Why do Black Workers Search Less?

A Transport-Mode Based Theory

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Abstract

We develop a search matching model in which blacks and whites are totally identical, except for the fact that they use different transport modes. We find that whites, who use faster transport modes (i.e. cars) than blacks (who use public transport), do search more intensively and extensively, and experience lower unemployment rate. Indeed, when deciding their optimal search intensities, all workers trade off short-run losses with long-run gains. However, because they use a faster transport mode, white job-seekers anticipate that they can reach jobs located further away so they can increase their maximal distance of search. This, in turn, induces firms to create more jobs, which finally motivate white workers to search more because of better opportunities. We also show that whites obtain higher wages. Indeed, in our model, each worker negotiates his/her wage with the firm using the Nash-bargaining rule. Because white workers have better outside options than blacks since their labor market tightness as well as the maximal distance of search are higher, they obtain a higher wage.

**Key words:** Job search, spatial labor markets, multiple job centers, ethnic minorities.

**JEL Classification:** D83, J15, J64, R1.

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1 Introduction

Why do ethnic minorities experience higher unemployment rates than whites? Different answers have been given to this crucial question but the recent debate, especially in the United States, has been focussing on the role of segregation in explaining these unemployment rate differences. The spatial mismatch hypothesis, first formulated by Kain (1968), states that, residing in urban segregated areas distant from and poorly connected to major centers of employment growth, black workers face strong geographic barriers to finding and keeping well-paid jobs. In the U.S. context, where jobs have been decentralized and blacks have stayed in the central part of cities, the main conclusion of the spatial mismatch hypothesis is to put forward the distance to jobs as the main culprit for the high unemployment rates among blacks.

Since the study of Kain, dozens of empirical studies have been carried out trying to test this hypothesis (see e.g. the literature surveys by Ihlanfeldt and Sjoquist, 1998, Ihlanfeldt, 2006). The usual approach is to relate a measure of labor-market outcomes, based on either individual or aggregate data, to another measure of job access, typically some index that captures the distance from residences to centers of employment. The weight of the evidence suggests that bad job access indeed worsens labor-market outcomes, confirming the spatial mismatch hypothesis.

The theoretical foundations behind these empirical results remain however unclear (see the survey article by Gobillon et al., 2005). Using an efficiency wage model, Brueckner and Zenou (2003) argue that suburban housing discrimination skews black workers towards the center and thus keeps black residences remote from the suburbs, where most jobs for blacks are located. Using a search-matching approach, Wasmer and Zenou (2002, 2006), Smith and Zenou (2003) show that distance to jobs prevents black workers from obtaining job information, thus isolating them from employment centers, while Coulson et al. (2001), assuming higher fixed entry costs for CBD firms and different search costs for workers, demonstrate that central city residents experience a higher rate of unemployment than suburban residents and suburban firms create more jobs than central firms.

The aim of this paper is to provide an alternative theory that explains the differences in unemployment rates between black and white workers based on differences in transport modes. Indeed, distance to jobs can be measured either in terms of physical distance (i.e. number of miles) or time distance. The latter means that the choice of transportation is crucial. This is particularly true in the United States where public transportation is not so
good\textsuperscript{1} and blacks tend to mostly use public transport to commute to their workplace whereas whites use more their cars.

In standard search-matching theory, individuals choose reservation wages and search intensity by comparing the marginal benefits and costs of search and equating them at the margin (Pissarides, 2000). Search costs include forgone earnings, time and other resources devoted for search activities while benefits from search include a higher chance to leave unemployment. In the present model, because space is included into a search-matching model, a new decision emerges from jobs seekers. They also decide how large an area to search (the extensive margin) and, holding the area constant, how much effort their put in searching (the intensive margin) since travel imposes costs. Contrary to the other spatial search-matching models mentioned above,\textsuperscript{2} we consider multiple employment centers and different transport modes, which allow us to explicitly address the issue of the extensive margin and the consequences in terms of labor-market outcomes of blacks and whites.

To be more precise, we develop a search matching model in which blacks and whites are totally identical, except for the fact that they use different transport modes. First, we find that whites, who use faster transport modes (i.e. cars) than blacks (who use public transport), do search more intensively and extensively, and experience lower unemployment rate. Indeed, when deciding their optimal search intensities, all workers trade-off short run losses with long run gains. However, because they use a faster transport mode, white job-seekers anticipate that they can reach jobs located further away so they can increase their maximal distance of search. This, in turn, induces firms to create more jobs, which finally motivate white workers to search more because of better opportunities. Second, we also show that whites will obtain higher wages. Indeed, in our model each worker negotiates his/her wage with the firm using the Nash-bargaining rule. Because white workers have better outside option than blacks since their labor market tightness as well as the maximal distance of search are higher, they obtain a higher wage.

The general idea behind these results is that black workers who mainly use public transportation may refuse jobs involving too long commutes. They may prefer to search for job opportunities in the vicinity of their neighborhood. Zax and Kain (1996) have illustrated

\textsuperscript{1}In U.S. Metropolitan Statistical Areas, the lack of good public transportation is a real problem. For instance, the New York Times of May 26, 1998, was telling the story of Dorothy Johnson, a Detroit inner-city black female resident who had to commute to an evening job as a cleaning lady in a suburban office. By using public transportation, it took her two hours whereas, if she could afford a car, the commute would have taken only 25 minutes.

\textsuperscript{2}See also Sato (2001, 2004), who does not focus on spatial mismatch but provides interesting urban search models with an endogenous job acceptance rule.
this issue by studying a ‘natural experiment’ (the case of a large firm in the service industry that relocated from the center of Detroit to the suburb Dearborn in 1974). Among workers whose commuting time was increased, black workers were over-represented, and not all could follow the firm. This had two consequences. First, segregation forced some blacks to quit their jobs. Second, the share of black workers applying for jobs to the firm drastically decreased (53% to 25% in 5 years before and after the relocation), and the share of black workers in hires also fell from 39% to 27%.

There is an important empirical literature on the different search behaviors between black and white workers and how access to cars impacts on these behaviors. Using the National Longitudinal Survey Youth Cohort (NLSY) for 1981 and 1982, Holzer et al. (1994) test the idea that different access to transit modes by blacks and whites contributes to racial differences in employment. They show that (i) blacks and inner-city residents not only have longer travel times to work, but they actually cover somewhat less distance while searching and working; (ii) the effects of travel distances while searching and working on employee wages are positive, as are the effects of automobile ownership. Studying the geographical search patterns of less-educated workers in Los Angeles and Atlanta from the Multi-city Study of Urban Inequality, Stoll (2005) show that racial residential segregation as well as blacks’ lower car access rates account for most of blacks’ relative greater skill mismatch.

These studies suggest that access to cars can have adverse labor market consequences for ethnic minorities. Using simulations, Stoll (1999) show that increasing blacks’ and Latinos’ access to cars or decreasing their average distance to search areas will lead to greater geographic job search. As in our model, this in turn will lead to higher employment and wages for these groups. Using data from the UK, Patacchini and Zenou (2005) find similar results. They find that, for a given time distance to jobs (measured by the average commuting time of the employed in a given area), unemployed white workers search more intensively than unemployed black workers. They also show that giving to black workers the mean level of white (time) distance to jobs and white car access would close the racial gap in search intensity by 50.31 percent. The main policy implication of our model is in accordance with this finding since improving the car access to blacks will have important effect on their labor-market outcomes by increasing the extensive and intensive margins of searching.

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3 See also Fernandez (1994) for a similar ‘natural experiment’.
4 For a recent survey, see Fernandez and Su (2004).
5 Raphael and Stoll (2001) also found that raising minority car-ownership rates to the white car ownership rate would considerably narrow inter-racial employment rate differentials. See also Raphael and Rice (2002) who found positive effects of car access on employment.
2 The general model

2.1 Model and notations

There is a continuum of workers and firms. The mass of workers is taken to be 1 and the mass of firms is $M > 1$. Following Salop (1979), we model heterogeneity by means of a circle along which both workers’ and firms’ locations are uniformly distributed on the circumference $C$ of a circle of length 1 (see, among others, Marimon and Zilibotti, 1999; Hamilton et al., 2000; Brueckner et al., 2002). This is the geographical space and we denote by $0 \leq x_{ij} \leq 1/2$ the geographical distance between a worker located in $i$ and a firm located in $j$.\(^6\) It is assumed that workers are unable to change their residential location. One way to justify this assumption is that homes are less mobile than jobs (Manning, 2003).

In the present model, as in Marimon and Zilibotti (1999), workers do not direct their search. Instead they search all the market and then, when they have a contact with a firm, decide to accept or not a job offer according to the rule described below (they will refuse jobs involving too long commute). An alternative would have been to have directed search as in Decreuse (2005). In the latter, workers do not search all the market but only the area of interest. This means that workers will never apply for firms that are located too far away from their residence because they know they will never take the job. Our interpretation is different. We assume that workers sample all the market without paying attention to the location of the firm (because for example it is not given in the adds) but, when they are contacted by a firm, decide to only accept jobs that are within the area of search chosen. We keep this modeling for simplicity since directed search complicates the analysis without changing any of our main results.

At each moment of time, a worker can be either employed in a certain firm (or more exactly within a certain geographical distance from a firm) or unemployed. All unemployed workers search for a job and we assume that there is no on-the-job search. Similarly, at each moment of time, a firm can have either a filled position or an open vacancy (and in this case search for a worker). We denote by $u(i)$ the number of unemployed (or equivalently the unemployment rate) at location $i$ and by $V(j)$ the number of vacancies at location $j$.

As in Marimon and Zilibotti (1999), we restrict attention to initial distribution such that the same proportion of workers are unemployed at all locations $i$, i.e. $u(i) = u$, $\forall i \in C$. It is easy to show (see Lemma 1 of Marimon and Zilibotti, 1999) that, in this case, a stationary equilibrium must have a uniform distribution of vacancies at all locations, i.e. $V(j) = V$, for

\(^6\)Because it is a circle of length 1 where distance is measured on both sides, the maximum distance between a firm and a worker is $1/2$. 

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all $j \in C$.

Time is continuous and workers live forever. A vacancy can be filled according to a random Poisson process. Similarly, unemployed workers can find a job according to a random Poisson process. In aggregate, these processes imply that there is a number of contacts (or matches) per unit of time between the two sides of the market that are determined by the following standard matching function:

$$M \equiv M(\bar{\pi} u, V)$$

(1)

Each unemployed worker has a search intensity equal to $s$, which is defined as how much effort he/she provides in the search process. Accordingly, $\bar{\pi}$ represents the average intensity of search of all the unemployed workers in the economy. This means that two aspects of the job search are taken into account in this model: intensive and extensive search. Indeed, workers decide $s$ the intensity of search, i.e. the number of hours per day devoted to search, but also $\tilde{x}$ the maximum area of search (extensive search).

As usual (Pissarides, 2000), $M(.)$ is assumed to be increasing in both its arguments, concave and exhibits constant returns to scale. The probability of filling a vacancy per unit of time for a firm is given by:

$$\frac{M(\bar{\pi} u, V)}{V} = M\left(\frac{1}{\theta}, 1\right) \equiv q(\theta)$$

where $\theta = V/(\bar{\pi} u)$ is a measure of labor market tightness in search intensity units. Similarly, the probability of obtaining a job per unit of time for an unemployed worker with search intensity $s$ is given by:

$$\frac{s M(\bar{\pi} u, V)}{\bar{\pi} u} = s M(1, \theta) \equiv s \theta q(\theta)$$

By using the properties of the matching function, it is easy to see that

$$q'(\theta) < 0 \text{ and } \frac{\partial [\theta q(\theta)]}{\partial \theta} > 0$$

(2)

since more vacancies increase the probability to find a job and decrease the probability to fill a vacancy. We also make the standard Inada-type assumptions on $M(.)$, which ensure that $\lim_{\theta \to +\infty} q(\theta) = \lim_{\theta \to -0} \theta q(\theta) = 0$, $\lim_{\theta \to +0} q(\theta) = \lim_{\theta \to +\infty} \theta q(\theta) = +\infty$.

