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URBAN LABOUR ECONOMIC THEORY

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ABSTRACT

Urban Labour Economic Theory

In this Paper we survey some recent developments in urban labour economic theory. We first present a benchmark model in which firms set efficiency wages to prevent shirking and to compensate workers for commuting. We show that both wages and unemployment depend on commuting costs, and that housing prices as well as location are based on workers' wages. We then extend the benchmark model in two different directions. First, by assuming that workers' effort depends on distance to jobs, we show how firms draw a red line beyond which they do not hire workers. Second, by introducing high relocation costs so that workers do not change residence as soon as they change employment status, we show that efficiency wages now depend on distance to jobs. Finally, we use these theoretical models to give some microfoundations of a well-known stylized relationship: the spatial mismatch between residential location and workplace.

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Keywords: commuting, efficiency wages, land rent and spatial mismatch

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1 Introduction

The functioning of the labor market is quite complex because it involves the determination of both wages and (un)employment. At the urban level, it is even more complex since the determination of wages and unemployment are not only affected by pure labor market aspects but also by spatial features such as location and housing prices. Even though the empirical features of urban labor markets are well documented, their theoretical explanations are still not yet fully analyzed. The aim of this chapter is to present some recent developments of urban labor economic theory by investigating the interaction between land and labor markets.

To the best of our knowledge, Zenou and Smith (1995) were the first to fully analyze the interaction between these two markets by developing a model in which housing prices and workers' location (land market), as well as wages and unemployment (labor market) are determined in equilibrium. This paper constitutes the benchmark model that we will use throughout this chapter. In this simple model where workers' relocation is costless, firms set efficiency wages to prevent shirking and to compensate workers for commuting. The interaction between these two markets is here explicit since both wages and unemployment depend on commuting costs, and housing prices as well as location are in turn based on workers' wages. We then extend this benchmark model in two different directions.

First, workers' effort now negatively depends on distance to jobs because workers who have longer commuting trips are more tired and are thus less able to provide higher levels of effort than those who reside closer to jobs. By assuming that firms cannot discriminate in terms of location (i.e. cannot make wages location-dependent), we show that, in equilibrium, firms draw a red line beyond which they will not hire workers. This is because, depending on their residential location, workers do not contribute to the same level of production, even though the wage cost is location-independent. As a result, the per-worker profit decreases with distance to jobs and firms stop recruiting workers residing too far away, i.e. when the per-worker profit becomes negative.

Second, we introduce high relocation costs so that workers do not change residence as soon as they change employment status. This extension provides new insights to the model since, in particular, it makes the interaction between land and labor markets even more stronger since now the efficiency wage explicitly depends on distance to jobs.

Finally, we use these theoretical models to give some microfoundations of a well-known stylized relationship: the spatial mismatch between residential location and workplace in which workers who reside far away from jobs have lower wages and experience higher unemployment rate than those who live closer to jobs.

Observe that, because we want to use the same model throughout this chapter (the urban efficiency wage model), we do not expose another stream of the urban labor economic theory literature, namely the urban search model (see e.g. Sato, 2001, or Wasmer and Zenou, 2002). It should however be clear that the intuition of the results are very close to those presented here since the interaction of land and labor markets is determined in a similar way. There are of course important differences in the wage setting (bargaining between firms and workers rather than efficiency wages) and in the formation of urban unemployment (search frictions rather than high and rigid wages).

2 The benchmark model[1]

There is a continuum of ex ante identical workers whose mass is N and a continuum of M identical firms. Among the N workers, there are L employed and U unemployed so that $N = L + U$. The workers are uniformly distributed along a linear, closed and monocentric city. Their density at each location is taken to be M. All land is owned by absentee landlords and all firms are exogenously located in the Central Business District (CBD hereafter). Workers are assumed to be infinitely lived, risk neutral and decide their optimal place of residence between the CBD and the city fringe. There are no relocation costs, either in terms of time or money. This is a simplifying assumption, which is quite standard in urban economics. We will relax this assumption in section 4.

