



Car ownership and the labor market of ethnic minorities [☆]

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ABSTRACT

We show how initial wealth differences between low-skilled minorities and white workers can generate differences in their labor-market outcomes. This even occurs in the absence of a taste for discrimination against ethnic minorities or exogenous differences in distance to jobs. Because of the initial wealth difference, minorities cannot afford to buy a car while whites can. Car ownership allows whites to reach more jobs per unit of time, which gives them a better bargaining position in the labor market. As a result, in equilibrium, ethnic minorities end up with both higher unemployment rates and lower wages than whites. Furthermore, we also show that it takes more time for minorities to reach their jobs even though they travel less miles when employed. Those predictions are consistent with the data. Better access to capital markets or better public transportation will reduce the differences in labor-market outcomes.

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Urban transit systems in most American cities . . . have become a genuine civil rights issue – and a valid one – because the layout of rapid-transit systems determines the accessibility of jobs to the Black community. If transportation systems in American cities could be laid out so as to provide an opportunity for poor people to get meaningful employment, then they could begin to move into the mainstream of American life. A good example of this problem is my home city of Atlanta, where the rapid-transit system has been laid out for the convenience of the white upper-middle-class suburbanites who commute to their jobs downtown. The system has virtually no consideration for connecting the poor people with their jobs.

Martin Luther King, Jr. (1986, pp. 325–326)

1. Introduction

Empirical evidence for the United States suggests that relative to white workers, African American workers: (i) are less likely to

own a car, (ii) experience higher unemployment rates and longer unemployment spells, (iii) earn lower wages, (iv) spend more time commuting to work, (v) travel less miles to go to their jobs, and (vi) search for jobs in a smaller area (see e.g. Holzer et al., 1994; Raphael and Stoll, 2001). Many papers, some of which are discussed below, offer explanations for a subset of those facts. The aim of this paper is to construct a model that can simultaneously explain all of them.

Most of the literature has focussed on why ethnic minorities¹ experience higher unemployment rates and earn lower wages than whites. Different answers have been given to those crucial questions but the recent debate, especially in the United States, has been focussing on the role of segregation in explaining these differences in unemployment rates. 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, African American workers² face strong geographical barriers to finding and keeping well-paid jobs. In the US context, where jobs have been decentralized and African Amer-

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¹ The term “ethnic minority” refers to any “visible minority”. This would include African Americans and Hispanics in the United States, Indians and Pakistanis in the UK, Turks in Germany, North Africans in France, etc.

² The recent debate on the spatial mismatch hypothesis in the US has also included Hispanic workers.

icans have stayed in the central part of cities, the main conclusion of the spatial mismatch hypothesis is to put forward 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. 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 bulk of the evidence suggests that bad job access indeed deteriorates labor-market outcomes, confirming the spatial mismatch hypothesis (for literature surveys, see Ihlanfeldt and Sjoquist, 1998; Gobillon et al., 2007; Ihlanfeldt, 2006; Zenou, 2009).

However, spatial mismatch cannot explain all the facts described above. In particular, it cannot explain why minority workers travel less miles to work but that it nevertheless takes more time for them. Therefore, it is important to introduce mode choices in the explanation.³ Some researchers have even put forward the idea of an *automobile* or *transportation mismatch* rather than a spatial mismatch to understand the adverse labor-market outcomes of black workers in the United States (see, in particular, Taylor and Ong, 1995). Since most minorities use mass transit,⁴ the choice of transportation is indeed crucial, in particular in large American metropolitan areas where public transportation is not that good (see e.g. Pugh, 1998).⁵ Indeed, mass transit is a much slower form of transport than private cars in the United States, not only because buses are slower but also because of the unreliability of the transit system that causes workers to frequently miss transfers and the fact that many areas are difficult to reach by public transport. In 2000, the average commuting time by public transport in the United States was about twice as high as by car (47.7 versus 24.1 min; see Kawabata and Shen, 2007). As a result, some jobs will be turned down by ethnic minorities, not because these jobs are too far away but because they are difficult to access. So our main point here is that car access can have a negative impact on the labor market of minority workers. In particular, because of urban sprawl and increasing job creation in the suburbs in the United States (Brueckner, 2000, 2001; Glaeser and Kahn, 2001, 2004; Glaeser and Shapiro, 2003; Nechyba and Walsh, 2004), minority families, who mostly reside in the central part of the cities, are

increasingly isolated from jobs that potentially match their skills (Wassmer, 2008).⁶ Given this sprawling, access to good transportation makes it possible for residents to conduct a geographically broader job search, accept offers further away from home, improve work attendance, and keep the burden of commuting at a reasonable level. In other words, in the highly auto-oriented US metropolitan areas, the number of accessible job opportunities is considerably lower for public transit users than for car users (Hess, 2005; Shen, 1998). It is then reasonable to hypothesize that car ownership is an important factor in improving the employment status of low-skilled minority workers. In our model, we show that not having access to cars has a dramatic impact on the labor-market outcomes.

It is well-known that taste discrimination and distance to jobs can explain the adverse labor-market outcomes of minority workers (see, for example, the spatial-mismatch literature discussed above). In this paper, we want to show that even if these aspects are not taken into account, car access will still lead to substantial differences between minority workers and white workers. Both job and car access are certainly important in explaining these differences and only an empirical test can give an answer to this question. Interestingly, Patacchini and Zenou (2005) show that distance to jobs and car access account for almost the same percentage (23.86 and 26.45, respectively) of the disparity between the search intensities of whites and nonwhites in the UK.

Let us now explain the model. As stated above, firms have *no taste for discrimination* and ex ante ethnic minorities and whites are located *at the same distance to jobs*. Apart from the color of their skin, the only difference between minorities and whites is an initial wealth difference.⁷ We show that this forces minority workers to choose public transportation while whites can afford cars. Since the set of jobs that can be reached by car is larger than the set that can be reached by public transportation, whites find jobs more quickly and experience shorter unemployment spells. Living far away from one's job could, in principle, signal car ownership but not if the home location is either unobservable or not verifiable (i.e. workers can always provide fake addresses). Employers do observe the worker's type (minority or white) and since whites on average have a better bargaining position, they earn higher wages. This is a standard statistical discrimination argument (see e.g. Arrow, 1973 or Phelps, 1972).

Thus, the main idea behind our results is that the set of available jobs for minority workers who mainly use public transportation is smaller than for whites who can travel much faster. In other words, ethnic minorities will refuse some jobs that are not accessible by public transportation while they would have accepted them if they had had a car.⁸ Zax and Kain (1996) have illustrated this issue by studying an interesting "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).⁹ Black workers were over-represented

³ The theoretical models that explicitly model the *spatial* aspects of the labor market (see, in particular, Coulson et al., 2001; Brueckner and Zenou, 2003; Smith and Zenou, 2003; Sato, 2001, 2004) have mainly tried to explain the spatial mismatch hypothesis, thus focussing on distance to jobs as the main culprit for the adverse labor-market outcomes of black workers (for an overview, see Zenou, 2009). There are also some search models that study how workers determine their maximum area of search (see e.g. Schwartz, 1976 or Seater, 1979) but neither mode choice nor race are introduced in their models. To the best of our knowledge, our paper is the first to develop a search-matching model where mode-choice decisions affect labor-market outcomes of minority and white workers.

⁴ Using data drawn from the 1995 Nationwide Personal Transportation Survey, Raphael and Stoll (2001) show that in the US, 5.4% of the white households have no automobile while 24% and 12% of the black and Latino households, respectively, do not own a car. Even more striking is that they show that 64% and 46%, respectively, of black and Latino households have only one or zero cars, whereas this number was 36% for white households. Using the 1991 Census data, Owen and Green (2000) show that in Great-Britain, people from minority ethnic groups are more than twice as likely to depend on public transport for commuting journeys as white people (33.2% versus 13.7%), with nearly three-fifths of Black-African workers using public transport to go to work. Furthermore, 73.6% of the whites use a private vehicle while this number is only 56.4% for ethnic minorities (and 39.6% for Black-African workers). Using the Labor Force Survey for England, Patacchini and Zenou (2005) find similar results.

