City Structure, Search and Workers' Job Acceptance Behavior

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Abstract: This paper develops a stochastic search model having a monocentric city structure and investigates how city structure affects workers' job acceptance behavior and a labor market. In the model, workers reside in a city and commute to the Central Business District (CBD) to work when employed and to be interviewed when unemployed. When a job searcher contacts a firm having a vacant job, he/she observes the level of training costs necessary for employment and decides whether to accept the job. It is shown that there exists a unique equilibrium in which the employed live close to the CBD and the unemployed reside far away from it. Analysis shows that 1) improvement of commuting technology induces job searchers to accept more costly jobs and lowers the unemployment rate in the city, and 2) as job searchers search more intensively, they become choosier if commuting costs are sufficiently small. Efficiency properties of the equilibrium are also explored.

Keywords: City structure; Stochastic job search; Job acceptance

1 INTRODUCTION

In the modern economy, many people reside and work in cities. In fact, World Urbanization Prospect (2001) reports that in 2000, 76 percent of the populations of developed countries live in urbanized areas, while this figure is 39 percent in developing countries. In light of this high degree of urbanization, urban economists have investigated the features of urban labor markets. Among the vast volume of studies on urban labor markets, there is a strand of studies that has focused on the relationship between cities and unemployment.

Recently, search and matching models with urban structures have been developed in order to analyze this relationship. For example, Wasmer and Zenou (2002) showed that when workers' search intensity is negatively affected by access to jobs, different configurations emerge in equilibrium: one is such that unemployed workers live close to jobs and the other is such that they reside far away from jobs. The latter is consistent with the spatial mismatch hypothesis that claims that the job decentralization to the suburbs not combined with residential movement of African Americans has created the high unemployment rate and low wages in inner-city neighborhoods where African Americans are concentrated (see Kain (1968)). Smith and Zenou (2003) showed that when search intensity is endogenously determined, another type of configuration is obtained in equilibrium: the unemployed live either close to or far away from jobs and the employed live in between the unemployed. Rouwendal (1998) demonstrated the possibility of excess commuting due to job search costs. Sato (2001) showed the link between agglomeration economies and a worker-firm matching process.

This paper aims to contribute this research area by constructing a stochastic search model having a monocentric city structure and examining how city structure affects a labor market *via* workers' job acceptance behavior. To the best of the author's knowledge, no existing study has analyzed this issue. Labor economists have shown that worker's job acceptance behavior is one of the most important factors that influence a labor market (see Pissarides (2000)). It would then be meaningful to shed light on the relationship between city structure and job acceptance behavior, if any.

In the model described in this paper, workers reside in a city in which there are no relocation costs. While employed workers commute to the Central Business District (CBD) to work, unemployed workers commute to the CBD to be interviewed. The employed are assumed to commute more frequently than do the unemployed. When a worker gets employed by a firm, he/she must bear the training costs, of which level is determined stochastically and is not observable for each worker until he/she contacts a firm. Contacting a firm having a vacant job, each job searcher observes the level of training costs and decides whether to accept the job. Under these assumptions, a unique market equilibrium is shown to exist in which both land and labor markets are solved simultaneously. In the equilibrium, the employed live close to the CBD and the unemployed reside far away from the CBD.

The main results are the following. First, improvement of commuting technology induces job searchers to accept more costly jobs and lowers the unemployment rate in a city. Second, as job searchers search more intensively, they become choosier if commuting costs are sufficiently small. Finally, it is shown that the equilibrium is not optimal since under-acceptance takes place in the workers' job acceptance decision. An adequate urban policy such as a subvention for commuting is shown to solve this problem.

2 MODEL

2.1 City structure

Consider a city that is closed and linear. The city is monocentric (i.e., it has one CBD that is approximated by a point and all firms are assumed to be exogenously located in the CBD). Its land is owned by absentee landlords. There is a continuum of risk-neutral workers of size n in the city. u of n are unemployed and $n-u$ are employed. Workers live infinitely and they reside, occupying the same amount of land (normalized to 1), outside the CBD. We assume that the density of land is 1. Employed workers commute to the CBD once per each unit time. Unemployed workers go to the CBD to be interviewed s times per unit time, where we assume that s is exogenous and that $0<s<1$. This assumption implies that the unemployed commute less frequently than do the employed. Larger s indicates that unemployed workers search for jobs more intensively. Let tx denote the commuting cost for the employed who reside at a location that is x distant from the CBD, with $t>0$. The commuting cost for the unemployed at location x is then stx. The cost of living in the city is the sum of the residential land rent $R(x)$ and the commuting cost: $R(x)+tx$ for an employee and $R(x)+stx$ for a job searcher.