Let us now focus of individual decisions. For simplicity, we assume that the housing consumption is fixed and normalized to 1 for all workers (employed and unemployed). The land rent $R$ paid by workers (employed and unemployed) has to be the same at each location since the number of unemployed and employed workers at each location is also the same.
Furthermore, contrary to the standard result in urban economics where only one employment center prevails (see e.g. Fujita, 1989), here land rent does not depend on distance to jobs because jobs are distributed around the circle and, over their lifetime, workers change jobs but not their residential location so that distance to jobs change stochastically over time. As a result, at the steady state, the average time and physical distance to jobs are the same for all workers, and thus the land rent $R$ does not depend on distance to jobs and has the same value at each location. We assume that land rents are own by absentee landlords.

We are now able to write the instantaneous utility function of both unemployed and employed workers. Assuming risk neutrality for all workers, the unemployed obtain the following instantaneous utility function:

$$b - R - f - C(s)$$

where $b$ denotes the unemployment benefit, $R$, the land rent at each location, $f$ the fixed cost of transportation and $C(s)$ is the total cost of searching for jobs. The latter encompasses the costs of buying newspapers, commuting contacting friends, phone calls, interviews, .... We assume that $C(0) = 0$, $C'(s) > 0$ and $C''(s) > 0$. For an employed working at a geographical distance $x$, his/her instantaneous utility function is given by:

$$w(x) - R - T(x)$$

where $0 \leq x \leq 1/2$ denotes the distance between a residential location and a firm, $w(x)$ is the wage paid to workers at a distance $x$ from the firm (this wage will be determined below) and $T(x)$ is the total cost of commuting as a function of the geographical distance to jobs. This cost is given by:

$$T(x) = f + \tau w(x) t(x)$$

where $\tau$ is a positive coefficient, $t(x)$ the time it takes to commute to jobs when residing at a distance $x$ and thus $\tau w(x) t(x)$ represents the total time cost for a person residing at a

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7 As this will become clear below, the wage setting will be such that $w$ is a function of $x$.

8 This is the common way of modelling transport cost in the transport mode choice literature; see for example LeRoy and Sonstelie (1983) and Sasaki (1990). For simplicity and without loss of generality, we have omitted in (3) the variable part of the commuting cost (i.e. the pecuniary commuting cost). Observe however that, in a more general model, the link between commuting costs and the wage paid is achieved through a labor-leisure choice, which implies that a unit of commuting time is valued at the wage rate (see, for example, Fujita, 1989, Chapter 2). However, such a model is cumbersome to analyze, and it is likely not to yield additional insights beyond those available from our simpler approach, which is consistent with the empirical literature that shows that the time cost of commuting increases with the wage (see, e.g. Small, 1992, and Glaeser et al., 2000).
distance $x$ from his/her job. As usual in this type of model, the wage here represents the opportunity cost of time. We have

$$t(x) = \frac{x}{\mu}$$

(4)

where $\mu$ denotes the (average) speed of a trip to jobs. If one for example uses a car to go to work, then he/she has a higher fixed cost $f$ but it takes less time to go to work (higher speed $\mu$). As a result, one can measure distance to jobs in terms of physical distance $x$ (i.e. number of miles) or time distance $t(x)$ (i.e. hours). In other words, two workers using different transport modes, will not reach the same physical distance during the same time.

Denote by $\delta$ the job destruction rate, by ‘0’ the unemployed state, and by ‘1’ the employed state. Then, in steady-state, $W_0$ and $W_1(x)$ denote respectively the expected discounted lifetime utility of an unemployed worker and an employed worker living at a distance $x$ from his/her job. They are given by the following Bellman equations:

$$rW_1(x) = w(x) \left(1 - \frac{\tau x}{\mu}\right) - R - f - \delta \left[W_1(x) - W_0(s)\right]$$

(5)

$$rW_0(s) = b - R - f - C(s) + s \theta q(\theta) \left[2 \int_0^{\bar{x}} [W_1(x) - W_0(s)] \, dx\right]$$

(6)

where $r \in (0, 1)$ is the discount rate and $\bar{x}$ is the maximum geographical distance for which the unemployed accept to take a job (beyond $\bar{x}$ all jobs will be turned down by the unemployed).

Let us comment these equations. Equation (5) has a standard interpretation. When a worker is employed today, he/she works at a distance $x$ and he/she obtains an instantaneous (indirect) utility equals to $w(x) \left(1 - \tau x/\mu\right) - R - f$. Then, this worker can lose his/her job with probability $\delta$ and, in this case, experiences a reduction in intertemporal utility equal to $W_1(x) - W_0(s)$. Let us now comment equation (6). First observe that $W_0(s)$ does not depend on $x$ because firms cannot sort workers by locations. When a worker is unemployed today, he/she provides a search effort of $s$ and his/her instantaneous utility is $b - f - R - C(s)$. Then, he/she may obtain a job and $s \theta q(\theta)$ represents the rate at which an unemployed worker has a contact with a randomly drawn firm. The match will then be acceptable only if the firm with which the worker has an interview turns out to be on a point along the arc of length $2\bar{x}$ centered on the worker’s location, otherwise it will be rejected. Observe that the term in bracket is multiplied by 2 because each worker considers the distance to jobs from both sides of his/her location. When this unemployed worker accepts a job offer at a distance $x$ from his/her residential location, he/she obtains an increase in intertemporal utility.

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\[9\] For the model to make sense, we assume throughout that $1 > \tau/(2\mu)$ since this guarantees that $1 > \tau x/\mu$, $\forall x \in [0, 1/2]$. 

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utility equals to $W_1(x) - W_0(s)$. Observe finally that the last term in (6) is not divided by $\hat{x}$ since the unemployed worker searches in the whole circle (whose length and thus density are 1) and not only in the arc of length $2\hat{x}$ centered on his/her location (whose density is $1/\hat{x}$). To make this last point clear, one can in fact write equation (6) as follows:

$$rw_0(s) = b - R - f - C(s) + s \theta q(\theta) \left[ \int_0^1 \max \{W_1(x) - W_0(s)\} dx \right]$$

which shows that the worker searches everywhere in the circle and accepts only jobs that give him/her a higher expected utility than his/her current one.

We can also write the Bellman equations for the firm. The expected discounted lifetime utility of a firm with a filled job and a firm with a vacancy, respectively denoted by $F_J(x)$ and $F_V$, are given by:

$$rF_J(x) = y - w(x) - \delta [F_J(x) - F_V]$$

$$rF_V = -\gamma + q(\theta) \left[ 2 \int_0^{\hat{x}} [F_J(x) - F_V] dx \right]$$

where $y$ is the productivity of a worker and $\gamma$ denotes the firm’s search cost per unit of time. The interpretation of (7) is similar to that of (5). Let us interpret (8). As it is written in (7), workers’ productivity $y$ does not depend on their distance to jobs $x$. As a result, all employed workers are identical from the firms’ viewpoint. However, when a firm has a vacant job and pays $\gamma$ to search for workers, it has a probability $q(\theta)$ to have a contact with a worker anywhere in the circle, but knows that workers with geographical distance greater than $\hat{x}$ from them will always turn down a job offer. As a result, even though firms are indifferent to hire workers with different distance to jobs (since they all produce $y$), their area of research is limited to $\hat{x}$ because they anticipate that beyond this distance workers will refuse to take a job. Equation (8) is the equivalent to (6) but for a firm with a vacant job.

### 2.2 Free-entry condition and labor demand

Firms enter in the market up to the point where they make zero (expected) profits, i.e. $F_V = 0$. Using (7) and (8), we have:

$$F_J(x) = \frac{y - w(x)}{r + \delta}$$

$$2q(\theta) \int_0^{\hat{x}} F_J(x) dx = \gamma$$
This equation means that the (expected) value of a job is equal to the expected search cost, i.e. the cost per unit of time multiplied by the average duration of search for the firm.

Combining these equations yields

\[
\int_0^{\bar{x}} (y - w(x))dx = \frac{\gamma (r + \delta)}{2q(\theta)}
\]

(11)

For a given wage \(w\), we can already examine here the relationship between \(\bar{x}\) and \(\theta\). By differentiating (11), we have

\[
\frac{\partial \theta}{\partial \bar{x}} = -\frac{y - w(\bar{x})}{\gamma (r + \delta)q(\theta)}^2 [q(\theta)]^2 > 0
\]

This is quite intuitive. When the area of search increases so that workers are ready to accept jobs located further away, firms create more jobs (or equivalently more firms enter in the labor market) because they have more chance to fill up a vacancy (workers are less “picky” and \(F_V\) increases).

2.3 Wage determination

Let us now determine the wage setting. At each period, the total intertemporal surplus is shared through a generalized Nash-bargaining process between the firm and the worker. The total surplus is the sum of the surplus of the workers, \(W_1(x) - W_0\), and the surplus of the firms \(F_J(x) - F_V\). Since \(F_V = 0\), at each period, the wage is determined by:

\[
(1 - \beta) [W_1(x) - W_0(s)] = \beta F_J(x)
\]

(12)

where \(0 \leq \beta \leq 1\) denotes the bargaining power of workers. In Appendix 1, we show that (12) is equivalent to:

\[
w(x) = \frac{\beta(y + s \gamma \theta) + (1 - \beta) [b - C(s)]}{1 - (1 - \beta)r x / \mu}
\]

(13)

which gives the bargain wage that each employed worker obtains depending on their distance to jobs. Observe that, for a given \(s\), not surprisingly, the wage increases with labor market tightness \(\theta\) since more vacancies or less unemployment increases the outside option of the workers. Observe also that, for a given \(\theta\), an increase in workers’ search effort \(s\) does not always lead to higher wages. There are in fact two opposite forces at work. Indeed, when \(s\) increases, workers have more chance to find a job when unemployed and thus their outside option rises. However, their cost of search \(C(s)\) also increases and this decreases their bargaining power. As a result, the net effect is ambiguous. Let us now comment the
properties of this wage for a given $\theta$ and a given $s$ (since these are endogenous variables that will depend in equilibrium on all the parameters). First, when the unemployment benefit $b$, the workers’ productivity $y$, or the workers’ bargaining power $\beta$ increases, firms increase the negotiated wage because the outside option of workers is higher. Second, let us see the impact of distance $x$ and transport mode $\mu$ on wages. When $x$, the distance to jobs increases, workers spend more time in commuting and thus their opportunity cost of time rises. As a result, firms have to increase wages to compensate workers for the increase in this cost. On the contrary, when $\mu$ increases (workers use faster transport modes), wages are reduced because the compensation is less due to lower opportunity cost of time.

The fact that wages increase with distance to jobs (or equivalently with commuting time) is a well-established empirical fact. For example, Manning (2003) using British data (the Labour force Survey for 1993-2001 and the British Household Panel Survey for 1991-2000) shows that an extra hour of commuting each day is associated, on average, with an increase in wages of 27 log points. This is even more true for highly educated workers since those with more education and in the higher-status occupations are more likely to have both high wages and a long commute. These results are consistent with the ones found in the US. For instance, Madden (1985) uses the PSID to investigate how wages vary with distance to the CBD. She finds that, for all workers who changed job, there is a positive relationship between wage change and change in commute.

