INTRAURBAN WAGE GRADIENTS:
EVIDENCE BY RACE, OCCUPATIONAL CLASS,
AND SECTOR

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Intraurban Wage Gradients: Evidence By Race, Occupational Class, and Sector

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FOREWORD

There is a concern among some policy makers that the mismatch between job location and resident location, particularly for Blacks, is growing. This paper adds to the little that we know about wage gradients in urban areas -- the way in which wage rates decline (or increase) as jobs are located greater distances from the Central Business District. The results here do not indicate that lower skilled black workers are paid a compensating wage differential to commute to suburbs, indicating a shortage of alternative central city jobs for low skilled black workers. This is an important and different finding.


Roy Bahl
Atlanta, GA
March 19, 1990
ABSTRACT

A general functional form is used to estimate intraurban wage gradients for various groups of workers with 1980 data from the Philadelphia metropolitan area. As predicted by the standard monocentric model of urban land use, the following results were obtained for most groups: negative and statistically significant wage gradients, steeper wage gradients for higher wage earners, and an increase in the steepness of wage gradients as the CBD is approached. Positive wage gradients were not found for lower skilled black workers, despite the fact that suburban employers hire large numbers of these workers who reside within the central city. This result is taken as support for the hypothesis that blacks have been disadvantaged by job suburbanization and continued housing market segregation.
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I. Introduction

The existence of intraurban wage gradients is of interest for several reasons. First, systematic spatial variation in wage rates within urban areas will influence the location of economic activity and the commuting patterns and transportation demands of urban workers. Second, because negative wage gradients are predicted by the standard monocentric model of urban land use, the existence of such gradients is a confirmation of this model. Third, the decentralization of lower-skilled jobs, combined with the suburban residential exclusion of low-income households, may cause a positive wage gradient for these jobs. If this is the case, and if housing market discrimination restricts the relative ability of blacks to offer their labor supply to suburban employers, then at least part of the racial difference in earnings can be attributed to housing segregation. Finally, the existence of wage gradients has important implications for studies that make earnings comparisons among different groups of workers. With few exceptions, these studies have treated intraurban variation in wage rates as part of the residual. However, this will lead to biased estimates if wage gradients exist, because the work locations of different groups of workers, for which earnings comparisons are frequently made, are not randomly distributed within urban areas (Ihlanfeldt, 1988).

A number of studies have investigated differences in the average wage paid across large intraurban work areas, where these areas are most frequently the central city and the suburban ring (Segal, 1960; Rees and Schultz, 1970; Wachter, 1972; Ehrenberg and Goldstein, 1975; Straszheim, 1980a, 1980b; Ihlanfeldt, 1988).\(^1\) However, only Eberts (1981) has estimated intraurban wage gradients. He found negative and statistically significant relationships between the wage rate and the airline distance between the location of the job
and the CBD for four of five groups of municipal public employees. Eberts believes his results for public sector labor markets can be used to infer characteristics of intraurban private sector labor markets, since evidence he cites suggests there is considerable mobility between public and private sector jobs. However, the pattern of unionization, and the laws governing collective bargaining, dispute resolution, and wage determination may be sufficiently different between the public and private labor markets to cause wage gradients to differ. It is, therefore, important to estimate separate gradients for private and public employees. An additional limitation of Eberts' analysis is that his data did not enable him to include any worker productivity variables in his equations, other than the number of hours worked per week. There is, therefore, a real possibility that the omission of relevant variables biased his results.

The purpose of this paper is to present evidence obtained from the 1980 Public-Use Microdata Sample (PUMS) for the Philadelphia MSA on the existence, shape, and slope of intraurban wage gradients. The PUMS contained a sufficient number of observations to estimate separate gradients for groups of workers categorized by occupation, race, and sector (private vs. public). It was therefore possible to investigate for the first time a number of hypotheses regarding differences in wage gradients between blacks and whites, and among different occupational groups.