[1] This section is based on Zenou and Smith (1995).

Each individual is identified with one unit of labor. As in the standard efficiency wage model without space (Shapiro and Stiglitz, 1984), there are only two possible levels of effort that a worker can exert: either the worker shirks, has zero effort, $e = 0$ and contributes to zero production or he/she does not shirk, provides full effort, $e > 0$ and contributes to e production. Each employed worker goes to the CBD to work and incurs a fixed commuting cost t per unit of distance. When living at a distance x from the CBD, he/she also pays a land rent $R(x)$, consumes 1 unity of land and earns a wage w (that will be determined in the labor market equilibrium) so that the instantaneous (indirect) utilities of an employed non-shirker and shirker residing at a distance x from the CBD are respectively given by:[2]

$$V_L^{NS} = w - e - t\,x - R(x) \tag{1}$$

$$V_L^{S} = w - t\,x - R(x) \tag{2}$$

Concerning the unemployed, they commute less often to the CBD since they mainly go there to search for jobs. So, we assume that they incur a commuting cost $s\,t$ per unit of distance, with $0 < s < 1$. For example, $s = 1/2$ implies that the unemployed make only half as many CBD-trips as the employed workers. Each unemployed worker earns a fixed weekly unemployment benefit $b > 0$, pays a land rent $R(x)$, consumes 1 unit of land. In this context, the instantaneous (indirect) utility of an unemployed worker is equal to:

$$V_U = b - s\,t\,x - R(x) \tag{3}$$

As stated in the introduction, we analyze the interaction between land and labor markets. As a result, a steady-state equilibrium requires solving simultaneously two problems:

(i) a location and rental price outcome (referred to as an urban land use equilibrium).

(ii) a (steady state) labor market equilibrium with determines wages and unemployment (referred to as a labor market equilibrium).

[2]The subscript L refers to the employed whereas the subscript U refers to the unemployed. Among the employed workers, the superscripts NS and S refer respectively to non-shirkers and shirkers.

Let us first focus on the urban land use equilibrium. In equilibrium (this will become clear below), none of the employed workers will shirk so that we need analyze only the urban land use equilibrium with non-shirking workers. Since there are no relocation costs, the urban equilibrium is such that all the employed enjoy the same level of utility $V_L^{NS} \equiv V_L$ while all the unemployed obtain V_U. Indeed, any utility differential within the city would lead to the relocation of some workers up to the point where all differences in utility disappear. We are now thus able to derive the bid rents of the (non-shirking) employed workers and the unemployed.[3] They are respectively given by:

$$\Psi_L(x, V_L) = w - e - t\,x - V_L \tag{4}$$

$$\Psi_U(x, V_U) = b - s\,t\,x - V_U \tag{5}$$

It is easy to see that the bid rent of the employed is steeper than that of the unemployed and thus the employed will occupy the core of the city. This is because the employed do commute more often to the CBD than the unemployed and thus value more the accessibility to the center.

As a result, the employed reside between 0 and L/M whereas the unemployed reside between L/M and N/M. For this equilibrium to exist (see e.g. Fujita, 1989), it has to be that the equilibrium land rent is everywhere continuous in the city. By normalizing the agricultural land rent (the rent outside the city) to zero, we easily obtain the equilibrium values of the instantaneous utilities of the employed and the unemployed. There are given by:[4]

$$V_L = w - e - tN/M + (1 - s)\,tU/M \tag{6}$$

$$V_U = b - s\,t\,N/M \tag{7}$$

[3]The bid rent is a standard concept in urban economics (see e.g. Fujita, 1989). It indicates the maximum land rent that a worker located at a distance x from the CBD is ready to pay in order to achieve a utility level.

[4]To obtain these utility levels, one has to check that the bid rents of the employed and the unemployed are equal at L/M and that the bid rent of the unemployed is equal to 0 at a distance N/M from the CBD.