One may argue that one needs to control for the type of jobs. Zax (1991), who uses data from a single company and regresses wages on commutes, also finds a positive relationship. For more evidence, see Small (1992) and White (1999).

Interestingly, from a theoretical perspective, few models have found this positive relationship between wages and distance to jobs. One exception is Zenou (2006), who, using an urban efficiency wage model, found a similar relationship. In his model, firms pay higher efficiency wages to remote workers to compensate them for their longer commute. Other models have found a positive relationship between wages and pecuniary commuting costs (see e.g. Wasmer and Zenou, 2002, who derive like here a bargain wage in search-matching framework).

### 2.4 Search intensity

We are now able to study the unemployed worker’s decision of $s$ (search intensity). Observe first that, when making this decision, the unemployed takes as given the unemployment rate $u$ in the economy, the vacancy rate $v$ in the economy, the average search intensity $\bar{s}$ (and thus $\theta = v/\bar{s} u$ the labor market tightness), the land rent where he/she lives $R$ and the expected
discounted lifetime utilities $W_0(s)$ and $W_1(x)$.

The expected discounted lifetime utility of an unemployed worker is defined by (6). Differentiating (6) with respect to $s$ gives the following first order condition:\footnote{The solution of this problem is unique since the second order condition is always satisfied because $-C''(s) < 0$.}

$$-C'(s) + \theta q(\theta) \left[ 2 \int_0^{\bar{x}} [W_1(x) - W_0(s)] dx \right] = 0$$

(14)

This is the behavioral equation for search intensity $s$. The intuition of (14) is straightforward. For a given $\theta$, when choosing $s$, the unemployed faces a fundamental trade-off between short-run and long-run benefits. On the one hand, increasing search effort $s$ is costly in the short run (more phone calls, more interviews, etc.) since it decreases instantaneous utility, but, on the other, it increases the long-run prospects of employment since workers have a higher chance to obtain a job.

Now, using (32) in Appendix 1, (14) can be written as:

$$-C'(s) + \gamma \theta \frac{\beta^2}{1 - \beta} = 0$$

(15)

Observe that (15) is not a behavioral equation for search intensity but a relation between intensity and labor-market tightness that holds in equilibrium. Let us have an explicit solution for $s$. From (15), we have:

$$s(\theta) = C'^{-1} \left[ \gamma \theta \frac{\beta}{1 - \beta} \right]$$

(16)

with

$$s'(\theta) = \frac{\gamma \theta \beta / (1 - \beta)}{C''(s)} > 0$$

(17)

This is quite natural since higher job opportunities (i.e. more vacancies or less job seekers) induce workers to search more.

Since all individuals are all identical, all unemployed workers choose the same search intensity $s$ given by (16). As a result, $\bar{s}$ the average search intensity is given by $\bar{s} = s$.

2.5 Maximum distance to jobs

We can finally determine the value of $\bar{x}$, beyond which workers refuse to take jobs. It is given by

$$W_1(\bar{x}) - W_0(s) = 0$$
or, equivalently, because of (12), by

\[ F_J(\hat{x}) = 0 \]

Using (9), this is equal to

\[ \frac{y - w(\hat{x})}{r + \delta} = 0 \]

which, by using (13) can be written as:

\[ y = \frac{\beta (y + s\gamma\theta) + (1 - \beta) [b - C(s)]}{1 - (1 - \beta) \tau \hat{x}/\mu} \]

This is equivalent to

\[ \hat{x}(s, \theta) = \frac{y - b + C(s) - s\gamma\theta\beta/(1 - \beta)}{y \tau/\mu} \]

which is assumed to be strictly positive.

One of the most interesting result here is the relationship between \( \hat{x} \) and \( \mu \) (for a given \( s \) and a given \( \theta \)). It is easy to see that workers with faster transport mode (higher \( \mu \)) are ready to accept jobs that are geographically further away than those who use slower transportation mode. The intuition is as follows. When \( \mu \) increases, the time cost of travelling becomes lower, which increases the instantaneous utility. As a result, workers can extend their area of search and thus \( \hat{x} \) increases.

Now, if, for a given \( \theta \), we differentiate (18) with respect to \( s \), we obtain:

\[ \frac{\partial \hat{x}(s, \theta)}{\partial s} = \frac{C'(s) - \gamma \theta \beta/(1 - \beta)}{y \tau/\mu} \]

Indeed, when \( s \) increases, there are two effects on \( \hat{x} \). On the one hand, it increases the present cost of searching so that workers are induced to extend their area of search but, on the other, it increases their chance to obtain a job so workers become more “picky” and thus reduce \( \hat{x} \). The overall effect is thus ambiguous. However, if we evaluate this derivative at the optimal \( s \), which is given by (15), then we see that one effect thwarts the other so that the net effect is nil.

Now, for a given \( s \), we can differentiate (18) with respect to \( \theta \), and we obtain:

\[ \frac{\partial \hat{x}(s, \theta)}{\partial \theta} = \frac{-s \gamma \beta/(1 - \beta)}{y \tau/\mu} < 0 \]

Indeed, for a given \( s \), when \( \theta \) increases, there are more opportunities in the labor market for workers since there are more vacancies and less unemployed. As a result, unemployed workers become more choosy and only accept jobs within a lower distance from their residence.
2.6 The steady-state equilibrium

Since each job is destroyed according to a Poisson process with arrival rate $\delta$, the number of workers who enters unemployment is $\delta(1 - u)$ and the number who leaves unemployment is $2\bar{x}s\theta q(\theta)$, i.e. the probability that an unemployed worker finds an acceptable match $2\bar{x}s\theta q(\theta)$ times the mass of unemployed $u$. In steady state, the rate of unemployment is constant and therefore these two flows are equal (flows out of unemployment equal flows into unemployment). We thus have:

$$u = \frac{\delta}{\delta + 2\bar{x}s\theta q(\theta)} \tag{21}$$

We can now write the set of equilibrium relations, except for the wage equation (13), since we substitute wages from (13) into the condition for the supply of jobs (11). The latter is now given by:

$$\int_0^{\bar{x}} \frac{y(1 - \beta) [1 - \tau x / \mu] - \beta s \theta - (1 - \beta) [b - C(s)]}{1 - (1 - \beta) \tau x / \mu} \, dx = \frac{\gamma(r + \delta)}{2q(\theta)} \tag{22}$$

We would like to focus on equilibria for which workers do not always accept job offers, i.e. $0 < \bar{x}(s, \theta) < 1/2$. Using (18), it is easy to verify that this is equivalent to

$$1 < \frac{y}{b - C(s) + \gamma s \theta \beta/(1 - \beta)} \leq \frac{1}{1 - \tau/(2\mu)} \tag{23}$$

Given this condition, Theorem 1 in Appendix 2 shows that there is a unique steady-state equilibrium $(u^*, \theta^*, s^*, \bar{x}^*, w^*)$.

We can now calculate, in equilibrium, the average search intensity $s^*$, the average distance to work $\bar{x}^*$ and the average commuting time $\bar{t}^*$. There are respectively given by (for the average time, we use (4)):

$$s^* = s^* \tag{24}$$

$$\bar{x}^* = \frac{1}{\bar{x}^*} \int_0^{\bar{x}^*} x \, dx = \frac{\bar{x}^*}{2} \tag{25}$$

$$\bar{t}^* = \frac{\bar{t}^*}{\mu} = \frac{\bar{x}^*}{2\mu} \tag{26}$$

Let us study the comparative statics of the equilibrium variables $(\theta^*, s^*, w^*, \bar{x}^*, \bar{t}^*)$. We assume

$$\eta_{\theta y} = \frac{\partial \theta^*}{\partial y} \frac{y}{\theta^*} < 1$$

\footnote{Do not forget that we have assumed that $1 > \tau/(2\mu)$.}
\[ \eta_{\theta \gamma} \equiv -\frac{\partial \theta^*}{\partial \gamma} \frac{\gamma}{\theta^*} < 1 \]

**Proposition 1** Assume (23). Then,

(i) When the productivity \( y \) increases, \( \theta^*, s^*, w^*, \tilde{x}^*, \tilde{x}^* \) and \( \bar{T} \) increase.

(ii) When the unemployment benefit \( b \) increases, \( \theta^* \) and \( s^* \) decrease but the effect on wages and search area are ambiguous. We have indeed:

\[
\frac{\partial w^*}{\partial b} \geq 0 \iff \beta \gamma s^* \frac{\partial \theta^*}{\partial b} + (1 - \beta) \geq 0 \\
\frac{\partial \tilde{x}^*}{\partial b} \geq 0 \iff -\gamma \frac{\beta}{1 - \beta} s^* \frac{\partial \theta^*}{\partial b} \geq 1
\]

(iii) When the destruction rate \( \delta \) increases, \( w^* \) and \( \tilde{x}^* \) (as well as \( \tilde{x}^* \) and \( \bar{T}^* \)) increase but \( \theta^* \), \( w^* \) and \( s^* \) decrease.

**Proof.** See Appendix 3.

The first result (i) is very intuitive. Indeed, when the match between a firm and a worker becomes more productive, firms create more jobs, wages are higher, unemployed workers search more intensively because the rewards of obtaining a job are greater, and workers are ready to accept jobs located further away. As a result, on average, workers spend more time in commuting to their jobs. An increase in unemployment benefits (result (ii)) has a negative impact on job creation and search intensity but an ambiguous effect on wages and the maximal area of search. Indeed, an increase in \( b \) gives a better outside option for workers when negotiating their wage so that wages increase. However, because it becomes more costly to create a job, firms enter less in the labor market, which, in turn, decrease the outside option for workers. These two opposite effects explain the ambiguous impact of \( b \) on \( \tilde{x}^* \). Finally, result (iii) shows that an increase in the job destruction rate reduces job creation, wages and the search intensity, but increases workers’ maximal area of search (workers are less picky since their chance to lose their jobs is higher) and, quite naturally, the equilibrium unemployment rate.

### 3 Black versus white workers

We would like now to use the previous analysis to explain unemployment rate, wage as well as search intensity differentials between black and whites.
3.1 Labor-market outcomes between blacks and whites

We assume that, even though blacks and whites are both low-skill workers and thus have the same level of human capital, they do not compete for the same jobs, and thus their labor markets are separated (or segmented). Indeed, recent evidence suggests that blacks are much likely to be employed at some types of firms that at others (Holzer and Reaser, 2000). For instance, federal contractors are more likely to employ blacks than are non-contractors (Leonard, 1990); larger firms are more likely to employ blacks than small firms (Holzer, 1998); and firms having more black customers are more likely to employ blacks than others (Holzer and Ihlanfeldt, 1998). Also, the employment of blacks in manufacturing has declined dramatically in the recent years and recent evidence suggests that most low-educated blacks work in services, like e.g. business and consumer services (Bound and Holzer, 1993). Another way to justify the fact that blacks and whites do not compete for the same jobs is that unskilled jobs are usually performed in teams. Thus, employers prefer to have teams composed of either blacks or whites but not mixed. Finally, it has also been argued that blacks and whites do not specialize in the same type of jobs because of cultural differences (Wilson, 1996).