⁵ In US 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. Using public transportation, it took her 2 h whereas, had she been able to afford a car, the commute would have taken only 25 min.

⁶ In the United States, between 1970 and 1990, the ratio of jobs to workers in the central city declined from 1.2 to 1 for whites, while for blacks the ratio declined to 0.7 (O'Regan and Quigley, 1998). This indicates that a sizable fraction of minority workers is reverse commuters, that is, they live in central cities and work in the suburban ring.

⁷ The wealth difference between African Americans and whites, and between Hispanics and whites in the United States is well-documented. See e.g. Smith (1995), Keister (2004) and Campbell and Kaufman (2006). For example, in 1995, the ratio of black/white mean and median wealth holdings was 0.17 and 0.12, respectively, and that of financial wealth still lower, at 0.11 and 0.01, respectively (Wolff, 1998). This is also true in Europe, in particular, in the UK between whites and African-Caribbean, and whites and Indian and Pakistani (see, e.g. Kelaher et al., 2009).

⁸ Using data from the European Community Household Panel (ECHP) for 1994–2001 and for a sample of currently unemployed job seekers, Rupert et al. (2009) report that 14.7% of the job offers were turned down due to commute distance. They also indicate that the impact of commute distance is roughly a third lower than the impact of the wage rate when the job acceptance decision must be made.

⁹ See also Fernandez (1994) for a similar "natural experiment".

among workers whose commuting time was increased, and not all of them could follow the firm. This had two consequences. First, segregation forced some African Americans to quit their jobs. Second, there was a drastic decrease in the share of black workers applying for jobs at the firm (53–25% 5 years before and after the relocation, respectively), and the share of black workers in hires also fell from 39% to 27%.¹⁰ This highlights the fact that African American workers may refuse jobs that involve too long commutes, not necessarily because they are far away in terms of miles traveled but because they cannot be reached by public transportation.

The paper is organized as follows. In Section 2, we discuss the model and its assumptions. Section 3 characterizes the equilibrium and derives the sources of differences in labor-market outcomes between blacks and whites. Section 4 discusses some policy implications of the model.

2. The model

2.1. Labor market flows

We consider a continuum of workers and firms. The total mass of workers is normalized to one. A fraction $(1 - p)$ of the workers is from an ethnic minority group and a fraction p is native whites. Both are assumed to be identical apart from the color of their skin and a difference in initial wealth. We assume that whites have higher wealth flows than ethnic minorities, i.e. $\Omega_W > \Omega_B$, where the subscript $k = B, W$ denotes the type of an individual. Differences in initial wealth can be justified on the grounds that minorities and whites did not experience the same history. For example, in the United States, Smith (1995) documents that racial and ethnic wealth disparities are large. These minority wealth disparities are partly due to differential inheritances and desired bequests as inequities perpetuate themselves across generations; the disparities are also due to lower minority incomes and poorer health.¹¹ We can also interpret the difference between Ω_W and Ω_B in terms of access to the capital market. It is well-documented that in the United States, black families have a more difficult access to the capital market. Indeed, they pay higher interest rates on loans used for purchasing housing (Charles and Hurst, 2002; Mayer et al., 2008) and vehicles (Cohen, 2007; Charles et al., 2008). For example, Cohen (2007) finds that roughly 43–72% of the blacks are charged interest rate “markups” while only 22–47% of the whites face these higher prices for vehicle financing. Charles et al. (2008) show that the interest rates for vehicle loans paid by blacks are, on average, a full 100 basis points higher: 10.6% versus 9.6%.

Following Salop (1979), we model workers' and firms' heterogeneity by means of a circle along which workers are uniformly distributed over the circumference C of length 1.¹² 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 .¹³ It is assumed that workers are unable to change their residential location. One way of justifying this assumption is that homes are less mobile than jobs (Manning, 2003).

Time is continuous and workers live forever. At each moment in time, a worker can be either employed or unemployed. All unem-

ployed workers search for a job and we assume there to be no on-the-job search. Similarly, at each moment in time, a firm can either have a filled position or an open vacancy. Let $u_k(i)$ be the number of type- k unemployed workers, $k = \{B, W\}$, (or equivalently the unemployment rate of type k -workers) at location i and $v(j)$ the number of vacancies (or equivalently the vacancy rate) at location j .

The uniform distribution of workers over the circle implies that $u_k(i) = u_k$, $\forall i \in C$. It is easily shown (see Lemma 1 of Marimon and Zilibotti, 1999) that, in this case, there exists a stationary equilibrium with a uniform distribution of vacancies at all locations, i.e. $v(j) = v$, for all $j \in C$. Gautier et al. (2006, 2010) show that this distribution must be unique. The intuition for this result is that if this distribution is non-uniform, there exists a profitable deviation for firms in non-dense areas (in terms of workers), namely moving to a denser area.

In standard search-matching models, individuals choose reservation wages by comparing the values of employment and unemployment and equating them at the margin.¹⁴ In the present model, we include space in a search-matching model which creates a new decision for job seekers and firms. Workers must now also decide how large the area of search is and firms where to locate, given the location of workers.

To be more precise, search is random and the number of contacts between workers and firms is given by:

$$M(u_B + u_W, v) \equiv M.$$

As usual (Pissarides, 2000), $M(\cdot)$ is assumed to be increasing in its arguments, concave and to exhibit constant returns to scale. Let $\theta = v/(u_B + u_W)$ be labor-market tightness. The contact rate for type k workers with a vacancy is given by:

$$\frac{M}{u_B + u_W} \equiv m(\theta). \quad (1)$$

The contact rate of a vacancy with a type- k worker is given by:

$$\frac{M}{v} \frac{u_k}{u_B + u_W} = \frac{u_k}{u_B + u_W} \frac{m(\theta)}{\theta}.$$

Using the properties of the matching function, it is easily seen that

$$m'(\theta) > 0 \quad \text{and} \quad \frac{\partial[m(\theta)/\theta]}{\partial\theta} < 0, \quad (2)$$

since more vacancies increase the rate at which workers find a job and decrease the rate at which firms fill a vacancy. We also assume the standard Inada conditions on $M(\cdot)$, which ensure that $\lim_{\theta \rightarrow +\infty} m(\theta) = \lim_{\theta \rightarrow 0} m(\theta)/\theta = +\infty$, $\lim_{\theta \rightarrow 0} m(\theta) = \lim_{\theta \rightarrow +\infty} m(\theta)/\theta = 0$.

We can now precisely model the matching process between a worker of type k and a firm. For a worker, a match will occur if and only if:

$$\text{Match}_{u_k \rightarrow v} = \underbrace{m(\theta)}_{\text{Random contact}} \times \underbrace{2\hat{x}_k}_{\text{Probability contact is acceptable}}$$

where “Match $_{u_k \rightarrow v}$ ” means a match between an unemployed worker of type k and a firm with a vacancy v . Indeed, a match is the product of a random contact rate $m(\theta)$ and an acceptance rule $2\hat{x}_k$. Independently of race, workers randomly get job contacts at the rate $m(\theta)$ (for example, workers read newspapers and observe advertisements). For a given job contact, workers must decide to apply for this job or not, depending on its location. This second stage depends on the chosen transport mode. Observe that the term \hat{x}_k is multiplied by 2 because each worker considers the distance to jobs from both sides of her location.

¹⁴ See e.g. Diamond (1982), Mortensen (1982) and Pissarides (2000).

¹⁰ For a survey on these issues, see Fernandez and Su (2004).

¹¹ This is a well-documented fact (see, e.g. Barsky et al., 2002). Because wealth is usually transferred from generation to generation, the large current racial wealth gap between African Americans and whites may be a function of past racial differences in economic conditions and opportunities (due to the very specific history of African Americans, i.e. slavery).

¹² See, among others, Helsey and Strange (1990), Marimon and Zilibotti (1999), Hamilton et al. (2000), Brueckner et al. (2002) and Gautier et al. (2006) for a similar way of modeling heterogeneity.