Let us now solve the steady-state equilibrium. Time is continuous. In the labor market, firms cannot perfectly monitor workers so that there is a probability of being detected shirking, denoted by θ. If a worker is caught shirking, he/she is automatically fired. We assume that changes in employment status are governed by a Poisson process in which a is the (endogenous) job acquisition rate and δ the (exogenous) destruction rate. The standard (steady-state) Bellman equations for the non-shirkers, the shirkers and the unemployed are respectively given by:

$$r\,I_L^{NS} = V_L^{NS} - \delta\,(I_L^{NS} - I_U) \tag{8}$$

$$r\,I_L^{S} = V_L^{S} - (\delta + \theta)\,(I_L^{S} - I_U) \tag{9}$$

$$r\,I_U = V_U + a(I_L - I_U) \tag{10}$$

where r is the discount rate, I_L^{NS}, I_L^S and I_U respectively represent the expected lifetime utility of a non-shirker, a shirker and an unemployed worker, and $V_L^{NS} \equiv V_L$ and V_U are given by (6) and (7) and $V_L^S = V_L + e$. The first equation that determines I_L^{NS} states that a non-shirker obtains today V_L^{NS} but can loose his/her job with a probability δ and then obtains a negative surplus of $I_U - I_L^{NS}$. For I_L^S, we have the same interpretation, except for the fact that a shirker can lose his/her job for two reasons: either the job is destroyed or if he/she is caught shirking. The last equation has a similar interpretation.

In this context, efficiency wages are determined by $I_L^{NS} = I_L^S = I_L$, which by using (8) and (9) can be written as:

$$I_L - I_U = \frac{e}{\theta} \tag{11}$$

This highlights the nature of the (urban) efficiency wage w_e. The intertemporal surplus of being employed $I_L - I_U$ is strictly positive and does not depend on spatial variables. This is a pure incentive effect (to deter shirking) that increases in effort and decreases in θ.

At the steady state, flows in unemployment should equal flows out unemployment, i.e.

$$a\,(N - L) = \delta\,L \tag{12}$$

By combining (11) and (12) and using (8)-(10), we are now able to give the efficiency wage. It is equal to:

$$w_e(L) = b + e + \frac{e}{\theta}\left(\frac{\delta\, N}{N - L} + r\right) + (1 - s)\, t\, L/M \tag{13}$$

This equation (13) is referred to as the Urban No-Shirking Condition (UNSC hereafter). We have the following comparative-statics effects of the efficiency wage. An increase in the unemployment benefit b, the job destruction rate δ, the discount rate r, or the commuting cost t, or a decrease in the monitoring rate θ or the unemployed CBD-trips s raises the efficiency wage. For the non-spatial elements, b, δ, r and θ, the reason is that firms have to increase their wage to meet the UNSC in order to prevent shirking. For the spatial elements, t and s, firms have to compensate their employed workers for spatial costs. Indeed, when setting their (efficiency) wage, firms must compensate the spatial cost differential between the employed and the unemployed. For the employed and the unemployed who both live at L/M (this is the border distance between the employed and the unemployed) and thus pay the same land rent, this differential is exactly equal to $(1 - s)tL/M$. Now, since mobility is costless, all the employed and unemployed workers obtain respectively the same (both instantaneous and intertemporal) utility level whatever their location. Therefore, the spatial cost differential between any employed and unemployed worker is equal to $(1 - s)tL/M$. All these elements imply that the efficiency wage has two roles: to prevent shirking (incentive component) and to ensure that workers are locationally indifferent (spatial compensation component).

It is easy to verify that the efficiency wage w_e is increasing and convex with respect to L, and that $\lim_{x_b \to N/M} w = +\infty$. This is a standard result (Shapiro and Stiglitz, 1984) that states that full employment is not compatible with efficiency wages. Indeed, if this were not true, then firms could always set an efficiency wage at the full employment level. In this context, workers would always shirk because, even if they were caught shirking, they could always find a new job. This is in contradiction with the mere nature of efficiency wages.