In the following section, hypotheses regarding intraurban wage gradients are reviewed. Section III contains a comparison for Philadelphia of work site and workers' residential locations for various occupational classes. These comparisons set the stage for the empirical work presented in Sections IV and V, which provide a description of the estimated equations
and a discussion of the results, respectively. The conclusions of the paper are stated in Section VI.

II. Hypotheses

A negative relationship between the price per unit of housing services and distance from the CBD (i.e., a declining housing price gradient) is predicted by the standard urban land use model. This prediction has generally been supported by those studies that have carefully controlled for other determinants of the price of housing (e.g., Muth, 1969; Mills, 1969; Jackson, 1979), including one that used data from the Philadelphia metropolitan area (Edelstein, 1974), which is the area studied in the present paper. If the metropolitan labor market conforms to the conditions required for perfect competition, in particular perfect mobility, a declining housing price gradient implies that the wage gradient must also be negative. Wage rates must be higher at work sites closer to the CBD to compensate workers for the higher cost of closer in housing or for the higher transportation cost incurred by commuting from more distant residential locations where housing costs are lower. Formally, the condition that must be satisfied in order for workers to be indifferent to their work location is that the decline in the wage rate from working one mile farther from the CBD must be equal to the savings in commuting costs: i.e.,

\[ \frac{\partial w(k)}{\partial k} = -0.125 t(k), \]

where \( w \) is the hourly wage rate, \( k \) is the number of miles that the job is located from the CBD, and \( t \) is the cost of one-mile of round-trip commuting. The multiplication of \( t(k) \) by 0.125 assumes that the cost of commuting is amortized over an eight hour workday.
In addition to the prediction that wage gradients have negative slope, additional hypotheses can be deduced by making reasonable assumptions regarding the components of t(k). Assume that commuting speed is 1/s miles per hour and that speed declines as the CBD is approached because congestion increases (Moses, 1962). Also assume that the value of one hour of travel time is equal to some constant fraction, a, of the hourly wage rate (Beesley, 1973; Keeler, et al., 1975). The value of t(k) can therefore be expressed as

\[ t(k) = 2(s(k) a w(k) + m), \]

where out-of-pocket commuting cost is m dollars per mile. The rate of change in the wage gradient as distance to the CBD increases is obtained by substituting (2) into (1) and differentiating with respect to k:

\[ \frac{\partial w_s(k)}{\partial k} = -0.25s(k)aw_k - 0.25s_kaw(k), \]

where a subscript indicates a partial derivative. Since the sign of (3) is positive, wage gradients will increase at an increasing rate as the CBD is approached. There are two reasons for this: (1) the first term on the right hand side of (3) indicates the wage rate increase per mile is larger closer in because travel time is more valuable for those workers with higher paying jobs closer to the CBD, and (2) the second term on the right hand side of (3) indicates that the increase is also larger closer in because the time necessary to travel another mile is higher because of greater traffic congestion.

Finally, substituting (2) into (1) and differentiating with respect to the wage rate indicates that gradients will be steeper for higher wage workers:

\[ \frac{\partial w_s(k)}{\partial w(k)} = -0.25as(k) \]
Equation (4) states that the increase in the steepness of the wage gradient as the wage rate increases at a particular distance from the CBD is directly related to the opportunity cost of traveling an additional mile.

In summary, three testable hypotheses regarding intraurban wage gradients are obtained from the standard urban land use model: (1) wage gradients will be negatively sloped, (2) wage gradients will not be linear, but will instead increase in steepness as the distance to the CBD declines, and (3) wage gradients will be steeper for higher wage workers.