¹³ Since it is a circle of length 1 where distance is measured on both sides, the maximum distance between a firm and a worker is $1/2$.

The rate at which vacancies match with a type- k worker is given by:

$$\text{Match}_{v \rightarrow u_k} = \underbrace{\frac{u_k}{u_B + u_W} \frac{m(\theta)}{\theta}}_{\text{Random contact}} \times \underbrace{2\hat{x}_k}_{\text{Probability contact is acceptable}}$$

where “Match $_{v \rightarrow u_k}$ ” means a match between a firm with a vacancy v and an unemployed worker of type k . The main difference between “Match $_{u_k \rightarrow v}$ ” and “Match $_{v \rightarrow u_k}$ ” is that in the former, we take the viewpoint of a worker while in the latter, we focus on the firm matching process. First, firms advertise their jobs. They are then contacted by workers and will only offer a job to type- k workers located within a distance $x \leq \hat{x}_k$.

We assume jobs to be destroyed at an exogenous rate δ so that the steady-state conditions for type k workers are given by:

$$2m(\theta)\hat{x}_k u_k = \delta e_k, \tag{3}$$

where e_k is the employment level (or rate) of workers of type k . Finally, normalizing the labor force to one implies that:

$$u_B + u_W + e_B + e_W = 1. \tag{4}$$

From, (3) and (4) and the definition of p , we can derive the following steady-state relationships:

$$\begin{aligned} 2m(\theta)\hat{x}_W u_W &= \delta(p - u_W), \\ 2m(\theta)\hat{x}_B u_B &= \delta((1 - p) - u_B), \end{aligned}$$

so that:

$$u_B = \frac{\delta(1 - p)}{\delta + 2\hat{x}_B m(\theta)}, \tag{5}$$

$$u_W = \frac{\delta p}{\delta + 2\hat{x}_W m(\theta)}. \tag{6}$$

2.2. Asset values of the various labor market states

Contrary to the standard assumption in urban economics of there being only one employment center (see e.g. Zenou, 2009), here there is a continuum of job locations and jobs are uniformly distributed around the circle. Over their lifetime, workers change jobs but not their residential location so that the distance to jobs changes stochastically over time. As a result, the average physical distance to jobs is the same for all workers of type k over their lifetime.¹⁵

Let Ω_k be the per-period wealth flow to which a worker has access, either through family funds or through the capital market. We assume that $\Omega_W > \Omega_B$, capturing the idea that black workers have less initial wealth than whites and/or that they have more difficult access to the capital or car insurance market.¹⁶ All unemployed workers receive unemployment benefits b (this can also be interpreted as home production) and pay a flow cost f_k for using transportation mode k .¹⁷ The cost f_k includes insurance, petrol, lease contract and maintenance for car owners (i.e. f_W) and a monthly public transportation card for mass transit users (i.e. f_B). Workers can only choose one transportation mode, either for commuting to work (when they are employed) or for job search and shopping (when they are unemployed). Thus, for both car owners and public transport users, the flow cost f_k will be the same independently of their employment status. All workers are risk neutral. Thus, an unemployed worker of type k obtains instantaneous utility $\Omega_k + b - f_k$,

while an employed worker, earning w_k and working at a geographical distance x , obtains instantaneous utility $\Omega_k + w_k - T_k(x)$, where $T_k(x)$ is the total commuting cost at distance x . As will be seen below, wages do not depend on x because the residential location of each worker is not directly observable.

Let τ be a positive coefficient and $t_k(x)$ the time it takes to commute to jobs when residing at distance x . This implies $\tau w_k t_k(x)$ which represents the total time cost for a person residing at a distance x from her job.¹⁸ Then, $T_k(x)$ is given by:

$$T_k(x) = f_k + \tau w_k t_k(x). \tag{7}$$

Below (in Section 3.4), we show that since $\Omega_W > \Omega_B$, there exists an equilibrium where even the most wealthy minority workers (those who have been employed most of the time) cannot afford a car while the least wealthy whites (those who have experienced the longest unemployment spells) can. So, from now on, when we talk about transportation issues, $k = B$ implies public transportation while $k = W$ implies cars. As a result, f_k is the pecuniary cost of transportation. We assume that switching transport mode is sufficiently costly so that once a transportation mode decision has been made, it is always optimal to stick to it even when becoming unemployed (see Section 3.4). Naturally, we assume that $f_W > f_B$, i.e. it is more costly to have a car than to use public transportation. As is usual in this type of model, the wage represents the opportunity cost of time. Let μ_k be the (average) speed of a trip to work for a worker of type k . Then,

$$t_k(x) = \frac{x}{\mu_k}. \tag{8}$$

We assume that $\mu_W > \mu_B$. Indeed, μ_k does not only measure how fast the transport mode is but also the “smoothness” of the transportation system. As stated in the Introduction, it is well-documented that in large US cities, there is a lack of good public transportation.

In this context, distance to jobs can be measured in terms of either physical distance x (i.e. number of miles) or time distance $t_k(x)$ (i.e. hours). In other words, two workers using different transport modes will not reach the same physical distance in the same period of time.

Let U_k be the steady-state expected discounted lifetime utility of an unemployed worker¹⁹ of type k and $E_k(x, w_k)$ be the steady-state expected discounted lifetime utility of an employed worker of type k living at a distance x from her job and earning a wage w_k . Then,

$$rU_k = \Omega_k + b - f_k + m(\theta) \left[2 \int_0^{\hat{x}_k} [E_k(x, w_k) - U_k] dx \right], \tag{9}$$

where $r \in (0, 1)$ is the discount rate, and \hat{x}_k is the maximum geographical distance a worker is willing to travel (beyond \hat{x}_k all jobs will be turned down by the unemployed workers). This equation can be understood as follows. When a worker of type k is unemployed today, her instantaneous utility is $\Omega_k + b - f_k$. She then meets vacancies at the rate $m_k(\theta)$ and a fraction $2\hat{x}_k$ of the vacancies are located at an acceptable distance from the worker. All jobs beyond distance \hat{x}_k will be turned down. When a worker accepts a

¹⁵ This is why we do not introduce land rent in this model, since it will not depend on distance to jobs and it will have the same value at each location. Therefore, it will not affect the results of the model.

¹⁶ See our discussion at the beginning of Section 2.1.

¹⁷ Since we focus below on the equilibrium with a one-to-one correspondence between type and transport mode, subscript k denotes both type and transport mode.

¹⁸ This is the common way of modeling 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, in (7) we have omitted the variable part of the commuting cost (i.e. the pecuniary commuting cost). However, observe 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. However, such a model is cumbersome to analyze, and it is likely to not yield any 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; Glaeser et al., 2008).

¹⁹ To save on notation, we omit subscript i when there is no possibility of confusion.

job offer at distance x from her residential location, she obtains a wealth increase of $E_k(x, w_k) - U_k$.²⁰ Observe that U_k does not depend on x because search is random (i.e. workers just read newspaper advertisements) so that firms cannot sort workers by locations.

The asset value for an employed worker who is employed at distance x from her home is given by²¹:

$$rE_k(x, w_k) = \Omega_k + w_k \left(1 - \tau \frac{x}{\mu_k}\right) - f_k - \delta [E_k(x, w_k) - U_k]. \quad (10)$$

Eq. (10) has a standard interpretation. When a worker of type k is employed today, she works at a distance x and she obtains an instantaneous utility equal to $\Omega_k + w_k(1 - \tau x/\mu_k) - f_k$. Then, this worker can lose her job with probability δ and experience a reduction in wealth equal to $E_k(x, w_k) - U_k$.