2.2 Matching framework

In the city, there are v firms that have vacant positions searching for workers. We assume that each firm can employ only one worker. Job contacts are generated by a Poisson process with the aggregate rate of $M=\mu(su,v)$. $\mu(su,v)$ is defined on $\mathbf{R}_+\times\mathbf{R}_+$ and strictly increasing in both its arguments. $\mu(su,v)$ is assumed to be twice differentiable, strictly concave, homogeneous of degree one, and to satisfy $0\le\mu(su,v)\le\min[su,v]$ and $\mu(su,0)=\mu(0,v)=0$. $\mu(su,v)$ is called the "technology of search." For each unemployed worker, such job contacts arrive at the rate of $p(\theta)=M/u=\mu(s,\theta)$, and for each vacant firm at the rate of $q(\theta)=M/v=\mu(s/\theta,1)$, where θ is

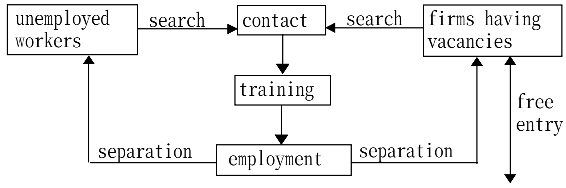

Figure 1: The outline of the model

the measure of labor market tightness and is defined as $\theta=v/u$. Note that $p(\theta)u=q(\theta)v$, $dp/d\theta>0$ and $dq/d\theta<0$ for any $\theta\in(0,+\infty)$. From this, we can see that there inevitably exist externalities in the matching process ($\partial p/\partial u<0$, $\partial q/\partial u>0$, $\partial p/\partial v>0$ and $\partial q/\partial v<0$). Finally, we assume that $\lim_{\theta\to0}dp/d\theta=\infty$ and $\lim_{\theta\to\infty}dp/d\theta=0$.

Just when an unemployed worker gets employed by a firm, the worker must train himself/herself and bear the costs for it. This assumption considers that because workers differ in their preference and ability to have heterogeneous skills, it is often the case that the skill of a particular worker does not meet the skill requirement of a particular firm and the worker needs to train himself/herself to adjust his/her skill in order to meet the skill requirement of the firm when becoming employed by it. The level of training costs is assumed to be match-specific and to be determined stochastically. A worker does not know the level of training costs until he/she contacts a firm. When a job searcher contacts a firm having a vacant job and perceives the level of training costs necessary to become employed by the firm, he/she decides whether or not to accept the job. If the searcher accepts it, he/she carries out training and gets employed by the firm. Otherwise, the searcher starts searching again. Thus, flows out of unemployment are given by acceptable job matches from job contacts. We assume that separation of a job and a worker is generated by a Poisson process with the exogenous aggregate rate of δ.

2.3 Workers

An unemployed worker, bearing the cost of living $R(x)+tx$, goes to the CBD to be interviewed and receives unemployment benefits b. Just when an unemployed worker becomes employed by a firm, the worker must bear training costs. The level of training costs c is assumed to be a random variable whose cumulative distribution function $F(c)$ is defined on $[0,\overline{c}]$ and is continuously differentiable, where $\overline{c}$ is a positive constant. A worker does not know c until he/she contacts a firm. When a job searcher contacts a firm having a vacancy and observes c, he/she decides whether to accept the job. If the searcher accepts it, he/she trains himself/herself and get employed by the firm. Otherwise, he/she starts searching again. It is assumed that after the training, every worker-firm pair attains the same level of productivity, which implies that every employed worker receives the same wage. An employed worker, bearing the cost of living $R(x) + tx$, goes to the CBD to work and receives a wage w. We assume that workers can change their location costlessly. Let $W(x)$ and $U(x)$ be the discounted expected incomes (asset values) of the employed and the unemployed, respectively. Let $\Lambda(x, c)$ represent the worker's value of contacting a vacant job that requires training costs of level c. Furthermore, we define $W_{\max}$ and $U_{\max}$ as the maximized values of $W(x)$ and $U(x)$ with respect to x (i.e., $W_{\max} = \max_x W(x)$ and $U_{\max} = \max_x U(x)$). These incomes are given by