The urban land use model assumes that locational choices are unconstrained. Workers therefore maximize their utility by selecting a residential location that is farther from the CBD than their job location and commute inward toward the CBD. The assumption of unconstrained residential location may be untenable in the case of unskilled or low-skilled workers. These workers are frequently excluded from suburban neighborhoods as the result of fiscal zoning, the racial or class prejudice of housing suppliers, and the necessity by lower income households to purchase less expensive, filtered-down housing within the central city. If these exclusions are sufficiently strong, as White (1976, 1978, 1988) has noted, a suburban firm located at some distance \( k' \) may find an insufficient labor supply farther out than the firm itself, and willing to work for the \( w(k') \) implied by the standard model. At this wage, the firm's labor demand exceeds supply. To satisfy its labor requirements, this firm will have to raise wages in order to induce workers who live beyond a distance \( k_L \) to outcommute, where \( k_L < k' \). Firms at distances greater than \( k' \) will have to pay correspondingly higher wage rates to compensate outcommuters for their longer commutes. Hence, beyond \( k_L \) the wage gradient changes from negative to positive in slope. Straszheim (1980a, 1980b) has
suggested that for lower-skilled black workers the wage gradient may be positive throughout the metropolitan area because these workers remain concentrated in ghettos located within or close to the CBD. In the context of White’s model, this equates to a $k’$ that is equal to zero. Straszheim’s model predicts that wage gradients for blacks will rise and for whites will decline. These predictions are based on the assumption that black workers outcommute and white workers incommute. It is also necessary to assume that a finite elasticity of substitution exists between equally skilled black and white workers. Wage gradients can only differ between blacks and whites if race is a factor in hiring decisions.

In summary, in the absence of outcommuting caused by labor shortages that may arise at some distance from the CBD, we would expect the negative wage gradients predicted by the standard urban land use model. However, if labor shortages for certain groups of workers do exist, the models of White and Straszheim suggest that positive gradients will prevail, at least beyond some distance from the CBD. In the next section, evidence is presented on whether or not there are shortages of resident labor for particular types of jobs within the suburbs of Philadelphia.

III. An Overview of the Spatial Characteristics of the Philadelphia Labor Market

For a small number of large metropolitan areas, the 1980 PUMS identifies the job and residential locations of individual workers for subcounty areas. Among this set of MSAs, Philadelphia was selected as the study area, because it provided the greatest amount of geographical disaggregation. Twenty-seven work areas are identified: the CBD, the rest of the central city, and twenty-five suburban planning districts. Residential location is identified
for these same areas, except the CBD is not separately identified within the central city.

Another unique characteristic of the Philadelphia PUMS that led to its selection is that the same work areas and residential areas are identified for the A (2.5%) and B (0.5%) samples. These samples were therefore combined to form a three percent sample.²

The areas identified were used to divide the SMSA into the central city, inner suburban ring, middle suburban ring, and outer suburban ring. For each of these divisions, the number of jobs within a particular occupational class found in the area was divided by the number of workers within that occupational class who reside in the area (labelled the "import ratio"). Separate import ratios were computed for blacks and whites. An import ratio greater than (less than) one indicates that the area is a net importer (net exporter) of workers within the designated occupational/racial class.

In the context of the standard urban land use model, workers' residential locations are more decentralized than their job locations. That is, the employment density gradient is steeper than the population density gradient. This implies that the magnitude of the import ratio will systematically decline for the four areas identified as distance from the CBD increases.

As indicated in Table 1, import ratios do get smaller for white workers the farther the area is located from the CBD. This holds true for all seven occupational classes. Import ratios are greater than one for the central city, and generally smaller than one for each of the suburban rings. The central city is therefore a net importer of suburban workers and the basic commuting direction is toward the CBD. In light of this evidence, the expectation is that
<table>
<thead>
<tr>
<th></th>
<th>Central City</th>
<th>Inner Ring</th>
<th>Middle Ring</th>
<th>Outer Ring</th>
</tr>
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<tbody>
<tr>
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<td>.70</td>
<td>.61</td>
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<td>.65</td>
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<td>Craftsmen</td>
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<td>.77</td>
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<tr>
<td>Laborers</td>
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<td>.88</td>
<td>.75</td>
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<tr>
<td><strong>Black</strong></td>
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<td></td>
<td></td>
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<td>1.29</td>
<td>1.08</td>
<td>1.00</td>
</tr>
</tbody>
</table>

**SOURCE:** 1980 Public-Use Microdata Sample.
negative wage gradients exist for all of Philadelphia’s white workers, regardless of their occupational class.