To close the model, let us now determine the labor demand L. There are M identical firms in the economy. Each firm $j = 1...M$ has the same production function $f(el)$, which is assumed to be twice differentiable with $f(0) = 0$, $f'(el) > 0$ and $f''(el) \leq 0$ for all l, and to satisfy the Inada conditions, i.e. $f'(0) = +\infty$ and $f'(+\infty) = 0$. All firms produce the same composite good and sell it at a fixed market price p (this good is taken as the numeraire so that its price p is set to 1). Each firm j chooses l_j that maximizes $f(el_j) - w_e l_j$ (remember that w_e is the efficiency wage that is given by (13)) so that $f'(el_j) = w_e$. At the aggregate level, the total level of employment is given by $L = lM$ so that $f'(el)$ is equivalent to $F'(eL)$ and the aggregate labor demand is defined by: $F'(eL) = w_e$. Because the labor demand is decreasing in wages and wages are increasing in employment (UNSC), it is easy to show that the steady-state equilibrium exists and is unique.

3 Redlining[5]

Let us extend the previous model by changing only one crucial aspect of the model. As above, there are only two possible levels of effort: either the worker shirks, exerting zero effort, $e = 0$, and contributing zero to production, or he/she does not shirk, providing full effort. However, the latter now depends on x, the distance to jobs, that is $e(x) > 0$, $\forall x \in [0, N]$, with $e(0) = e_0 > 0$ and $e(x)$ being the contribution to production. We assume that $e'(x) < 0$ and $e''(x) \geq 0$ so that the greater the distance to work, the lower the effort level and, for remote location, the marginal difference in effort is quite small.

This assumption $e(x)$ aims at capturing the fact that workers who have longer commuting trips are more tired and are thus less able to provide higher levels of effort (or productivity) than those who reside closer to jobs. This implies that commuting costs include more than just money and time costs. They also include these negative effects of a longer commute such as non-work-related fatigue. Moreover, this assumption can also capture the fact that workers who reside further away from jobs have less flexible working hours. For example, in some jobs (e.g. working in a restaurant), there are long breaks during the day (typically between 2 p.m. and 6 p.m. in restaurants). The

[5] This section is based on Zenou (2002).

worker who lives next door can go back home and relax whereas the others, who live far away, cannot rest home. This obviously also affects workers' productivity.

The worker's behavior can now be seen as a two-stage decision. First, each worker must decide to shirk or not, depending on their residential location. Since effort is costly, it is clear that the worker who lives the closest to jobs will be more inclined to shirk that those residing further away. Thus, contrary to Shapiro and Stiglitz (1984) and the previous model, the moral hazard problem is here locationally dependent. Second, once the worker has decided not to shirk (this is the behavior that will emerge in equilibrium), he/she must decide how much effort he/she provides. This decision is also locationally dependent since we assume that workers who have longer commutes are more tired and provide less effort than those who live closer to jobs.

Observe that the Shapiro-Stiglitz model is a special case of ours when $x = 0$, i.e., when workers are all located in one location, the CBD, or more generally when space does not affect effort. Observe also that our model is quite different from models with heterogeneous workers in which firms face an adverse selection problem because they do not observe the effort or the ability of each worker. In the present urban model, firms know the residential location (or the postal address) of each worker and it is assumed that workers cannot misreport their location. There is therefore no adverse selection problem but a moral hazard one.

All the locational analysis is exactly the same as in section 2, the only difference being that now e negatively depends on x. This creates a new locational trade-off for the employed. They would like to be close to jobs to save on commuting but would also like to be far away from jobs to provide lower levels of effort (since effort is costly). However, by assuming that $t > -e'(L/M)/(1-s)$, then we can guarantee that the employed reside close to the CBD whereas the unemployed live at the outskirts of the city. The intuition of this result is as follows. An increase in distance x has offsetting effects on employed workers: they pay higher commuting costs but lower effort is exerted on the job. The net effect is thus less than the pure commuting cost effect, and the question is whether this net effect is stronger than the shrunken commuting cost effect for unemployed workers, which is smaller than that of the employed worker because $s < 1$. In this context, when the commuting cost t is high enough, the employed workers reside close to jobs by outbidding the unemployed.