Blacks and white workers are assumed to be totally identical except for the fact that they do not use the same transport mode. We assume that whites mainly use private modes of transportation (cars) whereas blacks mainly use public transportation. Indeed, using data drawn from the 1995 Nationwide Personal Transportation Survey, Raphael and Stoll (2001) show that, in the US, 5.4 percent of white households have zero automobile while 24 and 12 percent of respectively black and Latino households do not hold a single car. Even more striking, they show that respectively 64 and 46 percent of black and Latino households have one or zero car whereas this number was 36 percent for white households. In Great-Britain, using the 1991 Census data, Owen and Green (2000) show that people from minority ethnic groups are more than twice as likely as white people to depend on public transport for commuting journeys (33.2 versus 13.7 percent), with nearly three-fifths of Black-African workers use public transport to go to work. Furthermore, 73.6 percent of whites use private vehicle while this number is only 56.4 percent for ethnic minorities (and 39.6 percent for Black-African workers). Using the Labour Force Survey for England, Patacchini and Zenou (2005) find similar results. They show that the percentage of whites and blacks using coach,

---

12 In section 4, we endogeneize the transport mode choice of workers.
13 These differences indicate that black and Latino households are disproportionately represented among households with no automobiles. Indeed, while black and Latino households were respectively 11.5 and 7.8 percent of all households in 1995, they accounted for 35 and 12 percent households with no vehicles.
bus or British rail train to travel to work is 15% and 40.2% respectively and the percentage of whites and blacks using car or scooters is 79.1% and 57.7% respectively. On the other hand, the percentage of white and black active job seekers owning or using a motor vehicle is 75.8% and 55.4% respectively.

In our model, this implies that the total cost of commuting to jobs for whites and blacks are respectively given by:

\[
T_W(x) = f_W + \tau w \frac{x}{\mu_W} \\
T_B(x) = f_B + \tau w \frac{x}{\mu_B}
\]

where the subscripts \(W\) and \(B\) refer respectively to whites and blacks. We assume: \(f_W > f_B\), \(\mu_W > \mu_B\), and \(\tau wx/\mu_W > \tau wx/\mu_B\), i.e. cars used by whites have higher fixed costs, lower variable costs and are faster.

We would like to study the impact of different transport modes on white and black unemployment rates, wages and search intensities. For that, we consider the same environment as before and study two economies (or labor markets) that differ only on the fact that transport modes are not the same.

We have the following result.

**Proposition 2** Assume that white use cars and blacks public transportation to commute to work. Then,

(i) Whites search more intensively and obtain a higher wage than blacks, i.e. \(s^*_W > s^*_B\) and \(w^*_W > w^*_B\).

(ii) Assume

\[
\bar{\lambda}^* > \frac{\beta \gamma s^* \mu}{y(1 - \beta)\tau} \frac{\partial \theta}{\partial \mu}
\]

then white unemployed have a larger area of search than blacks, i.e. \(\bar{\lambda}^*_W > \bar{\lambda}^*_B\), and have a shorter mean time commute, i.e. \(\bar{t}^*_W < \bar{t}^*_B\). Moreover, whites will also experience lower unemployment rates, i.e. \(u^*_W < u^*_B\), and lower unemployment duration than blacks, i.e. \(D^*_W < D^*_B\), and firms will create more jobs for whites, i.e. \(V^*_W > V^*_B\).

**Proof.** See Appendix 3.

The following comments are in order. First, whites who use faster transport modes (higher \(\mu\)) than blacks do search more intensively. Indeed, when whites decide \(s\), they trade-off short run losses with long run gains. However, because they use a faster transport mode, white unemployed workers anticipate that, for a given \(s\) and \(\theta\), they can reach jobs
located further away so they increase $\hat{x}$. This, in turn induces, firms to create more jobs and thus it increases $\theta$, which finally induces white workers to search more because of better opportunities (see (15)). Since all white workers behave the same way, their average search intensity is higher than that of blacks. Second, the effect on the labor market tightness is now straightforward. Indeed, because of a faster transport mode, for a given $s$ and $\theta$, whites have a higher $\hat{x}$, which in turn induces firms to create more jobs so that $\theta$ increases. Third, whites’ wages are higher because white workers have better outside option than blacks (because of higher $\theta$ and higher $\hat{x}$).

Finally, the general equilibrium effects of $\mu$ on $\hat{x}^*$ are interesting. Indeed, inspection of (18) shows that, for a given $s$ and a given $\theta$, a faster transport mode increases $\hat{x}$ (this is what we have used in the first three comments above of this proposition). This is because faster transport mode implies lower opportunity cost of time and thus workers are willing to accept jobs located further way. However, in equilibrium, one has to take into account not only this effect but also the indirect effect of $\mu$ on search intensity (since when $\mu$ increases, the effect on $s$ is ambiguous; see (19)) and on labor market tightness (since when $\mu$ increases, firms anticipate that workers will accept jobs located further away and thus create more jobs, which in turn induce workers to be more choosy and thus to reduce $\hat{x}$; see (20)). It turns out that, when $\mu$ increases, only the effect of commuting time and labor market tightness matter (indeed the search intensity effect cancels out because when $\mu$ increases, workers search more but it also costs more) and condition (27) expresses this result. It says that if the commuting time effect (the left hand side of (27)) dominates the labor market tightness effect (the right hand side of (27)), then a rise in $\mu$ increases $\hat{x}^*$. As a result, white unemployed workers will have a smaller area of research than blacks if (27) holds. Because of (26), the average time of commute will be shorter for whites since they use a faster transport mode and have a smaller area of employment if (27) holds.

Now, if (27) holds, then $\hat{x}_W > \hat{x}_B$ and thus because whites search more intensively and firms create more jobs, they will experience lower unemployment rates (see (21)) and lower unemployment duration (remember that, in a Poisson process, unemployment duration is equal to the inverse of the job acquisition rate) than blacks.

Few empirical studies have tried to test these two last results. For the UK, McCormick (1986) has shown that, because of labor discrimination, ethnic minorities (Asian and West Indian workers) are ready to accept jobs at locations that would be unacceptable to whites in order either to avoid a spell of unemployment or an inferior occupation. This is what we obtain if (27) does not hold. Of course, if discrimination was introduced in our model, then the McCormick’s result will be even more true. Moreover, most studies have shown that the
mean daily commute is lower for whites than for blacks (see e.g. Patachini and Zenou, 2005, for the UK, Chung et al. 2001, and Gottlieb and Lentnek, 2001, for the US.). This is what we obtained here because whites use faster transport mode and, if (27) holds, because they are on average closer to jobs than blacks.

Using the National Longitudinal Survey Youth Cohort (NLSY) for 1981 and 1982, Holzer et al. (1994) provide results that are very close to that of Proposition 2. Here is what they found:

Table 1. Search and labor market outcomes for blacks and whites in the US\textsuperscript{14}

<table>
<thead>
<tr>
<th></th>
<th>White males</th>
<th>Black males</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miles traveled to work</td>
<td>8.017</td>
<td>6.977</td>
</tr>
<tr>
<td></td>
<td>(11.352)</td>
<td>(9.879)</td>
</tr>
<tr>
<td>Miles traveled searching $\hat{x}^*$</td>
<td>19.923</td>
<td>18.558</td>
</tr>
<tr>
<td></td>
<td>(25.328)</td>
<td>(22.718)</td>
</tr>
<tr>
<td>Time spent travelling to work $\hat{t}^*$</td>
<td>15.841</td>
<td>18.603</td>
</tr>
<tr>
<td></td>
<td>(15.058)</td>
<td>(17.482)</td>
</tr>
<tr>
<td>Time spent per mile traveled</td>
<td>3.351</td>
<td>4.899</td>
</tr>
<tr>
<td></td>
<td>(3.851)</td>
<td>(5.963)</td>
</tr>
<tr>
<td>Log (wage), 1981 $w^*$</td>
<td>6.080</td>
<td>5.997</td>
</tr>
<tr>
<td></td>
<td>(0.393)</td>
<td>(0.370)</td>
</tr>
<tr>
<td>Log (wage), 1982 $w^*$</td>
<td>6.246</td>
<td>6.112</td>
</tr>
<tr>
<td></td>
<td>(0.447)</td>
<td>(0.421)</td>
</tr>
<tr>
<td>Employment, 1981 $1-u^*$</td>
<td>0.594</td>
<td>0.456</td>
</tr>
<tr>
<td></td>
<td>(0.447)</td>
<td>(0.421)</td>
</tr>
<tr>
<td>Employment, 1982 $1-u^*$</td>
<td>0.618</td>
<td>0.452</td>
</tr>
<tr>
<td>Log (duration of unemployment) $D^*$</td>
<td>1.591</td>
<td>1.838</td>
</tr>
<tr>
<td></td>
<td>(0.841)</td>
<td>(0.913)</td>
</tr>
</tbody>
</table>

These data are conformed to what we have obtained in Proposition 2. First, this table shows lower employment and wages for blacks, as well as durations of unemployment that are over 25-30 percent higher for blacks than for whites. Second, blacks spend significantly more time travelling to work than whites, even though the distance traveled are lower for blacks. This is certainly due to different transport modes (in their study, 68.5 percent of white males own a car while this number is 43.8 percent for blacks; also 4.1 percent of white

\textsuperscript{14}Values given in this table are means while those given in parentheses are standard deviations.
male use mass transit while this number is 18.9 percent for blacks). The time spent per
mile traveled is thus considerably higher for blacks – about 46 percent higher. All these
results are quite standard and obtained by most studies. The last outcome concerning the
miles traveled searching is less clear since different studies find different results. Here, black
job seekers have a lower area of search than whites. In Proposition 2, because of general
equilibrium effects, this was not always true and depended on the condition (27). In fact,
Stoll (1999), using data from the 1994 Los Angeles Survey of Urban Inequality, find that
blacks extensively spatial job search to a greater degree than whites as measured by the
number of areas searched. So there is no real consensus on this issue.

3.2 Spatial mismatch

We would like now to make comparisons within race. In particular, there has been an im-
portant debate about how access to jobs could be very harmful to unemployed workers,
especially to blacks. This is the spatial mismatch hypothesis that we discussed in the intro-
duction. The crucial element in this literature is the accuracy of the measure of job access.
Since, obviously, the unemployed do not work, this measure is quite difficult. One direct
measure of job access has been: “the mean commuting time of employed workers who live
nearby”. This has been used by, among others, Ihlanfeldt and Sjoquist (1990), Ihlanfeldt
(1992), Kasarda and Ting (1996), Patacchini and Zenou (2005). The intuition is as follows.
If an unemployed worker lives in an area where the employed have long commutes, it implies
that his/her connections to jobs are not good (for example the worker has low informa-
tion about jobs) and thus this worker has a bad access to jobs. Therefore, he/she should
experience higher unemployment rate. Let us see how this works in our model.

To measure the unemployed’s access to jobs, we use the employed’s average commuting
time in an area. Consider two areas, each of them being characterized by the economy we
have just described; in particular, workers and firms are located on the circumference of a
circle. The question we would like to answer is the following. If the transport mode is the
same in the two areas (i.e. same \(f\) and same \(\mu\)) and if we observe that, in area 1, the employed
workers have a higher average commuting time than in area 2, i.e. \(t^*_1 > t^*_2\), what could we
say in terms of differences in average search intensities, unemployment rates and wages? In
other words, within each race (i.e. same transport mode), do we have a spatial mismatch in
the sense that a bad access to jobs (as measured by the employed’s average commuting time
in the area) is harmful to the unemployed workers? The following proposition gives a clear
answer to this question.
Proposition 3 If the employed’s average commuting time in an area is a proxy for the unemployed’s job access, then, within each race, a worse job access leads to higher (average) search intensity, lower unemployment and higher wages.