The bottom of Table 1 presents the import ratios computed for blacks. In contrast to whites where import ratios are highest for the central city, for blacks import ratios are highest for the inner suburban ring for all seven occupational classes. For the professional and managerial, sales, and administrative support occupational classes, import ratios are larger than one for both the central city and the inner suburban ring and less than one for the middle and outer suburban rings. This indicates that for these groups commuting tends to be toward the CBD as implied by the standard model. Hence, for these groups, negative wage gradients are also expected.

For the remaining four occupations - craftsmen, service workers, operatives, and laborers, central city import ratios are less than one, which indicates that the central city is a net exporter of workers to the suburbs. This is further illustrated by the residential locations of black workers in these occupations who work within the inner suburban ring: forty-four percent live within the inner ring, forty-one percent live within the central city, and the other fifteen percent are located in the middle and outer suburban rings. Since for these groups suburban employers rely heavily on outcommuters from the central city, positive wage gradients are expected. The fact that import ratios are generally less than or equal to one for the middle and outer rings suggests that wage rates peak within the inner ring.

In this section, the locations of jobs relative to the locations of worker residences for the Philadelphia metropolitan area were described using the concept of the import ratio. The evidence presented suggested that negative wage gradients should apply for all white workers
and for all white-collar black workers. However, black workers in blue-collar and service occupations were observed to be net outcommuters from the central city to the suburbs. For them, at least some portion of the wage gradient is expected to be positively sloped. We now turn to the methods that were employed to estimate the wage gradients for the various groups.

IV. Estimated Equations

The relationship between the wage rate paid to the worker and the distance his job is located from the CBD was investigated by using the 1980 PUMS data for Philadelphia to estimate wage equations of the following general functional form:

$$ W_i^{(r)} = \beta_0 + \sum_{j=1}^{J} \beta_j X_{ij} + \alpha D_i^{(r)} + \epsilon_i, $$  \hspace{1cm} (5)

where $W_i$ is the hourly wage rate of the ith individual; $X_{ij}$ is the jth characteristic variable for the ith individual; $D_i$ is the distance in miles between the CBD and the ith worker’s job location; and $\epsilon_i$ captures the unobserved variables and is assumed to be $N(0, \sigma^2)$. $D_i$ was estimated by assigning each worker the airline distance between the CBD and the center of the largest city or town within the work area that his or her job was located.\textsuperscript{3} Because intra-area differences in work locations are not captured, $D_i$ contains an unknown amount of measurement error. However, because of the large number of work areas identified (27), these errors are not expected to cause unreliable results. Evidence in support of this expectation was obtained by conducting Hausman’s (1978) specification test on errors in variables.\textsuperscript{4}
The $X_{ij}$ variables included age, age squared, years of schooling, schooling squared, age times years of schooling, whether a disability limits work, past unemployment, veteran status, marital status, and sex. These variables represent a union of the sets of variables found significant in a number of earlier earnings studies employing PUMS data (Long, 1987; Gwartney, 1978; and Herzog, 1985).\footnote{5}

The sample was stratified by race (blacks and whites), by occupational class (professionals and managers, sales, administrative support, craftsmen, service, operatives and laborers), and by sector (private, federal government, state government, and local government). An equation was estimated for each subsample that included a minimum of 100 observations.

The transformations of the wage rate and distance variables are those proposed by Box and Cox (1964), namely,

$$W_{i}^{(\lambda_1)} = \frac{(W_{i}^{\lambda_1} - 1)}{\lambda_1}, \quad \lambda_1 \neq 0$$

$$= \ln W_i, \quad \lambda_1 \neq 0$$

$$D_{i}^{(\lambda_2)} = \frac{(D_{i}^{\lambda_2} - 1)}{\lambda_2}, \quad \lambda_2 \neq 0$$

$$= \ln D_i, \quad \lambda_2 \neq 0.$$  

The $\lambda_1$ and $\lambda_2$ parameters were permitted to take on values that resulted in the following alternative functional forms: linear, log-log, semi-log, reverse semi-log, reciprocal, logarithmic reciprocal, and exponential.\footnote{6} Also tested but not expressed by (5) where quadratic and cubic forms.
V. Results