Let us solve the equilibrium. The (steady-state) Bellman equations for non-shirker, shirker and unemployed workers are still given by (8)-(10), with the only difference that I_L^S is now a function of x and is thus written as $I_L^S(x)$ since $V_L^S(x)$ is now given by $V_L^S(x) = V_L + e(x)$.

Let us determine the wage setting. Even if firms observe workers' location and thus anticipate their effort level, we do not allow them to offer different wages according to residential location. This is a legal constraint based on the fact that, in the real world, one never observes firms that discriminate across identical workers according to their place of residence.

In the previous model, the efficiency wage has been set in order to make workers indifferent between shirking and not shirking. However, in the present model, the utility of shirkers is not constant over locations whereas it is constant for non-shirkers. It is in fact easy to see that the utility of shirkers increases as x, the distance to the CBD, decreases.[6] This implies, in particular, that the highest utility that a shirker can reach is at the $x = 0$ (the CBD) and the lowest is at $x = L/M$. As a result, the efficiency wage must be set such that workers are indifferent between shirking at location $x = 0$ and not shirking, since if the worker at $x = 0$ does not shirk, then all workers located further away will not shirk. In other words, the condition that determines the efficiency wage is now given by $I_L^{NS} = I_L^S(0) = I_L$. We easily obtain:

$$w_e^r(L) = b + e(L/M) + \frac{e_0}{\theta}\left(\frac{\delta N}{N-L} + r\right) + (1-s)t\,L/M \tag{14}$$

If one compares (13) and (14), then the main difference is that, in (14), the effort function $e(\cdot)$ now depends on x the distance to jobs. Two locations

[6] The intuition is straightforward. Since the land rent compensates for both commuting costs and effort levels, then shirkers, who do not provide effort, have a higher utility when residing closer to the CBD (since their commuting costs are lower).

are crucial: the CBD where $x = 0$ and effort is e_0, and the border between the employed and the unemployed where $x = L/M$ and effort is $e(L/M)$.

Our setting thus implies that there is a fundamental asymmetry between workers and firms. All workers obtain the same efficiency wage whatever their location. However, they do not contribute to the same level of production because their effort decreases with distance to jobs. In other words, even though the wage-cost is location-independent, the contribution to production is not. This implies that the per-worker profit decreases with distance to jobs. The next natural step of our analysis is thus to calculate the per-worker profit for each firm and to determine the red line beyond which firms do not hire workers, i.e. when the per-worker profit becomes negative. It is this asymmetry between workers and firms that makes the redline story interesting. If wages were location dependent, then there would be no redlining (at least from the firms' perspective) since the per-worker profit would be location independent, firms would just set their wages contingent on the effort level provided and will be willing to hire all workers.

The interesting implication of this paper is that it can explain why firms do not hire remote workers. Indeed, if firms cannot discriminate in terms of location (make wages location dependent), they do anticipate that remote workers provide lower effort level. So they stop recruiting workers residing too far away.

Let us now calculate the labor demand. We assume that all jobs are obtained through an employment agency that coordinates workers in such a way that each firm employs only one worker at each location.[7] Since all firms and

[7]In the first period, the timing is as follows. All N workers apply for a job in the employment agency and only L of them obtain a job and locate somewhere in the city (since they are indifferent between all locations between 0 and L/M). Then, the employment agency allocates workers to firms in such a way that each firm recruits one worker at each location. This is true at any moment of time (and in particular in the steady state) since, at each period, some workers with different locations lose their job and new workers obtain a job and reside somewhere in the city between 0 and L/M. Then again, the employment agency allocates these new workers to firms in such a way that each firm (those who has lost workers) employs only one worker at each location.

workers are (ex ante) identical and since the density of workers at each location is M, we focus on a symmetric equilibrium in which each firm sets the same redline L/M. This is quite reasonable since, ex ante (before location), all workers are equally productive (location is not a characteristic of a worker), and, ex post (once located), they are all indifferent to work in any of the M firms since all firms are located at 0 and offer the same wage $w_e^r(L)$. In this context, since all firms are identical, the employment level in each firm j is equal to: $l_j = l = L/M$.