Next, we present the Bellman equations for the firm. Let y be the productivity of a worker and γ denote the firm's search cost per unit of time. Since we assume constant returns to scale production, profits do not depend on firm size so we can consider all vacancies to be single worker firms. The expected discounted lifetime utility of a firm with a filled job and a firm with a vacancy, denoted by J_k and V , respectively, is given by:

$$rJ_k(w_k) = y - w_k - \delta(J_k - V), \quad (11)$$

$$rV = -\gamma + \frac{2m(\theta)}{\theta(u_B + u_W)} \left[u_B \int_0^{\hat{x}_B} (J_B - V) dx + u_W \int_0^{\hat{x}_W} (J_W - V) dx \right]. \quad (12)$$

In (11), a firm with a job filled by a worker of type k obtains an instantaneous net profit of $y - w_k$. This job can then be destroyed at the exogenous rate δ and, in that case, the firm loses $J_k - V$. In (12), a firm pays an advertisement cost γ . A contact with a worker occurs at the rate $m(\theta)$ and the firm can either meet a minority worker (with probability $u_B/(u_B + u_W)$) who will accept the offer only if the firm is within a geographical distance of \hat{x}_B , or meet a white worker (with probability $u_W/(u_B + u_W)$) who will accept the offer only if the firm is within a geographical distance of \hat{x}_W . Observe that according to (11), a workers' productivity y does not depend on her distance to the jobs, x . As a result, all employed workers are, in terms of productivity, identical from the point of view of the firms. However, as will be shown below, white workers can bargain for a higher wage because they have a better outside option due to the fact that $\hat{x}_W > \hat{x}_B$. This implies that firms prefer minority workers over white workers, but still hire white workers because it is more profitable to hire them than to keep the job vacant.

3. The steady-state equilibrium

A (steady-state) labor market equilibrium is a tuple that consists of wages, a maximum traveling distance for minority and white workers, unemployment levels, and labor-market tightness $(w_B^*, w_W^*, \hat{x}_B^*, \hat{x}_W^*, u_B^*, u_W^*, \theta^*)$ such that given the matching technology, all agents (workers and firms) maximize their respective objective function. Labor market tightness is determined by a free-entry condition, wages by Nash bargaining, and maximum traveling distance by an indifference condition between the value of unemployment and the value of employment at the maximum acceptable distance. Finally, unemployment and vacancy levels follow from equilibrium labor-market tightness and a steady-state condition on unemployment.

²⁰ The exact mathematical derivation of Eq. (9) is based on dynamic programming tools (Bellman equations) and can be found in Appendix B in Zenou (2009). The same applies for Eqs. (10)–(12) below.

²¹ For the model to make sense, we assume throughout that $\tau < 2\mu_B$ since this guarantees that $1 > \tau x/\mu_k$, $\forall x \in [0, 1/2]$ and $k \in \{B, W\}$.

3.1. Labor demand

Firms open vacancies up to the point where they make zero (expected) profits, i.e. $V = 0$. Using (11) and (12), we can write:

$$J_k = \frac{y - w_k}{r + \delta}, \quad (13)$$

$$\frac{u_B \hat{x}_B J_B + u_W \hat{x}_W J_W}{u_B + u_W} = \frac{\gamma \theta}{2m(\theta)}. \quad (14)$$

Combining (14) and (13) yields

$$\frac{u_B \hat{x}_B (y - w_B) + u_W \hat{x}_W (y - w_W)}{u_B + u_W} = \frac{\gamma \theta (r + \delta)}{2m(\theta)}. \quad (15)$$

For given wages w_B and w_W , we can derive the direct relationship between \hat{x}_k and θ . Differentiating (15), we obtain:

$$\frac{\partial \theta}{\partial \hat{x}_W} > 0 \quad \frac{\partial \theta}{\partial \hat{x}_B} > 0.$$

This result 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 the labor market) because they have more chances of filling a vacancy since workers are less "picky".

3.2. Wage determination

The total intertemporal surplus is shared through a generalized Nash-bargaining process between the firm and the worker. As previously mentioned, we assume that firms either do not observe the location of workers or, more precisely, their x (the distance between the workers and the firm's location) or that their location is not verifiable; if a worker living in location i were to earn more than the same worker living in location i' , workers in location i' would have incentives to report a fake address in location i .

As a result, a worker and a firm only bargain over observable factors.^{22,23} Even if firms do not know the exact location of each worker, they know that ethnic minorities use public transportation while whites use cars to commute to their jobs (this will be shown below). In other words, firms do not observe x but they observe \hat{x}_B and \hat{x}_W . Since the traveling time is non-verifiable, it is not part of the wage negotiation. As a result, in the wage bargaining, the value of employment is not given by (10) but by:

$$rE_k^d = \Omega_k + w_k - f_k - \delta[E_k^d - U_k^d], \quad (16)$$

where U_k^d , the disagreement payoff for the unemployed worker during bargaining, is still given by (9) while $E_k(x, w_k)$ is replaced by E_k^d . Hence, during the bargaining process, the actual x is of no importance since only the average x per type k is taken into account. This is a standard statistical discrimination argument. The match surplus of workers that is relevant for the wage bargaining is thus $E_k^d - U_k^d$, while the surplus for the firms is: $J_k - V$, which reduces to J_k because of the free-entry condition. Nash wage bargaining then implies that:

$$(1 - \beta)[E_k^d - U_k^d] = \beta J_k, \quad (17)$$

where $0 \leq \beta \leq 1$ denotes the bargaining power of workers. In Appendix A, we show that (17) implies:

²² See also Gautier (2002) for a similar approach.

²³ It could also be assumed that when a firm and a worker bargain over a wage, it is the average commuting distance of each type of worker that is taken into account. This will not change the main results of this paper but will make the wage a direct function of commuting costs.

$$w_k = \frac{(1 - \beta)(r + \delta)b + \beta[r + \delta + 2m(\theta)\hat{x}_k]y}{r + \delta + 2\beta m(\theta)\hat{x}_k} \quad (18)$$

For a given θ , wages are increasing in the unemployment benefit b , the workers' productivity y , and the workers' bargaining power β . More interestingly, for a given θ , by differentiating (18), we have:

$$\frac{\partial w_k}{\partial \hat{x}_k} = \frac{2(r + \delta)\beta m(\theta)(1 - \beta)(y - b)}{[r + \delta + 2\beta m(\theta)\hat{x}_k]^2} > 0. \quad (19)$$

When the area of search \hat{x}_k increases for type- k workers, they have a better outside option and can therefore bargain for higher wages. Since the labor-market tightness (i.e. job creation) for minority and white workers is the same and equal to θ , $\hat{x}_W > \hat{x}_B$ implies that white workers earn higher wages than ethnic minorities. In other words, by increasing the area of search, car access increases wages, which is a well-documented fact (see e.g. Gurley and Bruce, 2005).

3.3. Maximum distance to jobs

We must finally determine the maximum commuting distance a worker is willing to accept, \hat{x}_k . To determine \hat{x}_k , we use the asset values of unemployment and employment given by (9) and (10). Formally, \hat{x}_k is implicitly defined by the home-work distance that makes the worker indifferent between being employed or remaining unemployed:

$$E_k(\hat{x}_k, w_k) - U_k = 0. \quad (20)$$

In Appendix B, we show that (20) is equivalent to:

$$\frac{m(\theta)w_k\tau}{\mu_k} \hat{x}_k^2 + \frac{\tau w_k(r + \delta)}{\mu_k} \hat{x}_k - (w_k - b)(r + \delta) = 0. \quad (21)$$

It is easily verified that there is a unique positive solution to this equation which we denote by \hat{x}_k^* . In Appendix B, we show that a condition for both $\hat{x}_W^* < 1/2$ and $\hat{x}_B^* < 1/2$ and the net wage to be strictly positive is (33). Note that if $\hat{x}_k^* \geq 1/2$, for $k = B, W$, there will be a trivial equilibrium where all workers, whatever their type k , accept all job offers. We also show in Appendix B that for a given θ ,

$$\frac{\partial \hat{x}_k^*}{\partial \mu_k} > 0. \quad (22)$$

Indeed, when people use a faster transport mode, they also accept jobs involving longer commutes. If whites mainly travel by car while ethnic minorities use public transportation, then $\hat{x}_W^* > \hat{x}_B^*$.