$$rW(x) = w - R(x) - tx + \delta \{U_{\max} - W(x)\}, \quad (1)$$

$$\begin{aligned} rU(x) &= b - R(x) - stx + p(\theta) \\ &\quad \times \{E_c(\Lambda(x, c)) - U(x)\}, \qquad (2) \\ \Lambda(x, c) &= \max[W_{\max} - c, U(x)], \end{aligned}$$

where r is the discount rate and $E_c(\Lambda(x, c))$ is the expectation of $\Lambda(x, c)$ with respect to c.

2.4 Firms

Let J and V be the discounted expected incomes of a firm employing a worker and a firm having a vacant job, respectively. We assume that a firm having a vacancy must bear costs k per unit time. Output of a worker-firm pair y is assumed to be exogenous and to be larger than the unemployment income b. The discounted expected incomes are given by

$$rJ = y - w + \delta(V - J), \quad (3)$$
$$rV = -k + q(\theta)\Pr(\text{accept})(J - V), \quad (4)$$

where $\Pr(\text{accept})$ is the probability that the match is accepted by a worker when a firm contacts the worker.

3 EQUILIBRIUM

In order to determine the equilibrium, we will proceed as follows. We first derive conditions that determine the urban configurations (the spatial conditions). We then explore conditions that generate the labor market outcomes (the labor market conditions). The equilibrium is a set of variables that satisfies all these conditions simultaneously.

3.1 Spatial conditions

Since we assume that there are no relocation costs, no worker has an incentive to relocate in equilibrium. Hence, in equilibrium, all the employed workers enjoy the same level of income ($W(x) = W_{\max} = \overline{W}$) and all the unemployed workers enjoy the same level of income ($U(x) = U_{\max} = \overline{U}$). This implies that the worker's value of contacting a vacancy $\Lambda(x, c)$ does not depend on a location ($\Lambda(x, c) = \Lambda(c)$). In order to determine the equilibrium location of workers, we use the concept of bid rents. They are defined as the maximum land rent at location x which each type of worker is willing to pay in order to reach his/her respective equilibrium utility (in this paper, income) level. From this definition, (1) and (2) give the bid rents of the employed and unemployed, respectively:

$$\begin{aligned} \Omega_e(x, \overline{W}, \overline{U}) &= w - tx + \delta\overline{U} - (r + \delta)\overline{W}, \\ \Omega_u(x, \overline{W}, \overline{U}) &= b - stx + p(\theta)E_c(\Lambda(c)) \\ &\qquad - \{r + p(\theta)\}\overline{U}. \end{aligned}$$

Differentiating these gives the bid rent slopes of each type of worker: $\partial\Omega_e/\partial x = -t$, $\partial\Omega_u/\partial x = -st$. Since $0 < s < 1$, the bid rent of the employed is steeper than that of the unemployed. The residential land rent $R(x)$ is the upper envelope of all workers' bid rents and of the agricultural land rent that is assumed to be zero:

$$R(x) = \max[\Omega_e(x, \overline{W}, \overline{U}), \Omega_u(x, \overline{W}, \overline{U}), 0]$$

for each $x \in [0, \overline{x}]$, where $\overline{x}$ represents the edge of the city. The fact that the bid rent of an employed worker is steeper than that of an unemployed worker implies that the possible equilibrium urban configuration is such that the employed reside near the CBD and the unemployed live on the outskirts of the city. With this configuration, the edge of the city $\overline{x}$ is determined such that the bid rent of the unemployed is equal to the agricultural rent (the city edge condition):

$$R(\overline{x}) = \Omega_u(\overline{x}, \overline{W}, \overline{U}) = 0. \quad (5)$$

Let x_0 denote the location of the border between the employed and unemployed. Then, at location x_0, the bid rent of the employed is equal to that of the unemployed (the border condition):

$$R(x_0) = \Omega_e(x_0, \overline{W}, \overline{U}) = \Omega_u(x_0, \overline{W}, \overline{U}). \quad (6)$$

Since each worker occupies one unit of land, it must be the case that $\overline{x} = n/2$ and $x_0 = (n - u)/2$. The equilibrium urban configuration is determined by the above two conditions, which we refer to as the spatial conditions.

