ \delta + \lambda + m(\theta)(1 - \alpha\pi) \right\}}{\delta(\delta + \lambda + m(\theta)) \left[\delta + \lambda + m(\theta)(1 - \pi) \right]}$$

and

$$\bar{u}^i = \frac{(1 - \gamma) \left[\delta + \lambda + (1 - \alpha)\pi m(\theta) \right]}{\delta(\delta + \lambda + \pi m(\theta))}$$

Then $\lim_{\theta \to 0} \bar{\psi} = \gamma$ (there is no matching so the unemployment pool looks like the entry flow) and $\lim_{\theta \to \infty} \bar{\psi} = 0$ (instantaneous matching means all majority workers are employed all of the time). We know that Γ remains finite for all θ and that it is strictly positive for $\theta = 0$. This means that RHS of (5) limits to infinity as θ approaches 0 and limits to 0 as θ approaches infinity.

7.1.3 Step 3: Existence of Minority Disadvantaged Equilibrium

For a solution to (5) to be an equilibrium requires $\bar{\phi}^a \geq \dfrac{c}{V_h} > \bar{\phi}^i$. From (14) the first inequality will hold as long as $c \in (0, [\alpha(1 - \pi)/(1 - \alpha\pi)] V_h]$. From (13), the second inequality will hold as long as θ is large enough. As RHS of (5) limits to 0 as θ approaches infinity, for any $\hat{k}$ there exits some $\hat{\theta}$ such that for values of θ

greater than $\hat{\theta}$ RHS of (5) is always less than $\hat{k}$. We can choose $\hat{k}$ as the maximal value of k such that at the associated value of $\hat{\theta}$, $\bar{\phi}^i < c/V_h$.

8 References

Akin, S. and B. Platt [2012] "Running Out of Time: Limited Unemployment Benefits and Reservation Wages" *Review of Economic Dynamics*, **15:** 149-70.

Becker, G. [1971] *The economics of discrimination*, 2nd ed., Chicago: University of Chicago Press.

Blanchard, O. and P. Diamond [1989] "The Beveridge Curve" *Brookings Papers on Economic Activity*, **1989 (1):** 1–76.

Blanchard, O. and P. Diamond [1994] "Ranking, unemployment duration and wages" *Review of Economic Studies* **61:** 417–34.

Bowlus, A. and S. Seitz [2000] "Search Frictions in the U.S. Labor Market: Equilibrium Estimates from the PSID" in D.T. Mortensen (ed.) *Panel Data and Structural Labour Market Models,* London: Emerald 145-69.

Burdett, K., and D. T. Mortensen [1998] "Wage Differentials, Employer Size, and Unemployment" *International Economic Review* **39(2):** 257-73.

Coate, S. and G. Loury [1993] "Will Affirmative-Action Policies Eliminate Negative Stereotypes?" *American Economic Review,* **83:** 1220-40.

Goldin C. and C, Rouse [2000] "The Impact of "Blind" Auditions on Female Musicians" *American Economic Review,* **90:** 715-41.

Grieco, E. and R. Cassidy [2001] "Overview of Race and Hispanic Origin" *Census 2000 Brief,* US Census Bureau.

Hagedorn, M. and I. Manovskii [2008] "The Cyclical Behavior of Equilibrium Unemployment and Vacancies Revisited," *American Economic Review*, **98(4):** 1692-1706.

Holzer, H. and R. LaLonde [2000] "Job change and job stability among less skilled young workers", in Card, D. and R. Blank eds. *Finding jobs: Work and Welfare Reform* New York: Russell Sage.

Hornstein, A., P. Krusell and G. Violante [2011] "Frictional Wage Dispersion in Search Models: A Quantitative Assessment" *American Economic Review* **101:** 2873-98.

Hosios, A. [1990] "On the Efficiency of Matching and Related Models of Search and Unemployment," *Review of Economic Studies,* **57:** 279-98.

Krusell, P., T. Mukoyama, R. Rogerson and A. Sahin [2011] "A three state model of worker flows in general equilibrium" *Journal of Economic Theory*, **146:** 1107–33.

Lang. K., M. Manove and W. Dickens, [2005] "Racial Discrimination in Labor Markets with Posted Wage Offers" *American Economic Review,* **95:** 1327-40**.**

Mailath, G., Samuelson, Larry and A. Shaked [2000] "Endogenous Inequality in Integrated Labor Markets with Two-Sided Search", *American Economic Review*, **90:** 46-72.

Masters, A. [2009] "Matching with Interviews" *Journal of Economic Dynamics and Control,* **33:** 938-54.

Millard S. and D. Mortensen, [1997] "The unemployment and welfare effects of labour market policy", D. Snower and G. de la Dehesa, Eds. *Unemployment Policy: Government Options for the Labour Market*, Cambridge: Cambridge Univ. Press: 545–72.

Mortensen, D. and C. Pissarides [1994]. "Job Creation and Job Destruction in the Theory of Unemployment," *Review of Economic Studies*, **61(3):** 397-415.

Petrongolo, B. and C. Pissarides [2001] "Looking into the Black Box: A Survey of the Matching Function," *Journal of Economic Literature*, **39:** 390–431.

Sattinger, M.[1998] "Statistical Discrimination with Employment Criteria," *International Economic Review* **39:** 205–37.