Although there is only one positive root \hat{x}_k^* which is increasing and convex in w_k , at this stage we cannot rule out that there exist two equilibria for if we consider the relationship between \hat{x}_k and w_k in (18), we see that it is also increasing. However, note that (18) exhibits a concave relation between \hat{x}_k and w_k . A sufficient condition for a unique (\hat{x}_k, w_k) pair is thus that at $\hat{x}_k = 0$, the concave function (18) has a higher value of w_k than the convex function (21). Evaluating (18) at $\hat{x}_k = 0$ gives $w_k = (1 - \beta)b + \beta y$ which is indeed greater than the wage we obtain from evaluating (21) at $\hat{x}_k = 0$ which is $w_k = b$. Therefore, we have established a single crossing condition for Eqs. (18) and (21), implying that there exists a unique (\hat{x}_k, w_k) pair.

3.4. Transport mode decision

We now derive sufficient conditions for whites to choose cars and blacks to choose public transport. All whites use cars if they can afford to and no individual white worker reaches a higher utility by using public transport even if firms believe that she travels by car. Blacks will always use public transport if they cannot afford a car but can afford to use public transportation.

The highest income that a black worker can obtain is when she is employed forever and perfectly matched to a firm (i.e. $x = 0$). So, no black worker can afford a car if:

$$\Omega_B + w_B < f_W. \quad (23)$$

The worst labor market state for a black worker is unemployment (in that case x is of no importance). As a result, blacks can always afford public transport if:

$$\Omega_B + b > f_B. \quad (24)$$

Since we assumed that all workers can use exactly one transport mode, we can rule out that a worker chooses not to invest in transportation and simply collects b .

For whites, we need a condition that guarantees that all of them own a car. If the poorest white (who is unemployed) can afford a car, they all can. So a sufficient condition for all whites to own cars is:

$$\Omega_W + b > f_W. \quad (25)$$

Combining these three conditions gives:

$$f_B - b < \Omega_B < f_W - w_B < f_W - b < \Omega_W. \quad (26)$$

Finally, we need to show that it is not profitable for an individual white worker to switch to public transport even if employers still believe that she has a car. Since employers neither observe car ownership nor residential location, they statistically discriminate workers and base their expectations on aggregate car ownership rates for ethnic minorities and whites. If a sufficiently large number of whites own a car, then when a firm bargains with a white worker over the wage, it believes her area of search to be \hat{x}_W and thus offers a wage w_W defined by (18) for $k = W$. Let \hat{x}_W^{public} be the maximum acceptable distance for a white worker using public transport. Its value is given by (35) in Appendix C and we show that $\hat{x}_W^{public} < \hat{x}_W$ (\hat{x}_W is given by (21)). In Appendix C, we also show that a necessary and sufficient condition for whites to never deviate and use public transportation is given by:

$$\left(\hat{x}_W - \hat{x}_W^{public}\right)\Omega_W + \hat{x}_W(AI_W^{car} - f_W) - \hat{x}_W^{public}\left(AI_W^{public} - f_B\right) > \frac{r(f_W - f_B)}{2m(\theta)} \quad (27)$$

where Ai_W^{car} and Ai_W^{public} constitute the average income of a white worker having a car and using public transportation, respectively, and are given by (47) and (48).

To sum-up, ethnic minorities will not use cars if Ω_B and y are sufficiently low, implying that our model is only relevant for low-skill workers. Whites own cars if Ω_W is sufficiently large. Naturally, there exist weaker conditions where some minority workers own a car and/or some whites use mass transit but as long as a larger fraction of whites own a car, our results will be qualitatively the same. Finally, if a small fraction of ethnic minorities has the same wealth level as white workers, they may still choose mass transit because firms offer them lower wages since they assign a small probability to the event that a minority worker owns a car.

Observe that the benefit of owning a car is part of the mode-choice decision. It is already apparent in condition (26), where the wage of minority workers, i.e. w_B , appears. It is even more apparent in condition (27) where not only the wage but also the unemployment rate of white workers²⁴ is a crucial factor determining transport choice.

As stated in the Introduction, the initial wealth difference can also capture differences in the access to the capital market. Assumption (27) implies that if ethnic minorities have a more difficult access to the capital market than whites, they are more likely to use public transportation. Using US data from the 1992, 1995, 1998, and 2001 waves of the Survey of Consumer Finances (SCF),

²⁴ Which are included in Ai_W^{car} and Ai_W^{public} .

Charles et al. (2008) show that not only do African Americans pay higher interest rates than whites on the loans used to purchase vehicles, they are much more likely to have been recently turned down for a vehicle loan. Another explanation for why African Americans do not have access to a car is that dealers quote lower prices to whites than to blacks. Indeed, Ayres and Siegelman (1995), who study more than 300 paired audits at new-car dealerships, find that dealers quoted significantly lower prices to white males than African American males, using identical scripted bargaining strategies. In the context of our model, this means that not only is $\Omega_W > \Omega_B$ but the fixed price of buying a car, f_W , is also much higher for ethnic minorities than for whites. In that case, the required difference between Ω_W and Ω_B for minorities not to buy cars can be smaller.²⁵

3.5. The steady-state equilibrium

Definition 1. A steady-state equilibrium is a tuple $(w_B^*, w_W^*, \hat{x}_B^*, \hat{x}_W^*, u_B^*, u_W^*, \theta)$ such that Eqs. (18), (21), (5), (6) and (15) are satisfied.

Our main result can be stated as follows (the proof can be found in Appendix D):

Proposition 1. Assume that (26) and (27) hold. Then, white workers use cars while ethnic minorities take public transportation to commute to their workplace. Consequently, whites will search over a wider area than blacks, i.e. $\hat{x}_B^* < \hat{x}_W^* < 1/2$,²⁶ earn a higher wage, i.e. $w_W^* > w_B^*$, and experience a lower unemployment rate, i.e. $u_W^* < u_B^*$.

If the wealth difference between ethnic minorities and whites is sufficiently large, the latter will be able to buy a car while the former will be forced to use public transportation. Because of a slower mode of transportation, ethnic minorities have difficulties in reaching jobs located too far from their residential location and will therefore only accept job offers within their area of residence. In contrast, white workers will be ready to accept jobs located further away because of their faster and “smoother” transport mode. As a result, whites will spend less time being unemployed since more job offers will be acceptable for them and they will obtain a higher wage because their bargaining position is better.²⁷ The fact that white workers earn higher wages than ethnic minorities (especially African Americans and Hispanics) is well-documented in the United States (see, e.g., Welch, 2003 or Neal, 2006). But this is also true for Europe. For example, for the UK, controlling for individual characteristics and region, Bangladeshis and Pakistanis earn about 40% and 20% lower wages than white UK-born (Dustmann et al., 2003).

Note that in our model, the average distance to jobs (not to acceptable jobs) is the same for minorities and whites and it is equal to $1/4$. In the real-world, this is not true; in most US cities, jobs are located relatively far from where ethnic minorities live (see the spatial mismatch literature in the Introduction and, in particular, the literature overview of Ihlanfeldt and Sjoquist, 1998). If we had started with ex ante inequalities in terms of distance to jobs between ethnic minorities and whites, the differences in outcomes would thus have even been larger.

To sum-up, our model endogenously shows that as compared to whites, ethnic minorities: (i) do not own a car, (ii) experience higher unemployment rates ($u_B^* > u_W^*$) and longer unemployment spells

($1/[2m(\theta)\hat{x}_B^*] > 1/[2m(\theta)\hat{x}_W^*]$), (iii) earn lower wages ($w_B^* < w_W^*$), (iv) can on average spend more time commuting to work ($\hat{x}_B^*/(2\mu_B) > \hat{x}_W^*/(2\mu_W)$), (v) on average travel less miles to go to their jobs ($\hat{x}_B/2 < \hat{x}_W/2$), and (vi) search for jobs over a smaller area ($\hat{x}_B^* < \hat{x}_W^*$).