3.2 Labor market conditions

When a job searcher contacts a firm having a vacanct job and observes the level of necessary training costs, he/she will accept the job if the expected employed income minus the training costs $\overline{W} - c$ is higher than the expected unemployed income $\overline{U}$. If $\overline{W} - c$ is lower than $\overline{U}$, he/she will reject the job. Therefore, if the level of training costs c is lower (higher) than $\overline{W} - \overline{U}$, then the worker accepts (rejects) the job. This optimization behavior of a worker represents the labor supply condition. We define c^* as $c^* = \overline{W} - \overline{U}$, and we call c^* the reservation training level of a worker. From this, we can compute the probability that the match is accepted by a worker when an encounter between a worker and a firm takes place $\Pr(\text{accept})$ and the expectation of the worker's value of contact $E_c\left(\Lambda(c)\right)$. We assume free entry of firms. Therefore, vacant jobs are created until the expected income of a firm having a vacancy V is equal to zero:

$$V = 0. \tag{7}$$

This represents the labor demand condition. The wage is determined by Nash bargaining between a firm and a worker,which is commonly used in the search theoretic models (see Pissarides (2000), for example). Therefore, the wage w is determined to satisfy

$$\overline{W} - \overline{U} = \beta(\overline{W} + J - \overline{U} - V), \tag{8}$$

where β indicates the bargaining power of workers. Finally, we assume the steady state condition. This requires that the number of employed workers $n - u$ is unchanged given the number of workers n:

$$F(c^*)\mu(u, v) = \delta(n - u). \tag{9}$$

$F(c^*)\mu(u, v)$ represents the flow per unit time into the pool of employed workers, and $\delta(n - u)$ the flow per unit time out of the pool of it. We refer to the above four conditions (the labor supply condition $c^* = \overline{W} - \overline{U}$, the labor demand condition (7), the Nash bargaining condition (8), and the steady state condition (9)) as the labor market conditions.

3.3 Market Equilibrium

We are now ready to explore the equilibrium of the model. Remaining variables to be determined are the incomes of the employed and the unemployed ($\overline{U}$ and $\overline{W}$), the reservation training level (c^*), the measure of labor market tightness (θ), the wage (w) and the number of the unemployed (u). These are determined by the spatial conditions and the labor market conditions.

From the spatial conditions (5) and (6), we can prove that $\overline{U}$ and $\overline{W}$ are described as functions of c^*, θ, w, and u. The Nash bargaining condition (8) yields the wage w as a function of c^*, θ and u. Furthermore, the steady state condition (9) determines the number of unemployed workers u as a function of θ and c^*. Therefore, all the other variables are determined if c^* and θ are determined. c^* and θ are determined by the following two conditions. (These functions and conditions are described in Sato (2003).) One is the labor supply condition ($c^* = \overline{W} - \overline{U}$) and the other is the labor demand condition (7).

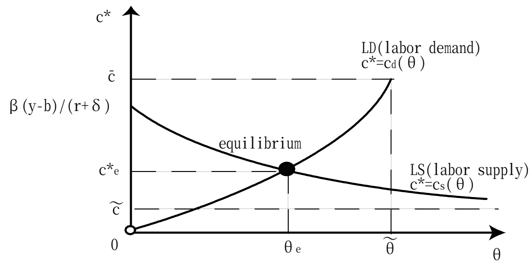

Figure 2: The equilibrium

The labor supply condition is represented by the labor supply function $c^* = c_s(\theta)$ and by the negatively sloped labor supply curve (**LS**) in the $\theta - c^*$ plane as described in Figure 2. When the measure of market tightness θ is high, there are many vacant jobs per job searcher. This enables job searchers to contact firms easily and allows them selectivity in rejecting jobs that require high training costs, which implies low c^*. The labor demand condition is represented by the labor demand function $c^* = c_d(\theta)$ and by the positively sloped labor demand curve (**LD**) in the $\theta - c^*$ plane as described in Figure 2. When job searchers are very selective and c^* is low, firms having vacant positions have difficulty in filling their vacancies. This indicates that the expected revenue of a firm having a vacant job is small while the cost of maintaining a vacancy is irrelevant to workers' behavior. Therefore, there is not much incentive for firms to open vacancies and the measure of market tightness θ is low.