In those cases where a statistically significant wage gradient was found, the Box-Cox loglikelihood function was maximized for $\lambda_1 = \lambda_2 = 0$, which is the double-log functional form. The null hypothesis that the wage-distance relationship is linear, $H: \lambda_1 = \lambda_2 = 1$, was consistently rejected at the five percent level of significance. The results therefore support the hypothesis that wage rates increase at an increasing rate as the CBD is approached.

Table 2 reports distance elasticities obtained from the estimated double-log equations for white and black private sector employees, respectively. (Also reported are mean wage rates for each occupational group.) For whites, negative and statistically significant (at the one percent level by a one-tailed test) wage gradients were found for five of the seven occupational classes. For the other two occupational classes, service workers and laborers, the estimated distance coefficient was positive, but statistically insignificant. As a check on these results, the hypothesis that there is no spatial variation in the wage rates paid to workers in these two occupational classes was tested. This involved estimating a wage equation that included the $X_{ij}$ variables and dummy variables for 26 of the 27 identified work areas. The joint significance of the area dummies was determined to test the null hypothesis,

$$H_0: \gamma_1 = \gamma_2 = \ldots = \gamma_{26} = 0.$$ 

The F-statistics for this test are 1.10 and .92 for service workers and laborers, respectively. These results indicate that the null hypothesis of insignificance cannot be rejected. An explanation for the absence of spatial wage variation for laborers is that roughly 35 percent are employed in construction and therefore do not have a fixed work location. The finding of an insignificant wage gradient for white service workers can partially be attributed to the fact...
<table>
<thead>
<tr>
<th>Occupational Class</th>
<th>Mean Wage</th>
<th>Estimated Coefficient</th>
<th>t-statistics</th>
<th>Obs.</th>
<th>Mean Wage</th>
<th>Estimated Coefficient</th>
<th>t-statistics</th>
<th>Obs.</th>
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</thead>
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<tr>
<td>Professional and Managerial</td>
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<td>$8.00</td>
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<td>.26</td>
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<td>-.030</td>
<td>-6.18</td>
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<td>-.021</td>
<td>-2.32</td>
<td>4230</td>
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</table>
that these workers earn, by far, the lowest wage rates of any occupational class and therefore have the lowest opportunity cost of commuting time. In addition, the import ratios of Table 1 suggest that job and worker gradients have similar slopes in the case of white service workers, which indicates that these workers tend to live relatively close to where they work. This was confirmed by computing mean travel to work times for each of the occupational classes. For white service workers the mean one-way commute was only 18.8 minutes. In comparison, white workers in the other occupational classes had mean travel times ranging from 22.7 to 27.3 minutes. Since white service workers are not required to make long commutes (and place a low value on travel time), employers need not provide much of a compensating differential for travel costs.

The estimated distance elasticities for white workers roughly conform to the hypothesis that wage gradients are steeper for higher wage workers. The largest distance elasticity (-.053) was found for the highest wage group -- professional and managerial workers, while no statistically significant gradient was found for the lowest wage group -- service workers. Excluding laborers, workers in occupations with mean wages in between the highest and lowest wage group had elasticities ranging between -.021 and -.037. There is no pattern between the mean wage rate and the magnitude of the estimated distance elasticity among these in between groups. However, the range in wage rates among these groups is only $2.65, which may be too small in light of the stochastic nature of the estimates to effectively test the hypothesis.

Turning to the results obtained for blacks, negative and statistically significant wage gradients were found for only two of the seven occupational groups; namely, professional and
managerial workers and administrative support workers. For these two groups, the Box-Cox log-likelihood function was again maximized for the double-log functional form. For the other five groups, estimated distance coefficients were not statistically significant for any of the various functional forms. Once again, joint significance tests using area dummy variables were performed and the null hypothesis of no spatial wage rate variation for these occupational groups was confirmed.