We are now able to calculate the total production (or effort) level provided in each firm. It is given by: $\overline{e} = \int_0^{L/M} e(x)dx$. Each firm $j = 1, ..., M$ has the same production function given by $f(\overline{e})$, which has the same properties as in the previous section, and chooses its recruitment area L/M that maximizes its profit by taking the efficiency wage as parametric. We obtain: $f'(\overline{e}) = w/e(L/M)$. This equation states that the optimal recruitment area L/M chosen by each firm is such that the marginal productivity of workers is equal to their cost per efficiency unit of labor. This determines the labor demand in each firm. Now, since all firms are identical, by symmetry, all L/M are equal. Since there are M firms in the economy, the aggregate production function $F\left(M\,\overline{e}\right) = M\,f\left(\overline{e}\right)$ and the total labor demand in the economy is equal to L. The aggregate equivalent is thus given by:

$$F'(M\,\overline{e}) = \frac{w}{e(L/M)}$$

As in the previous model, it is easy to show that the steady-state equilibrium exists and is unique because the labor demand is decreasing in wages and, using (14), wages are increasing in employment.

4 Mobility costs[8]

So far, we have assumed that there were no mobility/relocation costs, which implied that workers changed their residential location as soon as they changed their employment status. Empirical evidence indicate that there are in fact

[8]This section is based on Zenou (2003).

high mobility costs (especially for low-income households) and that they must be taken into account. So let us now examine how the model in section 2 can be modified to incorporate these costs.

Because it can be quite complicated, we take the other extreme assumption that there no mobility at all, i.e. relocation costs are infinite. As a result, people stay in the same location when they change their employment status and all workers are indifferent to any location in the city and reside anywhere between the CBD and N/M.

We assume perfect capital markets with a zero interest rate,[9] which enable workers to smooth their income over time as they enter and leave unemployment: workers save while employed and draw down on their savings when out of work. Because workers are able to smooth their income over time, a worker's residential location remains fixed as he/she enters and leaves unemployment.

We thus consider the average expected utility of a worker rather than, as in the previous models, the lifetime expected utilities of employed and unemployed workers. At any moment of time, workers can either be employed or unemployed. As before, we assume that changes in the employment status (employment versus unemployment) are governed by a continuous-time Poisson process so that job contacts (that is the transition rate from unemployment to employment) randomly occur at an endogenous rate a while the exogenous job separation rate is δ. In this context, the expected duration of employment is given by $1/\delta$ for non-shirkers and $1/(\delta+\theta)$ for shirkers whereas the expected duration of unemployment amounts to $1/a$. It then follows that a worker spends a fraction $a/(a+\delta)$ if non-shirker and $a/(a+\delta+\theta)$ if shirker of his/her lifetime employed and a fraction $\delta/(a+\delta)$ if non-shirker and $(\delta+\theta)/(a+\delta+\theta)$ if shirker of his/her lifetime unemployed. In steady state, flows into and out of unemployment are equal. Therefore, the unemployment rate of non-shirkers is given by:

$$u \equiv u^{NS} = \frac{\delta}{a+\delta}$$

[9] 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.

while the one of shirkers is equal to:

$$u^S = \frac{\delta + \theta}{a + \delta + \theta}$$

with $u^S > u^{NS}$, $\forall a, \delta, \theta > 0$.