The equilibrium is summarized by a tuple (c^*, θ) that is determined by these two equations. From Figure 2, we can see that the **LS** and **LD** intersect once at (c^*_e, θ_e) in the $\theta - c^*$ plane and that the equilibrium exists and is unique. The relevant variables of the equilibrium are marked with the subscript e. The following proposition summarizes the above arguments. Proofs of propositions are given in Sato (2003).

Proposition 1 *If $\overline{c} \geq \beta(y-b)/(r+\delta)$, the equilibrium exists and is unique.*

Hereafter, we assume the inequality $\overline{c} \geq \beta(y-b)/(r+\delta)$. This guarantees that the equilibrium consists of interior solutions.

4 INFLUENCE OF CHANGES IN CITY STRUCTURE ON THE LABOR MARKET

In this section, we investigate the effects of changes in the city's structural parameters on the equilibrium.

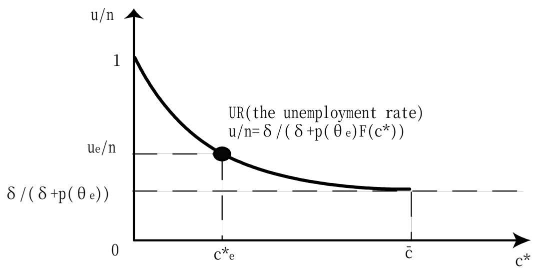

Figure 3: The unemployment rate

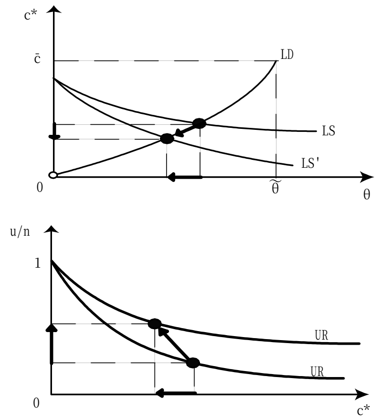

Figure 4: A change in commuting cost

In doing so, we focus on the effects on the reservation training level of a worker c_e^*, on the measure of market tightness θ_e and on the unemployment rate u_e/n. From (9), the unemployment rate u/n is given by

$$\frac{u}{n} = \frac{\delta}{\delta + p(\theta)F(c^*)}.$$

For a given θ, this is represented by the negatively sloped unemployment rate curve (UR) in the $c^* - u/n$ plane. The equilibrium unemployment rate u_e/n is described in Figure 3.

4.1 Commuting cost

First, we consider a change in commuting cost t. While a rise in t does not affect the labor demand condition, it does affect the labor supply condition and shifts the **LS** downward as described in Figure 4 (**LS** to **LS'**). From Figure 4, we can see that a rise in the commuting cost decreases both θ_e and c_e^*. Therefore, the **UR** move upward (**UR** to **UR'**) and u_e/n increases.

Proposition 2 *A rise in the commuting cost t decreases both the reservation training level of a worker c_e^* and the measure of market tightness θ_e, and increases the unemployment rate u_e/n.*

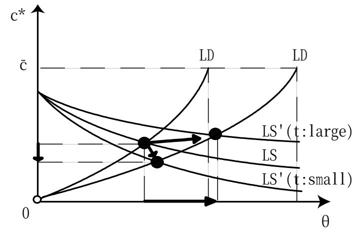

Figure 5: A change in search intensity

A rise in the commuting cost increases the burden from commuting of the employed more than that of the unemployed and lowers the attractiveness of being employed, which makes workers less tolerant of training given the likelihood of job interviews. This reduces the probability that each job interview bears fruit and lowers the expected revenue of a firm having a vacant position. Hence, the number of firms having vacant position decreases to lower the measure of market tightness and raise the unemployment rate.