The negative gradients found for professional and managerial workers and administrative support workers are consistent with the import ratios presented in Table 1, since these workers were found to commute toward the CBD. The relative magnitudes of the distance elasticities estimated for these groups are also consistent with the hypothesis that wage gradients are steeper for higher wage earners. However, since sales workers were also found on net to be incommuters, the insignificant gradient observed for them was unexpected. We can offer no explanation for this contrary result, expect to note that for this group the sample size may have been too small to pick up the wage gradient effect.

The central city is a net exporter and the inner suburban ring is a net importer of black blue-collar and service workers. Positively sloped wage gradients were expected, but were not found. These results suggest that extra compensation is not required in order to induce lower skilled black workers to reverse commute between the central city and the inner suburbs. There are two possible explanations for this finding: 1) employers located within the inner suburban ring may not be required to offer much of a wage inducement to workers imported from the central city if jobs within the inner ring are easily accessible to these workers; 2) a wage inducement may also be unnecessary if imported workers are unable to
find alternative employment within the central city at a competitive wage. To investigate the first explanation, mean one-way commuting times broken down by mode of transportation were computed for black blue-collar and service workers who resided in the central city and worked within the inner suburban ring. Seventy percent of these workers were found to commute by automobile and the mean commuting time was 38 minutes. Twenty-five percent used public transportation and on average took over 60 minutes to get to work. Clearly, jobs within the inner suburbs are not easily accessible to black central city residents. Black lower-skilled workers who outcommute to the inner suburbs and beyond, which the PUMS data indicate exceeds 15,000 individuals, are obviously suffering substantial declines in their earnings, net of commuting costs, as the result of their long commutes. The only reasonable explanation for this behavior is that these workers cannot find alternative employment within the central city at a competitive wage, and therefore suburban employers do not have to pay them a compensating differential to cover their commuting costs. If there is a shortage of jobs within the central city, we would also expect that the central city unemployment rate of lower-skilled black central city residents would be high, since many black workers may be unable or unwilling to make the long commute to a suburban job. The unemployment rate among black workers with no more than a high school education living within the city of Philadelphia in 1980 was 11 percent. In contrast, the unemployment rate of less educated black workers was 6 percent or less in a majority of the individual areas that constitute the inner suburban ring.

The wage, commuting time, and unemployment rate evidence presented for Philadelphia's lower-skilled black workers are all consistent with John Kain's (1968) spatial
mismatch hypothesis. According to this hypothesis, the suburbanization of lower-skilled jobs and continued housing market segregation have acted together to reduce the economic welfare of central city blacks.