Results (iv) and (v) are surprising and not straightforward but they are well-documented features of the spatial labor market of minority and white workers. Indeed, even though minorities are on average further away from jobs, they tend to live closer (in miles) to jobs when they are employed but spend more time traveling. The time cost per mile traveled is thus substantially higher for ethnic minorities than for whites. There is indeed a difference between *commuting distance* and *commuting time*. In the central city in the United States (where a large fraction of African Americans live) travel times are quite long, especially for people relying on public transportation. For example, in 1995, the average commute distance for workers using private transportation was 12 miles, as compared to 13 miles for those reliant on public transportation. Commute times, however, were more than twice as long on public transits than for those using private vehicles – 22 min as compared to 42 min (Hu and Young, 1999). The results (iv and v) are due to the lack of car access among the minority population, while the fact that African Americans are on average further away from jobs is often attributed to housing discrimination (Ross and Yinger, 2002; Dymski, 2006) and the willingness to live together (Ihlanfeldt and Scafdi, 2002). In our model, result (iv) is not always true since $\hat{x}_B^* < \hat{x}_W^*$ and $\mu_B < \mu_W$. However, if using cars is a much faster transport mode than using public transportation, this will hold because the first direct effect is stronger than the second indirect effect.

Most empirical studies (both for Europe and the US) have indeed shown the mean daily commute to be lower for whites than for ethnic minorities (see e.g. Patacchini and Zenou (2005), for the UK, Chung et al. (2001) and Gottlieb and Lentnek (2001), for the US) while white commuters have longer average commute distances than ethnic minorities (Holzer et al., 1994; Taylor and Ong, 1995). In particular, using the National Longitudinal Survey Youth Cohort (NLSY) for 1981 and 1982, Table 1 from Holzer et al. (1994) displays interesting statistics, which confirm results (i)–(v) and thus Proposition 1.

4. Discussion and policy implications

We have argued that because of wealth differences, whites mainly use cars whereas ethnic minorities use mass transit. The set of feasible jobs in terms of distance is therefore larger for whites. This improves their bargaining position and results in higher wages and lower unemployment rates for whites. Allowing workers to vary their search intensity would only make the differences larger because the returns to search are higher for whites.

All our results are obtained by assuming firms to have no taste for discrimination and that ex ante minorities and whites are located at the same average distance to jobs. It is well-documented that both discrimination (Altonji and Blank, 1999) and distance to jobs (Ihlanfeldt and Sjoquist, 1998) are important factors negatively affecting the labor-market outcomes of minority workers. Adding these elements to our model would lead to more pronounced outcomes between blacks and whites.

As in the standard search-matching models (Diamond, 1982; Mortensen and Pissarides, 1999; Pissarides, 2000), there are two types of search externalities: *negative intra-group externalities* (more job seekers reduce the job-acquisition rate) and *positive inter-group externalities* (more searching firms increase the job-acquisition rate). In addition, there are *intertype search external-*

²⁵ See also Ayres (1991) for similar evidence.

²⁶ A condition that guarantees that $\hat{x}_W^* < 1/2$, $\hat{x}_B^* < 1/2$ as well as the net wage $w_k(1 - \tau x/\mu_k)$ being always strictly positive whatever $x \in [0, 1/2]$, $k \in \{B, W\}$ is (33), which is given in Appendix C.

²⁷ We have run different numerical simulations (that are available upon request) of this model satisfying conditions (26) and (27). We obtain all the results of Proposition 1.

ities due to the fact that there is some asymmetry in the search process between ethnic minorities and whites. Indeed, white workers exert negative externalities on minority workers because they obtain a job at a faster rate (i.e. $\hat{x}_W^* > \hat{x}_B^*$) and are better paid ($w_W^* > w_B^*$), which eventually reduces the vacancy supply.²⁸

Investments in public transport can have a substantial impact on the search activities of low-income workers and thus, on their unemployment rate. Indeed, if the labor participation for minority workers is affected by poor access to job locations and poor worker mobility, and if public transportation services are designed to effectively link workers with areas of concentrated employment, then increased access to public transit should yield higher levels of employment, in particular for African Americans (Sanchez, 1998, 1999; Blumemberg and Manville, 2004).²⁹

Alternatively, programs helping job takers (especially African Americans) obtain a used car – a secured loan for purchase, a leasing scheme, a revolving credit arrangement – may offer real promise and help low-skill workers obtain a job. This is a standard policy that has been advocated in the US (see e.g. Pugh, 1998). Stoll (1999, 2005) shows that increasing blacks' and Latinos' access to cars will lead to a greater geographical job search. As in our model, this will, in turn, 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 minority workers. They also show that giving nonwhite 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%. 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), Gurley and Bruce (2005) and Baum (2009), who found positive effects of car access on employment).³⁰ Moreover, if one believes that the low rate of car ownership among minority families is driven by discrimination in the automobile insurance and credit markets, the government should enforce anti-discrimination laws preventing such behavior.

Some researchers believe that public funds should be spent helping welfare recipients secure cars (Blumenberg and Waller, 2003; O'Regan and Quigley, 1998; Ong, 2002; Waller and Hughes, 1999; Shen, 2001). In the United States, the welfare program allows states to use federal block grants to provide direct purchase assistance for automobiles, to help pay for insurance, and to provide loans for would-be buyers. Ways to Work, a partnership that secures two-year loans for Temporary Assistance for Needy Families (TANF) recipients in 23 cities across 17 states, reported in 2001 that over 85% of its loans had gone to vehicle purchase (Goldberg, 2001). Early evaluations of the program show that participants average as much as a 20% increase in monthly income,

²⁸ There is a second-order positive effect, namely that a higher \hat{x}_W^* has a positive effect on labor market tightness, θ .

²⁹ Researchers studying the relationship between transportation and employment find that reliable transportation leads to increased access to job opportunity, higher earnings, and increased employment stability (Blumemberg, 2000; Cervero et al., 2002; Ong, 2002; Holzer and Ihlanfeldt, 1996).

³⁰ Since car ownership and employment are likely to be simultaneously determined, most of these papers either find instruments or use a natural experiment to obtain a causal relationship. For example, Holzer et al. (2003) use an expansion of the San Francisco Bay Area's heavy rail system to have an exogenous change in the accessibility of inner-city minority communities to a concentrated suburban employment center. On the other hand, Raphael and Stoll (2001) use an instrument variable strategy to overcome the simultaneity problem between car ownership and employment. Gurley and Bruce (2005) convincingly instrument for car ownership and also find a positive relationship.

once the loan has been received.³¹ One disadvantage of stimulating car use is that average speed is likely to be decreasing with the total number of cars.

Our model sheds some light on the policies discussed above. In particular, by providing the exact mechanism through which car ownership affects the labor-market outcomes of minority workers, it helps designing the appropriate policy aiming at improving the outcomes of minority workers.

Although the lack of car ownership among African Americans in the United States contributes to their adverse labor-market outcomes, it cannot explain the entire gap in unemployment rates between blacks and whites. Since more than 50% of the jobs are found through friends and relatives (see, e.g. Holzer, 1987, 1988), social networks are also an important part of the story (see, e.g. Calvó-Armengol and Jackson, 2004; Calvó-Armengol et al., 2005; Zenou, 2008). We believe that access to cars is related to social networks in the following way. If ethnic minorities are isolated from whites because they live in segregated neighborhoods and have no access to cars, they will only have access to *closed* networks of friends, which are limited in obtaining information about possible jobs. Indeed, due to the lack of good public transportation in the US, it is costly (both in terms of time and money) to commute to business centers to meet other types of people (*weak ties*) who can provide other sources of information about jobs (Granovetter, 1973). If ethnic minorities mainly rely on their *strong ties* (their neighbors who are more likely to also belong to the minority group) and if the latter are mostly unemployed, there is little chance for them of escaping unemployment and finding a job.

Appendix A. Determination of the wage

The value Eq. (9) can be written as:

$$rU_k^d = \Omega_k + b - f_k + m(\theta) \left[2 \int_0^{\hat{x}_k} [E_k^d - U_k^d] dx \right] \\ = \Omega_k + b - f_k + 2m(\theta)\hat{x}_k [E_k^d - U_k^d]. \tag{28}$$

Now, by subtracting (28) from (16), we obtain:

$$E_k^d - U_k^d = \frac{w_k - b}{r + \delta + 2m(\theta)\hat{x}_k}. \tag{29}$$

Plugging the value of $E_k^d - U_k^d$ from (29) and of J_k from (13) into (17) yields

$$(1 - \beta) \left[\frac{w_k - b}{r + \delta + 2m(\theta)\hat{x}_k} \right] = \beta \left(\frac{y - w_k}{r + \delta} \right).$$

By manipulating this expression, we obtain (18).