4.2 Search intensity

Next, we explore the effect of a change in job search intensity s. A rise in s shifts the **LD** downward. It moves the **LS** upward when the commuting cost t is large and downward when t is small. As job searchers search more intensively, a firm's possibility of contacting a worker becomes higher ($\partial q/\partial s > 0$). This induces more firms to open vacancies for a given reservation training level of a worker and the **LD** moves downward. Compared with this, a rise in s has two effects on the **LS**. One is such that it reduces the difference in the cost of living between the employed and the unemployed, which raises the attraction of being employed and makes workers more tolerant of training given the likelihood of job interviews. The other is that it raises the worker's possibility of contacting a firm ($\partial p/\partial s > 0$), which makes workers more selective. When t is small (large), the latter (former) effect dominates the former (latter) and the **LS** shifts downward (upward). These are illustrated in Figure 5. From Figure 5, we can understand the effect of an increase in s on θ_e and c_e^*. The effect on u_e/n is ambiguous.

Proposition 3 *When the commuting cost t is large, an increase in the job search intensity s adds toθ_e. When t is small, it decreases c_e^*.*

5 WELFARE ANALYSIS

In this section, we explore the efficiency properties of the equilibrium. The efficiency criterion is the same as that used in Pissarides (2000), the output of the city.

The output of the city Π is defined as

$$\Pi = \int_0^\infty e^{-r\tau}\Bigg\{(n-u)y + ub - u\theta k - up(\theta)\int_0^{c^*} cf(c)dc - 2\int_0^{(n-u)/2} txdx - 2\int_{(n-u)/2}^{n/2} stxdx\Bigg\}d\tau.$$

The social planner is subject to the same matching constraints as workers and firms. Therefore, the evolution of unemployment that constraints social choices is the same as the one that constrains private choices:

$$\dot{u} = \delta(n-u) - p(\theta)F(c^*)u.$$

In this paper, we evaluate the optimal path in the steady state. Let $c^* = c_o(\theta)$ and $\theta = \theta_o(c^*)$ be the functions that represent the optimality conditions. The former is concerned with the reservation training level c^* and the latter is concerned with the measure of market tightness θ. (These conditions are fully described in Sato (2003).) Here, let $\theta = \theta_d(c^*)$ be the inverse function of the labor demand function $c^* = c_d(\theta)$.

Proposition 4 *The labor supply condition generates too little acceptance for a given measure of market tightness ($c_s(\theta) < c_o(\theta)$). The labor demand condition gives the optimal measure of market tightness for a given reservation training level ($\theta_d(c^*) = \theta_o(c^*)$) if and only if the bargaining power of workers β is equal to $1/\{1+\xi(c^*)\eta(\theta_d)\}$, where $\xi(c^*) = 1 - \int_0^{c^*} cf(c)dc/(F(c^*)c^*)$ and $\eta(\theta_d) = dp(\theta_d(c^*))/d\theta$. Therefore, the equilibrium is not optimal.*

Search and matching externalities generally cause distortions. However, the private return of an entering firm coincides with its social return, and the equilibrium condition with respect to the measure of market tightness generates its optimal level given other variables when the matching technology exhibits constant returns to scale and the bargaining power of workers takes some particular value (See Hosios (1990).).

Under the labor supply condition, some of the socially beneficial jobs are rejected. This is because while workers bear all the training costs, revenue from employment is devided between workers and firms through the Nash bargaining. Proposition 2 and 4 provide us one policy implication: an adequate transportation policy can solve the under-acceptance problem. More concretely, consider a subvention for commuting whose rate is σ. Then, the commuting cost per distance for workers becomes $(1-\sigma)t$. Let $c^* = c_{s\sigma}(\theta)$ be the labor supply function under the subvention whose rate is σ. It is easily shown that for any θ, there exists a particular subvention rate $\sigma^* > 0$ that eliminates the under-acceptance problem; that is, $c_{s\sigma^*}(\theta) = c_o(\theta)$ (see Sato (2003)).

6 CONCLUSIONS

This paper developed a stochastic search model having a monocentric city structure and investigated how urban structure affects workers' job acceptance behavior and a labor market. The unique equilibrium in which employed workers live close to the CBD and unemployed workers reside far away from the CBD was shown to exist. We showed that 1) improvement of transportation technology induces workers to accept jobs that require more training costs and lowers the unemployment rate in a city, and 2) as workers search for jobs more intensively, they become more selective if commuting costs are sufficiently small. It was also shown that the equilibrium is not optimal since workers underaccept jobs and that an adequate subvention for commuting can solve this problem.

These results indicate that urban structure has significant influence on workers' job acceptance behavior. Hence, it is worth recognizing them in determining such urban policies as commuting policies.

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