Proof. See Appendix 3.

The intuition of this result is as follows. If we compare two areas where, in both, the employed workers use the same transportation mode (because there are of the same race) but, in area 1, we observe that their commute time is on average higher, then it must be that, in area 1, workers are accepting jobs that are located further away (i.e. $\bar{x}_1^* > \bar{x}_2^*$) and are thus less picky. This in turn implies that firms will create more jobs because they are more likely to fill up their vacancies (i.e. $\theta_1^* > \theta_2^*$) and therefore, unemployed workers will search more because they have more chance to obtain a job. This implies that the unemployment rate is lower and that wages are higher because workers have better outside option. As a result, areas with higher average commuting time (of the employed) should be characterized by higher average search intensity (of the unemployed), lower unemployment rate and higher wages.

This result is interesting in that it contradicts the empirical results of the spatial mismatch literature. Of course, our result is valid if and only if one controls for both race and transport mode. Therefore, either the employed’s average commuting time is a bad measure of job access for the unemployed or the studies did not control for transport mode or the cities analyzed where mostly monocentric.

We can go further in the analysis of the spatial mismatch. We have the following result:

Proposition 4 Assume that white use cars and blacks public transportation to commute to work. If we compare two areas, one predominantly white and the other predominantly black but in both areas workers have the same access to jobs, i.e. live in areas where the employed have exactly the same average commuting time, then in the ‘white’ area, the unemployment rate is lower, wages are higher, and the unemployed search more intensively than in the ‘black’ area.

Proof. See Appendix 3.

This proposition is in some sense the dual of Proposition 3. Indeed, instead of fixing the transport $\mu$ and see the impact of different commuting time on search intensity, unemployment and wages, we here fix commuting time and evaluate the impact of different transport modes on labor market outcomes. If we are comparing white and black workers who both live in areas where the average commuting time of the employed is the same, i.e. whites and
blacks have the same job access, then because of $\mu_W > \mu_B$, it must be that whites are ready to accept jobs located further away than blacks, i.e. $\widehat{x}^*_W > \widehat{x}^*_B$. This, in turn, implies that firms will create more jobs in the white labor market than in the black one, which in turn leads white unemployed workers to search more intensively than black unemployed workers. In other words, faster transport modes broaden the spatial extent of search for whites. The impact on the unemployment rate has a similar flavor. Because $\widehat{x}^*_W > \widehat{x}^*_B$ firms create more jobs for whites, which increases whites' probability to find a job and thus reduces their unemployment rate. The same reasoning applies for wages.

So this proposition says that, if we control for job access, then because of different transport modes, whites search more intensively than blacks, experience lower unemployment rate and obtain higher wages.

4 Endogenous choice of transport mode

Our model can easily be extended to endogeneize the choice of transport mode. Following LeRoy and Sonstelie (1983) and Sasaki (1990), each worker decides which transport to choose between the bus (transport mode 1) and the car (transport mode 2). As in section 2, the transport cost of an unemployed worker is just given by the fixed cost $f^j$ ($j = 1, 2$) while for an employed worker, it is equal to $T^j_i(x) = f^j + \tau w_i x/\mu^j$, where $i = B, W$ and $j = 1, 2$ design the race and the transport mode, respectively. Because, for each racial group, cars have higher fixed cost, are faster, and entail smaller variable cost than buses, we have:

$$f^2 > f^1, \mu^2 > \mu^1 \text{ and } \tau w_i x/\mu^2 < \tau w_i x/\mu^1$$

(28)

In order to calculate the expected utility of each individual $i$, we assume perfect capital markets with a zero interest rate. With perfect capital markets, workers are able to smooth their disposable income over time so that at any moment in time, the disposable income of a type-$i$ worker is equal to his/her average income over the job cycle. Therefore, the expected utility of a worker of type $i = B, W$ choosing transport mode $j = 1, 2$ is given by:

$$EU^j_i = u_i \left[ b - C(s^*_i) \right] + (1 - u_i) \left[ w_i \left( 1 - \tau x/\mu^j \right) \right] - R - f^j$$

where $u_i$ and $1 - u_i$ are the equilibrium steady-state unemployment and employment rates of each worker $i$ (defined by (21)) and correspond to the respective fractions of time a worker

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15 When there is a zero interest rate, workers have no intrinsic preference for the present so that they only care about the fraction of time they spend employed and unemployed. Therefore, the expected utilities are not state dependent.
remains unemployed and employed over his/her infinite lifetime. The average wage \( \bar{\pi}_i \) of each worker \( i \) is given by:

\[
\bar{\pi}_i = \frac{1}{x_i} \int_0^{x_i} \pi^*_i(x)dx
\]

where \( \pi^*_i(x) \) is determined by (13). As a result, each worker belonging to racial group \( i = B, W \) chooses mode 1 (the bus) if and only EU\(_1\) \( > \) EU\(_2\), which is equivalent to:

\[
f_2 - f_1 > u_2^* [b - C(s^*_2)] - u_1^* [b - C(s^*_1)] + (1 - u_2^* \left[ \bar{\pi}^*_2 (1 - \tau x / \mu^2) \right] - (1 - u_1^* \left[ \bar{\pi}^*_1 (1 - \tau x / \mu^1) \right])
\]

and chooses mode 2 (the car) otherwise. It is easy to verify that the break-even point of the two modes is higher for individuals with higher expected income, who will thus be more likely to choose a car than a bus. This is not surprising because time costs are higher for higher income groups, who thus prefer faster transportation modes.

We now assume some difference between blacks and whites that will lead to different transport mode choices. In order to be consistent with the fact that the labor markets of black and white workers are segmented, we simply assume that the job destruction rate is higher for blacks than for whites, i.e. \( \delta_B > \delta_W \). Indeed, since the labor markets of blacks and whites are different, this just reflects the fact that blacks end up in more unstable jobs than whites. It is well-documented that blacks tend to occupy jobs in the secondary sector (which are typically unstable and not well-paid) and have difficulties to obtain jobs in the primary sector (which are more stable and better-paid) while it is much more easier for whites to get a job in the primary sector (see e.g. Wial, 1991). Using Proposition 1, result (iii), this implies that \( u_B^* > u_W^*, \bar{x}_B > \bar{x}_W, \theta_B^* < \theta_W^*, w_B^*(x) < w_W^*(x) \) at each \( x \), and \( s_B^* < s_W^* \).

The results are now straightforward to obtain. It is easy to find values of \( \delta_B \) and \( \delta_W \) such that whites (which have higher expected income than blacks) only choose cars (transport mode 2) while blacks only use buses (transport mode 1) to commute. The mechanism is as follows. All workers are forward looking and blacks know in particular that their jobs are relatively unstable (i.e. their job destruction rate is relatively high). So, when deciding their mode choice, black workers anticipate their future income and rationally decide to use buses for commuting, even though they understand impacts of this system choice on labor market outcomes. The same prevails for whites who decide to choose cars. Observe that, since \( r = 0 \), workers have no intrinsic preference for the present, and thus, at each moment in time, make the same choice in terms of transportation.

Interestingly, contrary to the model developed in sections 2 and 3, here both different types of jobs (i.e. different destruction rates) as well as different transport modes explain the differences in labor-market outcomes between blacks and whites. However, there are
amplifying effects. Indeed, the difference in job-destruction rates directly implies differences in labor-market outcomes between black and white workers, but because it also influences transport mode choices, these differences in the labor market are even larger and are thus amplified.

5 Why do whites use faster transport modes than blacks?

There are other mechanisms that can explain why whites use a faster transport mode than blacks. A natural explanation of why relatively few blacks in the United States have a car is the discrimination in the automobile insurance market. Indeed, it is well-documented that ethnic minorities, especially African Americans, are not treated the same way as whites in this market, and, in particular, tend to pay significantly higher premiums than whites with comparable driving records (see e.g. Wiegers, 1989; Squires et al., 1991; Harrington and Niehaus, 1998). Similarly, discrimination in the credit market, making loans in the minority community riskier and thus more expensive than for whites, can also explain the relative low fraction of car owners among black families. Since location and race are highly correlated, insurance and credit companies can engage in racial discrimination in the form of “redlining” that raises prices and restricts availability of coverage in areas with large minority populations (Squires et al., 1991; Harrington and Niehaus, 1998).

The usual explanation of discrimination in these two markets revolves around either lenders’ pure racial discrimination (Becker, 1957) believing that it is riskier to give loans to blacks than to whites or statistical discrimination (see e.g. Arrow, 1973 or Phelps, 1972). For the latter, the argument runs as follows. If it is costly to gather information on individual borrowers, and if borrowers’ race and economic fundamentals are correlated, lenders can rationally use neighborhood racial composition as a low-cost substitute for costly information-gathering (Lang and Nakamura, 1993). Another argument explains redlining as due to neighborhood externalities and information costs (Lang and Nakamura, 1993). The argument goes that in any community, the return on lending depends on the total volume of lending there. Given this, lenders concentrate their lendings where other lenders are making loans. This highlights a coordination problem among lenders. As in the statistical

---

16 The racial homogeneity of neighborhoods is a well documented phenomenon in US cities. In 1979, for example, the average black lived in a neighborhood that was 63.6% black, even though blacks formed only 14.9% of the population (Borjas, 1998). In the 1990 census, the figures were similar (Cutler et al., 1999).

17 To explain the argument, we use the credit market, but, of course, the same intuition prevails for the automobile insurance market.
discrimination case, this leads to the fact that loans in the minority community will be
riskier.\footnote{See the recent literature survey on discrimination in the credit and housing markets by Dymski (2006).}

Smith and Wright (1992) provide an alternative interesting explanation. They want to explain why automobile insurance premiums vary dramatically across localities or cities. Their argument is that high premiums can be attributed to large numbers of uninsured motorists in some localities, while uninsured motorists can be attributed to high premiums. A key assumption is limited liability, or a bankruptcy constraint, since it is the fact that low-income families cannot reimburse their victims (in case of an accident) that makes premiums go up. If we use the same argument and replace low-income families with black families, one can explain why some localities or areas with a large fraction of black families will have much higher insurance premiums than other areas with fewer blacks.

6 Conclusion

We develop a model in which whites mainly use cars to commute whereas blacks use public transportation. We show that, for both whites and blacks, living in areas where employed workers’ average commuting time is higher yield the unemployed to search more than in areas with lower commuting time. Because of different transport modes, we also show that white unemployed workers search more intensively than blacks even if both live in areas where employed workers have exactly the same average commuting time. We also find that whites earn higher wages, experience both lower unemployment rates and durations, and tend to search in larger area.