The distance elasticities estimated for public sector employees are reported in Table 3. Many of the cells contained too few observations (i.e., less than 100) for reliable estimation, including all of those defined for state government workers. However, in most cases sample sizes were sufficiently large to estimate wage gradients for professional and managerial workers, administration support workers, and service workers employed in the federal government and local government sectors. For white workers, negative and statistically significant wage gradients were found for all five groups where estimation was conducted. For professional and managerial workers and administrative support workers employed by the federal government, estimated distance elasticities were very similar to those obtained for the private sector. In addition, the elasticity for professional and managerial workers employed by local government was exactly the same as that obtained for the private sector. However, the elasticities estimated for administrative support and service workers employed by local government were substantially larger than those obtained for private sector workers. Service workers employed by local government have better paying jobs (mean wage rate = $7.00) than service workers in the private sector (mean wage = $4.50) because of occupational differences. Service workers employed by local government are most frequently policemen and firemen, while service workers in the private sector are most frequently employed in private household, food preparation, or personal service occupations. Therefore, the higher estimated distance elasticity estimated for local government workers is consistent with the
<table>
<thead>
<tr>
<th></th>
<th>Federal</th>
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<th></th>
<th>Local</th>
<th></th>
<th></th>
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<tr>
<td></td>
<td>Mean Wage</td>
<td>Estimated Coefficient</td>
<td>$t$-statistics</td>
<td>Obs.</td>
<td>Mean Wage</td>
<td>Estimated Coefficient</td>
<td>$t$-statistics</td>
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<tr>
<td><strong>White</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Professional and Managerial</td>
<td>$10.78</td>
<td>-0.048</td>
<td>-3.05</td>
<td>472</td>
<td>$9.89</td>
<td>-0.053</td>
<td>-3.74</td>
</tr>
<tr>
<td>Administrative Support</td>
<td>7.99</td>
<td>-0.036</td>
<td>-2.13</td>
<td>716</td>
<td>5.56</td>
<td>-0.076</td>
<td>-3.92</td>
</tr>
<tr>
<td>Service</td>
<td>less than 100 obs.</td>
<td></td>
<td></td>
<td></td>
<td>6.93</td>
<td>-0.098</td>
<td>-5.55</td>
</tr>
<tr>
<td><strong>Blacks</strong></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Professional and Managerial</td>
<td>less than 100 obs.</td>
<td></td>
<td></td>
<td></td>
<td>8.37</td>
<td>-0.039</td>
<td>-1.01</td>
</tr>
<tr>
<td>Administrative Support</td>
<td>8.25</td>
<td>-0.086</td>
<td>-2.39</td>
<td>259</td>
<td>6.64</td>
<td>-0.049</td>
<td>-1.20</td>
</tr>
<tr>
<td>Service</td>
<td>less than 100 obs.</td>
<td></td>
<td></td>
<td></td>
<td>6.62</td>
<td>-0.047</td>
<td>-1.14</td>
</tr>
</tbody>
</table>
expectation that higher wage workers have steeper wage gradients. However, the magnitudes of the elasticities estimated for both local government service workers (-0.098) and local government administrative support workers (-0.76) are higher than those obtained for any other group, public or private. These high elasticities may reflect the fact that there is an inverse relationship between distance from the CBD and the population size of the local government unit. Larger governments may have the budgetary wherewithal to hire employees with more specialized skills and therefore tend to pay higher average wage rates. Unfortunately, the data did not permit an investigation of this hypothesis.

The wage gradients estimated for black public sector workers were all negative and distance coefficients were comparable in magnitude to those obtained for blacks with white-collar jobs in the private sector. However, although the distance coefficients in all four of the estimated equations had associated t-statistics greater than one, only the coefficient estimated for administrative support workers employed by the federal government was significant at the five-percent level. Small samples, especially for blacks working in local government sector jobs in the suburbs, may account for these results.

Thus far the discussion has focused on the existence of wage gradients and not much has been said regarding their quantitative importance. To study this, the implied percentage decline in wages between working at the CBD and working at various distances from the CBD was computed for those groups of workers where a statistically significant wage gradient was found. Table 4 reports the total percentage wage decline at 5, 10, and 20 miles from the CBD, respectively. Working 10 miles from the CBD reduces the earnings of private sector workers by 5.0 percent to 18.7 percent, depending on the group considered. Working
TABLE 4

Total Percentage Decline in Wages at Various Distances From the CBD
in Comparison to a CBD Work Location