Since workers have a zero discount rate, they only care about the average income over time. For the non shirker, it is equal to:

$$\begin{aligned} EV^{NS} &= \left(1 - u^{NS}\right)\left[w - e - tx - R(x)\right] + u^{NS}\left[b - stx - R(x)\right] \\ &= \frac{a}{\delta + a}(w - e) + \frac{\delta}{\delta + a} b - \left(\frac{a + s\delta}{\delta + a}\right) tx - R(x) \end{aligned}$$

whereas for the shirker, it is given by:

$$\begin{aligned} EV^{S} &= \left(1 - u^{S}\right)\left[w - e - tx - R(x)\right] + u^{S}\left[b - stx - R(x)\right] \\ &= \frac{a}{\delta + \theta + a} w + \frac{\delta + \theta}{\delta + \theta + a} b - \left[\frac{a + s\left(\delta + \theta\right)}{\delta + \theta + a}\right] tx - R(x) \end{aligned}$$

Now, firms know that workers have a zero discount rate so they equate these two equations, i.e. the average income over time of a non shirker is equal to the one of a shirker. By doing that, we easily obtain the following efficiency wage:

$$w_e^m(x) = b + e + \frac{e}{\theta}\left(\delta + a\right) + \left(1 - s\right) tx$$

By using (12), we finally obtain:

$$w_e^m(x) = b + e + \frac{e\delta}{\theta}\frac{N}{N - L} + \left(1 - s\right) tx \tag{15}$$

The following comments are in order. First, compared to (13), the efficiency wage (15) is the same when $r \to 0$ and $x = L/M$. Second, what is new here is the fact that the efficiency wage is now distance-dependent. Indeed, because workers are totally immobile and care only about the fraction of time they spent in each employment state, firms have to compensate workers for different commute costs. The intuition is as follows. As above, the efficiency wage has two roles: to prevent shirking (this is captured by the negative relationship between the efficiency wage and the unemployment level) and to compensate workers for commuting costs (this is captured by the positive relationship between the efficiency wage and the distance to jobs and the commuting costs). Thus, compared to someone who lives closer to the CBD, a worker who live further away from jobs has to be compensated for the extra cost of commuting he/she spends to work to the CBD when employed. Third, it is interesting to observe that when the commuting costs of the employed and the unemployed are assumed to be the same (as in Brueckner and Zenou, 2003), then the efficiency wage becomes independent of x and is exactly equal to (13) with $r \to 0$.

We are now able to calculate the bid rent of all workers in the city (nobody will shirk in equilibrium). The expected utility of a worker is given by[10]

$$\begin{aligned} EV &= \frac{a}{\delta + a}(w_e^m(x) - e) + \frac{\delta}{\delta + a}b - \left(\frac{a + s\delta}{\delta + a}\right) tx - R(x) \\ &= b + \frac{ea}{\theta} - stx - R(x) \end{aligned}$$

If we denote that I the (expected) utility reached by all workers in the city, then the bid rent is equal to

$$\begin{aligned} \Psi(x, I) &= b + \frac{ea}{\theta} - stx - I \\ &= b + \frac{e}{\theta}\frac{\delta(1-u)}{u} - stx - I \end{aligned}$$

Interestingly, when a, L, b, e, δ increase or when θ, u, s, t, I decrease, the bid rent increases. The utility I is pin down by the fact that the bid rent at the city-fringe is equal to the agricultural rent (normalized to zero). We thus obtain:

$$I = b + \frac{e}{\theta}\frac{\delta(1-u)}{u} - stN \tag{16}$$

We can now determine the labor market equilibrium. As in section 3, we focus on a symmetric equilibrium in which each firm hires a worker at each location. Each firm adjusts employment until the marginal product of an additional worker equals the efficiency wage so that we have

$$M \int_0^{N/M} w_e^m(x)dx = pF'((1-u)N) \tag{17}$$

[10]Recall that $u = \delta/(\delta + a)$ or equivalently $a = \delta(1 - u)/u$.

which is equivalent to

$$\left[b + e + \frac{e\delta}{\theta u}\right] N + (1-s)\, t \frac{N^2}{M} = pF'((1-u)N) \tag{18}$$

We have thus two equations (16) and (18) and two unknowns I and u. It is easy to show that there exists a unique equilibrium (I^*, u^*).