The results of our model have strong policy implications. They suggest that subsidizing car ownership for ethnic minorities could have a substantial impact on their search activities and thus on their unemployment rate. This is a standard policy that has been advocated in the US (see e.g. Pugh, 1998) and has strong empirical support. In particular, as shown by Raphael and Stoll (2001) for the US and Patacchini and Zenou (2005) for the UK, our model predicts that raising minority car-ownership rates to the white car ownership rate would considerably narrow inter-racial unemployment rate differentials. Also, if one believes that the low rate of car ownership among black families is driven by discrimination in the automobile insurance and credit markets, then the government can enforce anti-discrimination laws that prevent such behaviors.
References


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Appendix 1: Determination of the wage

Proof of (13)

By subtracting (6) to (5), we obtain:

\[
[W_1(x) - W_0(s)] = \frac{1}{r + \delta} \left[ w \left( 1 - \frac{\tau x}{\mu} \right) - (b - C(s)) - 2s \theta q(\theta) \int_0^{\bar{x}} [W_1(x) - W_0(s)] \, dx \right]
\]

(30)

Plugging this value in (12) and using (9) yields

\[
(1 - \beta) \left[ w \left( 1 - \frac{\tau x}{\mu} \right) - (b - C(s)) - 2s \theta q(\theta) \int_0^{\bar{x}} [W_1(x) - W_0(s)] \, dx \right] = \beta (y - w)
\]

(31)

Now, using (12) and (9), we have

\[
W_1(x) - W_0(s) = \frac{\beta}{1 - \beta} \frac{y - w}{r + \delta}
\]

which implies that

\[
\int_0^{\bar{x}} [W_1(x) - W_0(s)] \, dx = \frac{\beta}{1 - \beta} \frac{1}{r + \delta} \int_0^{\bar{x}} (y - w) \, dx
\]

which, by using (11), is equal to

\[
\int_0^{\bar{x}} [W_1(x) - W_0(s)] \, dx = \frac{\gamma}{2q(\theta)} \frac{\beta}{(1 - \beta)}
\]

(32)

Using (32), equation (31) can now be written as:

\[
(1 - \beta) \left[ w \left( 1 - \frac{\tau x}{\mu} \right) - f - (b - C(s)) \right] = \beta (y - w + s \gamma \theta)
\]

which, after some manipulations, leads to (13). □
Appendix 2: Existence and uniqueness of equilibrium

**Theorem 1** Assume (23). Then, there exists a unique equilibrium \((u^*, \theta^*, s^*, \tilde{x}^*, w^*)\), in which \(0 < u^* < 1, \theta^* > 0, s^* > 0, 0 < \tilde{x}^* < 1/2 \) and \(w^* > 0\).

The equilibrium equations are given by (21), (22), (16) and (18) for four unknowns \(u, \theta, s\) and \(\tilde{x}\) (the wage \(w\) has already been substituted in (22)). The model is recursive. There is one block formed by (22), (16) and (18) that gives the solutions for labor market tightness \(\theta\), search intensity \(s\) and maximum acceptance distance \(\tilde{x}\). With \(\theta, s\) and \(\tilde{x}\) known, we obtain the equilibrium unemployment using (21) and the equilibrium wage using (13).

The first equilibrium equations that we have to solve are thus (22), (16) and (18). Since the two latter equations give explicit values of \(s\) and \(\tilde{x}\), we can reduce these three equations into one. We have indeed:

\[
\int_0^{\tilde{x}(\theta)} \frac{y(1 - \beta) (1 - \tau x/\mu) - \beta s(\theta) \gamma \theta - (1 - \beta) [b - C(s(\theta))]}{1 - (1 - \beta) \tau x/\mu} dx = \frac{\gamma (r + \delta)}{2q(\theta)}
\]

where \(\tilde{x}(\theta)\) is defined by (18) and \(s(\theta)\) by (16). Denote by

\[
h(\theta, x) = \frac{y(1 - \beta) (1 - \tau x/\mu) - \beta s(\theta) \gamma \theta - (1 - \beta) [b - C(s(\theta))]}{1 - (1 - \beta) \tau x/\mu}
\]

and

\[
H(\theta) = \int_0^{\tilde{x}(\theta)} h(\theta, x) dx
\]

We have the following lemma.

**Lemma 1**

(i) The function \(g(\theta)\) is increasing and convex in \(\theta\) and \(\lim_{\theta \to 0} g(\theta) = 0\) and \(\lim_{\theta \to +\infty} g(\theta) = +\infty\).

(ii) The function \(H(\theta)\) is decreasing in \(\theta\) and \(\lim_{\theta \to 0} H(\theta) > 0\).
Proof.

(i) By observing that \( \lim_{\theta \to 0} q(\theta) = +\infty, \lim_{\theta \to +\infty} q(\theta) = 0 \) and \( q'(\theta) < 0 \), then the results are straightforward to obtain by differentiating \( g(\theta) \) with respect to \( \theta \).

(ii) First observe that

\[
\frac{\partial H(\theta)}{\partial \theta} = \int_0^{\tilde{x}(\theta)} \frac{\partial h(\theta, x)}{\partial \theta} \, dx + h(\theta, \tilde{x}(\theta)) \frac{\partial \tilde{x}(\theta)}{\partial \theta}
\]

We have

\[
\int_0^{\tilde{x}(\theta)} \frac{\partial h(\theta, x)}{\partial \theta} \, dx = \frac{(1 - \beta)C''(s)s'(\theta) - \beta \gamma [s(\theta) + s'(\theta) \theta]}{1 - (1 - \beta)\tau x/\mu}
\]

which, using (15), is equal to

\[
\int_0^{\tilde{x}(\theta)} \frac{\partial h(\theta, x)}{\partial \theta} \, dx = \frac{-\beta \gamma s(\theta)}{1 - (1 - \beta)\tau x/\mu} < 0
\]

Using again (15), it is easy to see that:

\[
\frac{\partial \tilde{x}(\theta)}{\partial \theta} = \frac{1}{1 - \beta} \frac{-\beta \gamma s(\theta)}{y \tau/\mu} < 0
\]

As a result, since \( h(\theta, \tilde{x}(\theta)) > 0 \), we have:

\[
\frac{\partial H(\theta)}{\partial \theta} < 0
\]

Finally, when \( \theta = 0 \), we have

\[
H(\theta = 0) = \int_0^{\tilde{x}(0)} \frac{y(1 - \beta)(1 - \tau x/\mu) - (1 - \beta)b}{1 - (1 - \beta)\tau x/\mu} \, dx > 0
\]

where

\[
\tilde{x}(0) = \frac{y - b}{y \tau/\mu}
\]

Using Lemma 1, it is clear that (33) has a unique solution given by \( \theta^* \). Plugging this value in (16) gives a unique \( s^* \). Then, plugging \( \theta^* \) and \( s^* \) in (18) yields a unique \( \tilde{x}^* \). Finally, using these values and (24) in (13) and (21) leads to a unique \( w^* \) and \( u^* \). \( \blacksquare \)
Appendix 3: Proofs of propositions

Proof of Proposition 1

The equilibrium is defined by (33), in which \( \bar{x}(\theta) \) is defined by (18) and \( s(\theta) \) by (16). Let us use the same notation as in Lemma 1, i.e.

\[
h(\theta, x) \equiv \frac{y(1 - \beta)(1 - \tau x / \mu) - \beta s(\theta) \gamma \theta - (1 - \beta) [b - C(s(\theta))]}{1 - (1 - \beta) \tau x / \mu}
\]

\[
H(\theta) \equiv \int_0^{\bar{x}(\theta)} h(x) dx
\]

\[
g(\theta) \equiv \frac{\gamma(r + \delta)}{2q(\theta)}
\]

so that the equilibrium condition writes

\[
\int_0^{\bar{x}(\theta)} h(\theta, x) \equiv H(\theta) = g(\theta)
\]

We have shown in Lemma 1 that \( H'(\theta) - g'(\theta) < 0 \).

(i) By totally differentiating (33), we obtain:

\[
\frac{\partial \theta^*}{\partial y} = \frac{\int_0^{\bar{x}(\theta)} (1 - \beta)(1 - \tau x / \mu) dx + h(\theta, \bar{x}) \frac{\partial \bar{x}}{\partial y}}{H'(\theta) - g'(\theta)}
\]

Let us calculate \( \frac{\partial \bar{x}}{\partial y} \). By differentiating (18), we have:

\[
\frac{\partial \bar{x}}{\partial y} = \frac{y - [y - b + C(s^*) - s^* \gamma \theta \beta/(1 - \beta)]}{y^2 \tau / \mu} = \frac{b - C(s^*) + s^* \gamma \theta \beta/(1 - \beta)}{y^2 \tau / \mu} = \frac{\beta}{y^2 \tau / \mu} > 0
\]

As a result,

\[
\frac{\partial \theta^*}{\partial y} > 0
\]

Similarly, by totally differentiating (33), we obtain:

\[
\frac{\partial \theta^*}{\partial \gamma} = \frac{\int_0^{\bar{x}(\theta)} -\beta \gamma (\frac{\partial \bar{x}}{\partial y} + s^*) + (1 - \beta) C(s^*) \frac{\partial s^*}{\partial y} dx - \frac{(r + \delta)}{2q(\theta)} + h(\theta, \bar{x}) \frac{\partial \bar{x}}{\partial \gamma}}{H'(\theta) - g'(\theta)}
\]
which by using (15) can be written as

\[
\frac{\partial \theta^*}{\partial \gamma} = \int_0^{\tilde{x}(\theta^*)} \frac{-\beta s^*}{1-(1-\beta)\tau y/\mu}dx - \frac{(r+\delta)}{2g(\theta^*)} + h(\theta, \tilde{x}) \frac{\partial \tilde{x}}{\partial \gamma}
\]

Let us calculate \( \frac{\partial \xi}{\partial \gamma} \). By differentiating (18) and using (15), we have:

\[
\frac{\partial \tilde{x}}{\partial \gamma} = -\frac{s^* \theta \beta}{y \tau / \mu} < 0
\]

which implies that:

\[
\frac{\partial \theta^*}{\partial \gamma} < 0
\]

Finally, by totally differentiating (33), we obtain:

\[
\frac{\partial \theta^*}{\partial b} = -\frac{\int_0^{\tilde{x}(\theta^*)} \theta (1-\beta) dx + h(\theta, \tilde{x}) \frac{\partial \tilde{x}}{\partial b}}{H'(\theta) - g'(\theta)}
\]

Let us calculate \( \frac{\partial \tilde{x}}{\partial b} \). By differentiating (18), we have:

\[
\frac{\partial \tilde{x}}{\partial b} = \frac{-1}{y \tau / \mu} < 0
\]

which implies that:

\[
\frac{\partial \theta^*}{\partial b} < 0
\]

We also have:

\[
\frac{\partial \theta^*}{\partial \delta} = \frac{\gamma r}{H'(\theta) - g'(\theta)} < 0
\]

\( (ii) \) By totally differentiating (15), we obtain:

\[
\frac{\partial s^*}{\partial y} = -\frac{\beta \gamma}{(1-\beta) \frac{\partial \theta^*}{\partial \gamma}} \frac{\gamma r}{C''(s)} > 0
\]

\[
\frac{\partial s^*}{\partial \gamma} = -\frac{\beta}{(1-\beta)} \left( \frac{\gamma r \theta^*}{C''(s)} + \theta^* \right)
\]

which implies that

\[
\frac{\partial \theta^* \gamma}{\partial \theta^*} \geq 0 \iff \frac{\partial \theta^* \gamma}{\partial \gamma} \leq 1
\]

Two effects: When \( \gamma \) increases, there is a direct effect since the surplus \( W_1 - W_0 \) of being employed increases but, there is an indirect effect, since firms create less jobs \( \frac{\partial \theta^*}{\partial \gamma} < 0 \) and thus there is less chance to find a job.
As a result
\[
\frac{\partial s^*}{\partial \gamma} \geq 0 \iff \eta_{\theta \gamma} \equiv -\frac{\partial \theta^*}{\partial \gamma} \frac{\gamma}{\theta^*} \leq 1
\]

Finally, by totally differentiating (15), we have:
\[
\frac{\partial s^*}{\partial b} = -\frac{\gamma}{(1 - \beta)} \frac{\partial s^*}{\partial \psi} < 0
\]