Appendix B. Determination of the maximum area of search

First, since the value of employment for type k depends linearly on x and only through traveling time $\frac{x}{\mu_k}$, we can write

$$\frac{1}{\hat{x}_k} \int_0^{\hat{x}_k} E_k(x, w_k) dx = \mathbb{E}_x[E_k(x, w_k) | x < \hat{x}_k] = E_k[\mathbb{E}_x(x | x < \hat{x}_k), w_k] \\ = E_k(\hat{x}_k/2),$$

where the last step follows from $\mathbb{E}_x(x | x < \hat{x}_k) = \hat{x}_k/2$. Therefore,

³¹ Tennessee has also recognized the importance of car access for welfare recipients. In addition to a standard vehicle asset exemption amount, their unique benefit program, First Wheels, provides zero-interest loans for the purchase of a used automobile for program participants and leavers up to twelve months after the end of cash assistance payments. Gurley and Bruce (2005) show that this program has increased the probability of being employed and leaving welfare.

$$\int_0^{\hat{x}_k} E_k(x, w_k) dx = \hat{x}_k E_k(\hat{x}_k/2). \tag{30}$$

This implies that (9) can be written as:

$$[r + 2m(\theta)\hat{x}_k]U_k = \Omega_k + b - f_k + 2m(\theta)\hat{x}_k E_k(\hat{x}_k/2).$$

If we evaluate (10) at $x = \hat{x}_k/2$, we get:

$$(r + \delta)E_k(\hat{x}_k/2, w_k) = \Omega_k + w_k \left(1 - \tau \frac{\hat{x}_k/2}{\mu_k}\right) - f_k + \delta U_k.$$

Combining these two equations leads to:

$$rU_k = \frac{(\Omega_k + b - f_k)(r + \delta)}{r + \delta + 2m(\theta)\hat{x}_k} + \frac{2m(\theta)\hat{x}_k}{r + \delta + 2m(\theta)\hat{x}_k} \left[\Omega_k + w_k \left(1 - \tau \frac{\hat{x}_k/2}{\mu_k}\right) - f_k \right]. \tag{31}$$

If we evaluate (10) at $x = \hat{x}_k$, we get:

$$(r + \delta)E_k(\hat{x}_k, w_k) = \Omega_k + w_k \left(1 - \tau \frac{\hat{x}_k}{\mu_k}\right) - f_k + \delta U_k.$$

Using this last equation, (20) can be written as:

$$\Omega_k + w_k \left(1 - \tau \frac{\hat{x}_k}{\mu_k}\right) - f_k = rU_k.$$

Using the value of rU_k in (31), this last equation can be written as:

$$\frac{(\Omega_k + b - f_k)(r + \delta)}{r + \delta + 2m(\theta)\hat{x}_k} + \frac{2m(\theta)\hat{x}_k}{r + \delta + 2m(\theta)\hat{x}_k} \left[\Omega_k + w_k \left(1 - \tau \frac{\hat{x}_k/2}{\mu_k}\right) - f_k \right] = \Omega_k + w_k \left(1 - \tau \frac{\hat{x}_k}{\mu_k}\right) - f_k,$$

which is equivalent to:

$$\frac{m(\theta)w_k\tau}{\mu_k} \hat{x}_k^2 + \frac{\tau w_k(r + \delta)}{\mu_k} \hat{x}_k - (w_k - b)(r + \delta) = 0.$$

There are two roots in this equation but only one is strictly positive. It is given by:

$$\hat{x}_k^* = -\frac{\tau(r + \delta)}{2m(\theta)\tau} + \frac{\mu_k}{2m(\theta)w_k\tau} \times \sqrt{\left(\frac{\tau w_k(r + \delta)}{\mu_k}\right)^2 + 4\frac{m(\theta)w_k\tau(w_k - b)(r + \delta)}{\mu_k}}.$$

Since w_k is not directly affected by μ_k but only indirectly through \hat{x}_k (see (18)), we have:

$$\frac{\partial \hat{x}_k}{\partial \mu_k} = \frac{m(\theta)w_k\tau\hat{x}_k^2 + \tau w_k(r + \delta)\hat{x}_k}{2m(\theta)w_k\tau\hat{x}_k\mu_k + \tau w_k(r + \delta)\mu_k} > 0. \tag{32}$$

Denote

$$\Phi(\hat{x}_W) = \frac{m(\theta)w_W\tau}{\mu_W} \hat{x}_W^2 + \frac{\tau w_W(r + \delta)}{\mu_k} \hat{x}_W - (w_W - b)(r + \delta).$$

Since $\hat{x}_W > \hat{x}_B$, for $\hat{x}_W < 1/2$ and $\hat{x}_B < 1/2$, we must check that $\Phi(1/2) > 0$,

which is equivalent to:

$$\frac{\tau}{2\mu_W} \left(1 + \frac{m(\theta)}{2(r + \delta)}\right) > 1 - \frac{b}{w_W}.$$

Combining this condition with the one guaranteeing that the net wage $w_k(1 - \tau x/\mu_k)$ is strictly positive, $\forall x \in [0, 1/2]$, $k \in \{B, W\}$, i.e. $\tau < 2\mu_B$, we obtain

$$\left(1 - \frac{b}{w_W}\right) \left[\frac{2(r + \delta)}{2(r + \delta) + m(\theta)}\right] \mu_W < \frac{\tau}{2} < \mu_B, \tag{33}$$

which is feasible since $\left(1 - \frac{b}{w_W}\right) \left[\frac{2(r + \delta)}{2(r + \delta) + m(\theta)}\right] < 1$.

Appendix C. Condition for whites to prefer cars

We need to verify that whites always prefer to use a car over public transportation because the net benefits of a car exceed its net cost. Therefore, we define the following steady-state value function of an unemployed white worker having a car:

$$rU_W^{car} = \Omega_W + b - f_W + m(\theta) \left[2 \int_0^{\hat{x}_W} [E_W^{car}(x, w_W) - U_W^{car}] dx \right], \tag{34}$$

which is (9). Let \hat{x}_W^{public} be the maximum acceptable distance of a white worker who deviates by using mass transit. Observe that this white person will still earn the same wage w_W as other whites who use cars because firms do not directly observe transport mode and expect that all whites use cars. This is a standard statistical discrimination argument. The values of \hat{x}_W^{public} can be calculated in a similar way as in (21). We obtain:

$$\frac{m(\theta)w_W\tau}{\mu_B} \left(\hat{x}_W^{public}\right)^2 + \frac{\tau w_W(r + \delta)}{\mu_B} \hat{x}_W^{public} - (w_W - b)(r + \delta) = 0. \tag{35}$$

Since μ_B , the speed of the public transportation system, is lower than μ_W , the speed of cars, and since $\frac{\partial \hat{x}_k}{\partial \mu_k} > 0$ (see (22)), it should be clear that $\hat{x}_W^{public} < \hat{x}_W \equiv \hat{x}_W^{car}$. Therefore, we can write the steady-state value function of this white worker who deviates by using public transportation as:

$$rU_W^{public} = \Omega_W + b - f_B + m(\theta) \left[2 \int_0^{\hat{x}_W^{public}} [E_W^{public}(x, w_W) - U_W^{public}] dx \right]. \tag{36}$$