5 Spatial mismatch

We would like now to use the two models of sections 3 and 4 to give some theoretical foundations for a well-established empirical fact: the spatial mismatch between workers' location and their workplace. The spatial mismatch hypothesis, first formulated by Kain (1968), states that black workers, residing in urban segregated areas distant from and poorly connected to major centers of employment growth, face strong geographic barriers to finding and keeping well-paid jobs. In the US context, and perhaps because of discrimination and high prices in the housing market in the suburbs, black workers were forced to stay in the central part of the city, far away from jobs that are nowadays mostly created in the suburbs. So the main contribution of the spatial mismatch hypothesis is to explain the high unemployment rates and the low wages among blacks via the increasing distance between their residential location and their workplace.

Several papers have tested this relationship and have shown that bad job accessibility indeed worsens labor-market outcomes, confirming the spatial mismatch hypothesis (see the surveys by Holzer, 1991, Kain, 1992, and Ihlanfeldt and Sjoquist, 1998). However, most of the papers do not have no theoretical foundation. Thus, using the two models of sections 3 and 4, we would like to provide an economic mechanism for the spatial mismatch hypothesis.

The model of section 3 offers an explanation by focusing on the point of view of firms. If firms cannot discriminate on the basis of race by offering different wages for the same job, then they can discriminate on the basis of location by setting higher job rejection rates for those residing far away from jobs, which is frequently the case for ethnic minority workers. In other words, even though firms have no prejudices against black workers, it is rational for them not to hire black workers if they live too far away (i.e. beyond the recruitment area determined by firms). One of the main ideas developed in this model is that residential distance to jobs is a key factor in understanding the labor market policy of firms. In particular, workers who reside in remote areas far away from jobs have less chance to obtain a job than those living closer.

The model of section 4 can be extended (Brueckner and Zenou, 2003) to account for the spatial mismatch. These authors consider a closed linear city with absentee landlords with an employment center at each end of the segment: the Central Business District (CBD) and the Suburban Business District (SBD). There are two continua of individuals, blacks and whites, who are uniformly distributed in the city and go to work in one center or the other. Each individual chooses the location of his/her job by comparing the wages offered in each center net of commuting costs. The authors assume housing market discrimination so that blacks are not authorized to live in the suburbs (close to the SBD). In this context, black workers are skewed towards the CBD and blacks' residences are thus remote from the SBD. For a black worker, working in the SBD involves high commuting costs, which may deter many of them from accepting SBD jobs. As a result, the black CBD labor pool is large relative to the black SBD pool, and the competition among blacks for central jobs is thus fiercer.

The labor market of black workers is exactly the one described in section 4. Relocation costs are very high and wages are endogenously determined to deter shirking (efficiency wages) but, because commuting costs are exactly the same when workers are employed or unemployed, the efficiency wage is equal to (15), with $x = 0$, i.e. $w_e^m(0) = b + e + \frac{e\delta}{\theta}\frac{N}{N-L}$. Space (either through x or t) has no effect on wages and we are basically back to the Shapiro's and Stiglitz's wage when $r \to 0$. This simplifies the analysis and allows the authors to characterize the labor market equilibrium as follows. Because labor demand is the same at the CBD and the SBD but labor supply is asymmetric, it is easy to see that the unemployment rate of blacks is higher and their wage lower when they work in the CBD than in the SBD. This is because, unemployment acting as a worker discipline device, enables employers to pay low wages when unemployment is high. So the main argument of this paper is that suburban housing discrimination skews black workers towards the CBD and thus keeps black residences remote from the suburbs. Since black workers who work in the SBD have more costly commutes, few of them will accept SBD jobs, which makes the black CBD labor pool large relative to the SBD pool. Under an efficiency wage model, this enlargement of the CBD pool leads to a high unemployment rate among CBD workers.

This analysis thus generates a link between unemployment and a seemingly unrelated phenomenon: racial discrimination in the housing market. In this respect, it gives a theoretical foundation for the spatial mismatch relationship since, compared to a market with no mobility restriction, housing discrimination imposes to black workers longer commutes, which, via the efficiency wage mechanism, results in higher unemployment rate and lower (average) income.

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