We also have:
\[
-C'(s) + \gamma \theta \frac{\beta}{1 - \beta} = 0
\]
\[
\frac{\partial s^*}{\partial \delta} = -\frac{\gamma}{(1 - \beta)} \frac{\partial s^*}{\partial \psi} < 0
\]

(iii) By totally differentiating (18), we obtain:
\[
\frac{\partial s^*}{\partial y} = \frac{[1 + C'(s^*) \frac{\partial s^*}{\partial y} - \gamma \beta/(1 - \beta) \left( \frac{\partial \theta^*}{\partial y} + s^* \frac{\partial \theta^*}{\partial y} \right)] y - [y - b + C(s) - s \gamma \theta \beta/(1 - \beta)]}{y^2 \tau/\mu}
\]

which by using (15) can be written as
\[
\frac{\partial s^*}{\partial y} = \frac{b - C(s) + s^* \gamma \beta/(1 - \beta) \left( \theta^* - \frac{\partial \theta^*}{\partial y} y \right)}{y^2 \tau/\mu}
\]

Thus, a sufficient condition for
\[
\frac{\partial s^*}{\partial y} > 0
\]

is thus
\[
\eta_{\theta y} \equiv \frac{\partial \theta^*}{\partial y} \frac{y}{\theta^*} < 1
\]

By totally differentiating (18), we have:
\[
\frac{\partial s^*}{\partial \gamma} = \frac{C'(s^*) \frac{\partial s^*}{\partial \psi} - \beta/(1 - \beta) \left[ \left( \frac{\partial \theta^*}{\partial \psi} + s^* \frac{\partial \theta^*}{\partial \psi} \right) \gamma + s^* \theta^* \right]}{y \tau/\mu}
\]

which by using (15) reduces to
\[
\frac{\partial s^*}{\partial \gamma} = \frac{-\beta/(1 - \beta) s^* \left[ \frac{\partial \theta^*}{\partial \gamma} \gamma + \theta^* \right]}{y \tau/\mu}
\]

As a result,
\[
\frac{\partial s^*}{\partial \gamma} \leq 0 \iff \eta_{\theta \gamma} \equiv -\frac{\partial \theta^*}{\partial \gamma} \frac{\gamma}{\theta^*} \leq 1
\]
Finally, by totally differentiating (18) and using (15), we obtain:

\[
\frac{\partial \tilde{x}^*}{\partial b} = -\frac{1 - \gamma \beta}{1 - \beta} \frac{s^* \partial \theta^*}{\tau / \mu}
\]

which implies

\[
\frac{\partial \tilde{x}^*}{\partial b} \geq 0 \iff -\gamma \frac{\beta}{1 - \beta} s^* \frac{\partial \theta^*}{\partial b} \geq 1
\]

Using (15), we also have:

\[
\frac{\partial \tilde{x}^*}{\partial \delta} = -\frac{\gamma \beta}{1 - \beta} \frac{s^* \partial \theta^*}{\tau / \mu} > 0
\]

(iv) By totally differentiating (13) and using (15), we have:

\[
\frac{\partial w^*}{\partial y} = \frac{\beta + \beta s^* \frac{\partial \theta^*}{\partial y}}{1 - (1 - \beta) \tau x / \mu} > 0
\]

\[
\frac{\partial w^*}{\partial \gamma} = \frac{\beta s^* \left[ \frac{\partial \theta^*}{\partial y} \gamma + \theta^* \right]}{1 - (1 - \beta) \tau x / \mu}
\]

which implies

\[
\frac{\partial w^*}{\partial \gamma} \geq 0 \iff \eta_{\theta, \gamma} = -\frac{\partial \theta^*}{\partial \gamma} \gamma \leq 1
\]

\[
\frac{\partial w^*}{\partial \theta} = \frac{\beta \gamma s^* \frac{\partial \theta^*}{\partial y} + (1 - \beta)}{1 - (1 - \beta) \tau x / \mu}
\]

which implies

\[
\frac{\partial w^*}{\partial b} \geq 0 \iff \beta \gamma s^* \frac{\partial \theta^*}{\partial y} + (1 - \beta) \geq 0
\]

Two effects: When \( b \) increases, there is a direct effect that increases wages (higher outside option), but because wages increase, firms create less jobs (lower \( \theta^* \)) and thus the chance to get a job is lower, which in turn reduces wages. The net effect is thus ambiguous.

\[
\frac{\partial w^*}{\partial \delta} = \frac{\beta \gamma s^* \frac{\partial \theta^*}{\partial y}}{1 - (1 - \beta) \tau x / \mu} < 0
\]

\[
\frac{\partial w^*}{\partial x} = \frac{\beta (y + s \gamma \theta) + (1 - \beta) [b - C(s)]}{[1 - (1 - \beta) \tau x / \mu]^{2}} (1 - \beta) \tau / \mu > 0
\]

(vii) By totally differentiating (21), we have:

\[
\frac{\partial u^*}{\partial y} = -\frac{\hat{x}^* \left[ \frac{\partial \theta^*}{\partial y} q(\theta) + s^* \frac{\partial \theta^*}{\partial y} \frac{\partial \theta^*}{\partial y} \right] + s^* \theta^* q(\theta)^* \frac{\partial \hat{x}^*}{\partial y}}{[\delta + 2 \hat{x}^* s^* \theta^* q(\theta)]^2} < 0
\]
\[ \frac{\partial u^*}{\partial \gamma} = -2\delta \frac{\tilde{x}^* \left[ \frac{\partial s^*}{\partial \gamma} q(\theta) + s^* \frac{\partial q(\theta)}{\partial \gamma} \right] + s^* \theta^* q(\theta^*) \frac{\partial \theta^*}{\partial \gamma}}{[\delta + 2\tilde{x}s^* q(\theta)]^2} \]

The net sign is ambiguous.

\[ \frac{\partial u^*}{\partial b} = -2\delta \frac{\tilde{x}^* \left[ \frac{\partial s^*}{\partial b} q(\theta) + s^* \frac{\partial q(\theta)}{\partial b} \right] + s^* \theta^* q(\theta^*) \frac{\partial \theta^*}{\partial b}}{[\delta + 2\tilde{x}s^* q(\theta)]^2} \]

However, if

\[ -\gamma \frac{\beta}{1 - \beta} s^* \frac{\partial \theta^*}{\partial b} < 1 \]

then

\[ \frac{\partial \tilde{x}^*}{\partial b} < 0 \]

and thus

\[ \frac{\partial u^*}{\partial b} > 0 \]

Finally

\[ \frac{\partial u^*}{\partial \delta} = 2\delta \frac{s^* \theta^* q(\theta^*) \left[ \tilde{x} - \delta \frac{\partial \tilde{x}^*}{\partial \delta} \right] - \delta \tilde{x}^* \left[ \frac{\partial s^*}{\partial \delta} q(\theta) + s^* \frac{\partial q(\theta)}{\partial \delta} \right]}{[\delta + 2\tilde{x}s^* q(\theta)]^2} \]

A sufficient condition is

\[ \eta_{\tilde{x} \delta} \equiv \frac{\delta}{\tilde{x}} \frac{\partial \tilde{x}^*}{\partial \delta} < 1 \]

for

\[ \frac{\partial u^*}{\partial \delta} > 1 \]

\( (vi) \) Using (25) and (26), it is easy to see that \( \mathbf{d} \) and \( \mathbf{d}^* \) vary exactly as \( \tilde{x}^* \).

**Proof of Proposition 2**

- First, let us show that

\[ \frac{\partial s^*}{\partial \mu} > 0 \]

By totally differentiating (15), we easily obtain:

\[ \frac{\partial s^*}{\partial \mu} = \frac{\gamma \beta}{(1 - \beta)} \frac{\partial \theta^*}{\partial \mu} > 0 \]  \[ (34) \]

To obtain this result, we need to show that

\[ \frac{\partial \theta^*}{\partial \mu} > 0 \]
The equilibrium variable $\theta^*$ is defined by (33) in which $\tilde{x}(\theta)$ and $s(\theta)$ are respectively defined by (18) and (16). If we use the notations above (i.e. in the proof of Theorem 1), then equation (33) is given by: $H(\theta) - g(\theta) = 0$. By totally differentiating this equation, we obtain:

$$\frac{\partial \theta^*}{\partial \mu} = -\frac{\partial H(\theta)/\partial \mu}{\partial H(\theta)/\partial \theta - \partial g(\theta)/\partial \theta}$$

In Lemma 1, we have shown that $\partial H(\theta)/\partial \theta - \partial g(\theta)/\partial \theta < 0$. Let us show that $\partial H(\theta)/\partial \mu > 0$. We have

$$H(\theta) \equiv \int_{0}^{\tilde{x}(\theta)} \frac{y(1 - \beta)}{1 - (1 - \beta)\tau x/\mu} \left(1 - \beta s(\theta) \gamma \theta - (1 - \beta) \left[ b - C(s(\theta)) \right] \right) dx$$

$$\frac{\partial H(\theta)}{\partial \mu} = \int_{0}^{\tilde{x}(\theta)} \frac{\partial h(\theta, x)}{\partial \mu} dx + h(\theta, \tilde{x}(\theta)) \frac{\partial \tilde{x}(\theta)}{\partial \mu}$$

Now, it is easy to verify that

$$\int_{0}^{\tilde{x}(\theta)} \frac{\partial h(\theta, x)}{\partial \mu} dx$$

$$= \int_{0}^{\tilde{x}(\theta)} \frac{(1 - \beta)\tau x \left[ \beta y + s(\theta) \gamma \theta \right] + (1 - \beta) \left[ b - C(s(\theta)) \right]}{\mu^2 \left[ 1 - (1 - \beta)\tau x/\mu \right]^2} > 0$$

Furthermore, let us show that $\partial \tilde{x}(\theta)/\partial \mu > 0$. By differentiating (18), we obtain:

$$\frac{\partial \tilde{x}^*}{\partial \mu} = \frac{y - b + C(s) - s \gamma \theta \beta/(1 - \beta)}{y \tau} > 0$$

As a result, $h(\theta, \tilde{x}(\theta)) \partial \tilde{x}(\theta)/\partial \mu > 0$, and thus

$$\frac{\partial \theta^*}{\partial \mu} = -\frac{\partial H(\theta)/\partial \mu}{\partial H(\theta)/\partial \theta - \partial g(\theta)/\partial \theta} > 0 \quad (35)$$

Since $s^* = s^*$, this implies that

$$\frac{\partial s^*}{\partial \mu} > 0 \quad (36)$$

- Second, let us show that

$$\frac{\partial w^*}{\partial \mu} > 0$$

Let us differentiate (13). Using (15), we have

$$\frac{\partial w^*}{\partial \mu} = \beta \gamma \frac{\partial \theta^*}{\partial \mu} s^* \left[ 1 - (1 - \beta)\tau x/\mu \right]$$

$$\frac{1}{\left[ 1 - (1 - \beta)\tau x/\mu \right]^2} + \frac{\beta (y + s \gamma \theta) + (1 - \beta) \left[ b - C(s) \right]}{\beta \tau x/\mu^2} \beta \tau x/\mu^2$$

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which is clearly positive.