Note that this is the most favorable case for an individual white worker who takes public transport since she has a wage of w_W but pays the lowest transportation fee f_B . If this person prefers to have a car rather than using mass transit, this will guarantee that, in equilibrium, all white workers will own a car. The underlying statistical discrimination mechanism is that employers do not directly observe the transport mode and the location of each worker but believe that all white workers have a car. The only disadvantage of using public transportation for a white worker who deviates by using mass transit is the smaller set of jobs that is available, i.e. $\hat{x}_W^{public} < \hat{x}_W$. The steady-state value functions of an employed white worker who has a car and the one who deviates by using mass transit are, respectively, given by:

$$rE_W^{car}(x, w_W) = \Omega_W + w_W \left(1 - \tau \frac{x}{\mu_W}\right) - f_W - \delta [E_W^{car}(x, w_W) - U_W^{car}], \tag{37}$$

$$rE_W^{public}(x, w_W) = \Omega_W + w_W \left(1 - \tau \frac{x}{\mu_B}\right) - f_B - \delta [E_W^{public}(x, w_W) - U_W^{public}]. \tag{38}$$

The condition that guarantees that whites always prefer a car over public transportation can be written as: $U_W^{car} > U_W^{public}$. Since U_W^{car} and U_W^{public} do not depend on x , Eqs. (34) and (36) can be written as:

$$[r + 2m(\theta)\hat{x}_W]U_W^{car} = \Omega_W + b - f_W + 2m(\theta) \int_0^{\hat{x}_W} E_W^{car}(x, w_W) dx, \tag{39}$$

$$[r + 2m(\theta)\hat{x}_W^{public}]U_W^{public} = \Omega_W + b - f_B + 2m(\theta) \int_0^{\hat{x}_W^{public}} E_W^{public}(x, w_W) dx. \tag{40}$$

Given than $\hat{x}_W > \hat{x}_W^{public}$ (whites know that if they have a car, then $\hat{x}_W > \hat{x}_W^{public}$), we have: $r + 2m(\theta)\hat{x}_W > r + 2m(\theta)\hat{x}_W^{public}$. As a result, using (39) and (40), the condition $U^{car} > U^{public}$ can be written as:

$$2m(\theta) \left[\int_0^{\hat{x}_W} E_W^{car}(x, w_W) dx - \int_0^{\hat{x}_W^{public}} E_W^{public}(x, w_W) dx \right] > f_W - f_B. \tag{41}$$

Using a similar argument as in (30), we can write

$$\int_0^{\hat{x}_k} E_k(x, w_k) dx = \hat{x}_k E_k(\hat{x}_k/2), \tag{42}$$

which we use to write (39) and (40) as:

$$\begin{aligned} [r + 2m(\theta)\hat{x}_W]U_W^{car} &= \Omega_W + b - f_W + 2m(\theta)\hat{x}_W E_W^{car}(\hat{x}_W/2), \tag{43} \\ [r + 2m(\theta)\hat{x}_W^{public}]U_W^{public} &= \Omega_W + b - f_B + 2m(\theta)\hat{x}_W^{public} E_W^{public}(\hat{x}_W^{public}/2). \tag{44} \end{aligned}$$

Eq. (42) also implies that (41) can be written as

$$2m(\theta) \left[\hat{x}_W E_W^{car}(\hat{x}_W/2) - \hat{x}_W^{public} E_W^{public}(\hat{x}_W^{public}/2) \right] > f_W - f_B. \tag{45}$$

If we now evaluate $E_W^{car}(x, w_W)$ and $E_W^{public}(x, w_W)$, defined by (37) and (38), at $x = \hat{x}_k/2$, we obtain:

$$\begin{aligned} (r + \delta)E_W^{car}(\hat{x}_W/2, w_W) &= \Omega_W + w_W \left(1 - \tau \frac{\hat{x}_W/2}{\mu_W} \right) - f_W + \delta U_W^{car}, \\ (r + \delta)E_W^{public}(\hat{x}_W^{public}/2, w_W) &= \Omega_W + w_W \left(1 - \tau \frac{\hat{x}_W^{public}/2}{\mu_B} \right) - f_B + \delta U_W^{public}. \end{aligned}$$

Using (43) and (44), these two equations are equivalent to:

$$\begin{aligned} rE_W^{car}(\hat{x}_W/2, w_W) &= \Omega_W - f_W \\ &\quad + \frac{\delta b + [r + 2m(\theta)\hat{x}_W]w_W \left(1 - \tau \frac{\hat{x}_W/2}{\mu_W} \right)}{[r + \delta + 2m(\theta)\hat{x}_W]}, \\ rE_W^{public}(\hat{x}_W^{public}/2, w_W) &= \Omega_W - f_B \\ &\quad + \frac{\delta b + [r + 2m(\theta)\hat{x}_W^{public}]w_W \left(1 - \tau \frac{\hat{x}_W^{public}/2}{\mu_B} \right)}{[r + \delta + 2m(\theta)\hat{x}_W^{public}]}. \end{aligned}$$

Plugging the above two equations into (45) leads to:

$$\begin{aligned} \Omega_W(\hat{x}_W - \hat{x}_W^{public}) &+ \frac{\hat{x}_W \left[\delta b + w_W \left(1 - \tau \frac{\hat{x}_W}{2\mu_W} \right) (r + 2m(\theta)\hat{x}_W) \right]}{r + \delta + 2m(\theta)\hat{x}_W} \\ &- \frac{\hat{x}_W^{public} \left[\delta b + w_W \left(1 - \tau \frac{\hat{x}_W^{public}}{2\mu_B} \right) (r + 2m(\theta)\hat{x}_W^{public}) \right]}{r + \delta + 2m(\theta)\hat{x}_W^{public}} \\ &> \frac{r(f_W - f_B)}{2m(\theta)} + \hat{x}_W f_W - \hat{x}_W^{public} f_B. \tag{46} \end{aligned}$$

Observe that

$$u_W^{car} = \frac{\delta}{r + \delta + 2m(\theta)\hat{x}_W},$$

and

$$u_W^{public} = \frac{\delta}{r + \delta + 2m(\theta)\hat{x}_W^{public}},$$

are the probabilities of being unemployed for respectively a white who owns a car and a white who deviates by using mass transit. Note that $u_W^{car} < u_W^{public}$ since $\hat{x}_W > \hat{x}_W^{public}$. Therefore, (46) can be written as:

$$\begin{aligned} \Omega_W(\hat{x}_W - \hat{x}_W^{public}) &+ \hat{x}_W \left[u_W^{car} b + (1 - u_W^{car})w_W \left(1 - \tau \frac{\hat{x}_W}{2\mu_W} \right) \right] \\ &- \hat{x}_W^{public} \left[u_W^{public} b + (1 - u_W^{public})w_W \left(1 - \tau \frac{\hat{x}_W^{public}}{2\mu_W} \right) \right] \\ &> \frac{r(f_W - f_B)}{2m(\theta)} + \hat{x}_W f_W - \hat{x}_W^{public} f_B. \end{aligned}$$

Denote each average income by:

$$A_W^{car} = u_W^{car} b + (1 - u_W^{car})w_W \left(1 - \tau \frac{\hat{x}_W}{2\mu_W} \right) \tag{47}$$

and

$$A_W^{public} = u_W^{public} b + (1 - u_W^{public})w_W \left(1 - \tau \frac{\hat{x}_W^{public}}{2\mu_W} \right). \tag{48}$$

Using these notations, the above inequality reduces to:

$$(\hat{x}_W - \hat{x}_W^{public})\Omega_W + \hat{x}_W(A_W^{car} - f_W) - \hat{x}_W^{public}(A_W^{public} - f_B) > \frac{r(f_W - f_B)}{2m(\theta)}$$

which is (27). Observe that we have shown that $U_W^{car} > U_W^{public}$ which, using (41), automatically implies that $E_W^{car} > E_W^{public}$.

Appendix D. Proof of Proposition 1

Note that $\frac{\partial \hat{x}_k}{\partial \mu_k} > 0$ (see (32)). Since whites use a faster transport mode than ethnic minorities, i.e. $\mu_W > \mu_B$, this implies that $\hat{x}_W^* > \hat{x}_B^*$. Furthermore, since we have seen that $\frac{\partial w_k}{\partial \mu_k} > 0$ (see (19)), this implies that $w_W^* > w_B^*$. Finally, it immediately follows from (5) and (6) that $u_W^* < u_B^*$.

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