- Third, let us show that if (27) holds, then

\[ \frac{\partial x^*}{\partial \mu} > 0 \]

By totally differentiating (18) and using (15), we obtain:

\[ \frac{\partial x^*}{\partial \mu} = \frac{y(1 - \beta)\tau x^*/\mu^2 - \beta \gamma s^* \partial \theta}{y(1 - \beta)\tau/\mu} \]

which implies that

\[ \frac{\partial x^*}{\partial \mu} \geq 0 \iff x^* \geq \frac{\beta \gamma s^* \partial \theta}{y(1 - \beta)\tau} \]

- Fourth, let us show that both

\[ \frac{\partial u^*}{\partial \mu} < 0 \] and \[ \frac{\partial V^*}{\partial \mu} > 0 \]

For that we have to use (21). By differentiating (21), we obtain:

\[ \frac{\partial u^*}{\partial \mu} = -2\frac{\tau^* + \partial \theta q(\theta^*)}{\theta^* s^*} \left[ \frac{\partial s^* \partial \theta q(\theta^*)}{\partial \theta^*} + \frac{s^* \partial q(\theta^*)}{\partial \theta^*} \right] \]

Observe that, by using (2), (36) and (35), is strictly positive. Now using (27), \( \frac{\partial x^*}{\partial \mu} > 0 \) and as a result \( \frac{\partial u^*}{\partial \mu} < 0 \).

For V, we use the fact that

\[ \theta^* = \frac{V^*}{s^*u^*} \]

which implies that

\[ V^* = \theta^* s^* u^* \]

Differentiating this expression gives

\[ \frac{\partial V^*}{\partial \mu} = \left[ \frac{\partial s^*}{\partial \mu} \theta^* u^* + s^* \frac{\partial \theta^*}{\partial \mu} u^* - \frac{\theta^* s^* \delta}{\theta^* s^* q(\theta^*)} \left[ \frac{\partial s^*}{\partial \mu} \theta^* q(\theta^*) + s^* \frac{\partial q(\theta^*)}{\partial \theta^*} \right] \right] \frac{\partial u^*}{\partial \mu} \]

\[ = \frac{\partial s^*}{\partial \mu} \theta^* u^* + s^* \frac{\partial \theta^*}{\partial \mu} u^* - \frac{\theta^* s^* \delta}{\theta^* s^* q(\theta^*)} \left[ \frac{\partial s^*}{\partial \mu} \theta^* q(\theta^*) + s^* \frac{\partial q(\theta^*)}{\partial \theta^*} \right] \frac{\partial u^*}{\partial \mu} \]

\[ = \frac{\partial s^*}{\partial \mu} \theta^* u^* + s^* \frac{\partial \theta^*}{\partial \mu} u^* - \frac{\theta^* s^* \delta}{\theta^* s^* q(\theta^*)} \left[ \frac{\partial s^*}{\partial \mu} \theta^* q(\theta^*) + s^* \frac{\partial q(\theta^*)}{\partial \theta^*} \right] \frac{\partial u^*}{\partial \mu} \]

\[ = \frac{\partial s^*}{\partial \mu} \theta^* u^* + s^* \frac{\partial \theta^*}{\partial \mu} u^* - \frac{\theta^* s^* \delta}{\theta^* s^* q(\theta^*)} \left[ \frac{\partial s^*}{\partial \mu} \theta^* q(\theta^*) + s^* \frac{\partial q(\theta^*)}{\partial \theta^*} \right] \frac{\partial u^*}{\partial \mu} \]

\[ = \frac{\partial s^*}{\partial \mu} \theta^* u^* + s^* \frac{\partial \theta^*}{\partial \mu} u^* - \frac{\theta^* s^* \delta}{\theta^* s^* q(\theta^*)} \left[ \frac{\partial s^*}{\partial \mu} \theta^* q(\theta^*) + s^* \frac{\partial q(\theta^*)}{\partial \theta^*} \right] \frac{\partial u^*}{\partial \mu} \]

\[ = \frac{\partial s^*}{\partial \mu} \theta^* u^* + s^* \frac{\partial \theta^*}{\partial \mu} u^* - \frac{\theta^* s^* \delta}{\theta^* s^* q(\theta^*)} \left[ \frac{\partial s^*}{\partial \mu} \theta^* q(\theta^*) + s^* \frac{\partial q(\theta^*)}{\partial \theta^*} \right] \frac{\partial u^*}{\partial \mu} \]

\[ = \frac{\partial s^*}{\partial \mu} \theta^* u^* + s^* \frac{\partial \theta^*}{\partial \mu} u^* - \frac{\theta^* s^* \delta}{\theta^* s^* q(\theta^*)} \left[ \frac{\partial s^*}{\partial \mu} \theta^* q(\theta^*) + s^* \frac{\partial q(\theta^*)}{\partial \theta^*} \right] \frac{\partial u^*}{\partial \mu} \]

\[ = \frac{\partial s^*}{\partial \mu} \theta^* u^* + s^* \frac{\partial \theta^*}{\partial \mu} u^* - \frac{\theta^* s^* \delta}{\theta^* s^* q(\theta^*)} \left[ \frac{\partial s^*}{\partial \mu} \theta^* q(\theta^*) + s^* \frac{\partial q(\theta^*)}{\partial \theta^*} \right] \frac{\partial u^*}{\partial \mu} \]

\[ = \frac{\partial s^*}{\partial \mu} \theta^* u^* + s^* \frac{\partial \theta^*}{\partial \mu} u^* - \frac{\theta^* s^* \delta}{\theta^* s^* q(\theta^*)} \left[ \frac{\partial s^*}{\partial \mu} \theta^* q(\theta^*) + s^* \frac{\partial q(\theta^*)}{\partial \theta^*} \right] \frac{\partial u^*}{\partial \mu} \]
where $\rho > 0$ is defined as:
\[
\rho = \frac{\partial (\theta^* q(\theta^*))}{\partial \theta^*} \frac{\theta^*}{\theta^* q(\theta^*)}
\]
By using the properties of the matching function, it is easy to verify that $\rho < 1$ (see e.g. Pissarides, 2000). As a result this expression is strictly positive and thus $\partial V^* / \partial \mu > 0$.

We have thus shown that if (27) holds, then
\[
\frac{\partial u^*}{\partial \mu} < 0 \quad \text{and} \quad \frac{\partial V^*}{\partial \mu} > 0
\]
(37)
This implies that, if (27) holds, the unemployment duration of whites is lower than that of blacks, i.e.
\[
\frac{1}{2} b_x W \theta W q(\theta W) > \frac{1}{2} b_x B \theta B q(\theta B)
\]

\section*{Proof of Proposition 3}

Let us first show the impact on average search intensity $\bar{s}^*$. Take two areas with the same $\mu$. Assume that, in area 1, the employed have a higher commuting time than in area 2, i.e. $\bar{t}_1 > \bar{t}_2$. Then, using (26), it is easy to see that it implies that $\bar{x}_1^* > \bar{x}_2^*$ and $\bar{s}_1^* > \bar{s}_2^*$ (since $\mu$ is fixed). This in turn implies that firms will create more jobs (or equivalently will enter more in the labor market), i.e. $\theta_1^* > \theta_2^*$ since they are more likely to fill a vacancy because the maximum distance to accept a job is higher in area 1. To see this point, we have to differentiate (22). Let us use the same notation as in Lemma 1, where this entry equation is written as:
\[
\int_0^{\bar{x}(\theta)} h(x) dx - g(\theta) = 0
\]
where $H(\theta) \equiv \int_0^{\bar{x}(\theta)} h(x) dx$. Then, by differentiating (22), we obtain:
\[
\frac{\partial \theta}{\partial \bar{x}} = -\frac{H(\bar{x})}{\partial H(\theta)/\partial \theta - \partial g(\theta)/\partial \theta}
\]
In Lemma 1, we have shown that $\frac{\partial H(\theta)/\partial \theta}{\partial \theta} - \frac{\partial g(\theta)/\partial \theta} < 0$, and, since $H(\bar{x}) > 0$, then $\partial \theta / \partial \bar{x} > 0$.

Furthermore, $\theta_1^* > \theta_2^*$ implies that $s_1^* > s_2^*$ (see (17)) since better opportunities increase search intensity, which in turn leads to higher average search intensities, i.e. $\bar{s}_1^* > \bar{s}_2^*$. This argument can of course be generalized to any number of areas with different commuting times.
Second, let us show the impact on \( u^* \). Take two areas with the same \( \mu \). Assume that, in area 1, the employed have a higher commuting time than in area 2, i.e. \( \overline{t}_1 > \overline{t}_2 \). Then, using (26), it is easy to see that it implies that \( x_1^* > x_2^* \) and \( \hat{x}_1^* > \hat{x}_2^* \) (since \( \mu \) is fixed). As we have seen above, this in turn implies that \( \theta_1^* > \theta_2^* \). Now, using (21), which defines \( u^* \) in the steady-state equilibrium, it is easy to verify that \[
\frac{\partial u^*}{\partial \theta^*} = -\frac{2\hat{x}_1^*\delta}{[\delta + 2\hat{x}_1^*\theta q(\theta)]^2} \frac{\partial (\theta^* q(\theta^*))}{\partial \theta^*} < 0
\]
using (2). As a result, \( \theta_1^* > \theta_2^* \) implies that \( u_1^* < u_2^* \). This argument can also be generalized to any number of areas with different commuting times.

Finally, let us show the impact on \( w^* \). Take two areas with the same \( \mu \). Assume that, in area 1, the employed have a higher commuting time than in area 2, i.e. \( \overline{t}_1 = \overline{t}_2 \). Then, using (26), it is easy to see that it implies that \( x_1^* > x_2^* \) and \( \hat{x}_1^* > \hat{x}_2^* \) (since \( \mu \) is fixed). As we have seen above, this in turn implies that \( \theta_1^* > \theta_2^* \). Now, using (13), which defines \( w^* \), it is easy to verify that \[
\frac{\partial w^*}{\partial \theta^*} > 0
\]
As a result, \( \theta_1^* > \theta_2^* \) implies that \( w_1^* > w_2^* \). This argument can also be generalized to any number of areas with different commuting times.

**Proof of Proposition 4**

Let us first show the impact on average search intensity \( \bar{s}^* \). We are comparing two areas with the same \( \overline{t} \), i.e. \( \overline{t}_W = \overline{t}_B \) but with different transportation mode, i.e. \( \mu_W > \mu_B \), i.e. whites use faster transportation mode than blacks. Then, using (26), it is easy to see that it implies that \( \bar{s}_W > \bar{s}_B \) and \( \hat{x}_W > \hat{x}_B \) (since \( \overline{t} \) is the same). This in turn implies that firms will create more jobs in the white labor market than in the black one, i.e. \( \theta_1^* > \theta_2^* \) (see the proof of Proposition 3) since the two labor markets are different. Finally, \( \theta_1^* > \theta_2^* \) implies that \( s_W^* > s_B^* \) (see (17)) since better opportunities increase search intensity, which in turn leads to higher average search intensities, i.e. \( \bar{s}_W > \bar{s}_B \).

Let us now show the impact on \( u^* \). Take two areas with the same \( \overline{t} \), i.e. \( \overline{t}_W = \overline{t}_B \) but with different transportation mode, i.e. \( \mu_W > \mu_B \). Then, using (26), it is easy to see that it implies that \( \bar{s}_W > \bar{s}_B \) and \( \hat{x}_W > \hat{x}_B \) (since \( \overline{t} \) is the same). As we have seen above, this in turn implies that \( \theta_W^* > \theta_B^* \). Now, using (21), \( \theta_W^* > \theta_B^* \) implies that \( u_W^* < u_B^* \) (see the proof of Proposition 3).

For wages, we have exactly the same reasoning.