<table>
<thead>
<tr>
<th></th>
<th>Five Miles From CBD</th>
<th>Ten Miles From CBD</th>
<th>Twenty Miles From CBD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Private Sector Employees</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Whites</td>
<td></td>
<td></td>
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<tr>
<td>Professional and Managerial</td>
<td>9.5</td>
<td>12.7</td>
<td>16.1</td>
</tr>
<tr>
<td>Sales</td>
<td>6.6</td>
<td>8.9</td>
<td>11.3</td>
</tr>
<tr>
<td>Administrative Support</td>
<td>5.4</td>
<td>7.2</td>
<td>9.1</td>
</tr>
<tr>
<td>Craftsmen</td>
<td>3.8</td>
<td>5.0</td>
<td>6.4</td>
</tr>
<tr>
<td>Operatives</td>
<td>4.5</td>
<td>6.0</td>
<td>7.6</td>
</tr>
<tr>
<td>Blacks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Professional and Managerial</td>
<td>13.9</td>
<td>18.7</td>
<td>23.7</td>
</tr>
<tr>
<td>Administrative Support</td>
<td>7.5</td>
<td>10.1</td>
<td>12.8</td>
</tr>
<tr>
<td><strong>Public Sector Employees-Federal</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Whites</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Professional and Managerial</td>
<td>8.6</td>
<td>11.5</td>
<td>14.6</td>
</tr>
<tr>
<td>Administrative Support</td>
<td>6.4</td>
<td>8.6</td>
<td>11.0</td>
</tr>
<tr>
<td>Blacks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Administrative Support</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Public Sector Employees-Local</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Whites</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Professional and Managerial</td>
<td>9.5</td>
<td>12.7</td>
<td>16.1</td>
</tr>
<tr>
<td>Administrative Support</td>
<td>13.6</td>
<td>18.2</td>
<td>23.1</td>
</tr>
<tr>
<td>Services</td>
<td>17.5</td>
<td>23.5</td>
<td>29.8</td>
</tr>
</tbody>
</table>
20 miles from the CBD reduces earnings by 6.4 percent to 23.7 percent. The results, therefore, indicate that the wage gradient phenomenon is an important source of wage variation within metropolitan areas.

One way to judge the reasonableness of these estimates is to assume realistic values of the operating and time costs involved in commuting and calculate an implied percentage wage decline per mile. Based upon such assumptions for a typical worker and the assumption of a linear wage gradient, Mills and Hamilton (1989) have estimated that wages should decline about one percent for each additional mile the job is located from the CBD. The numbers in Table 4 are roughly consistent with this expectation for jobs located at distances of ten miles or less from the CBD. Beyond ten miles, the estimated gradients become relatively flat, implying wage declines of much less than one percent per mile.

VI. Conclusions

This paper has provided some rare evidence on intraurban wage gradients. The negative slope and curvilinear shape of the gradients found for white-collar and blue-collar white workers and for white-collar black workers are consistent with the predictions obtained from the standard monocentric model of urban land use. The model is appropriate for these groups because they were observed to commute toward the CBD.

In contrast to the above groups, black blue-collar and service workers were found to be net outcommuters from the central city. The models of White and Straszheim predict that outcommuting will result in positive wage gradients. These models assume that workers can find alternative employment with the central city, and therefore suburban employers must pay
imported workers a compensating differential to cover their commuting costs. The results of this study are contrary to this prediction and indicate that lower-skilled black workers do not earn more outside the central city, despite the long average commute associated with a suburban job. These findings are consistent with the hypothesis that there exists a surplus of resident black labor within the central city. Policies to improve the accessibility of suburban jobs to lower-skilled black workers are strongly recommended by this study.
FOOTNOTES

1 These studies should not be confused with those that have made earnings comparisons between central city and suburban residents (Vrooman and Greenfield, 1980; Reid, 1985 Price and Mills, 1985). The purpose of the latter studies has been to investigate the effect of residential location on earnings and not to provide evidence on the spatial variation in wage rates within urban areas.

2 The A and B samples of the PUMS are actually five and one percent samples, respectively. However, as a cost-saving measure the Census Bureau only recorded work location for one-half of these samples. Observations including work location information constitute random subsamples of the total files.

3 For central city workers whose job was located outside the CBD, $D_i$ equalled one-half of the mean of the north, south, east, and west radial distances between the edge of the CBD and the city limits.

4 This test involves comparing OLS and instrumental variable (IV) estimates. An IV estimator is asymptotically unbiased, but also inefficient. The OLS estimator is efficient but possibly biased if measurement errors are present. A test of the difference between IV and OLS estimates is a test of the null hypothesis of no misspecification. To construct the IV, all workers who reported they used private motorized transportation to get to a job located within the CBD were extracted from the total sample. This subsample was used to compute for each work area the mean travel time to the CBD. Non-CBD workers were assigned the time for that area within which their job was located. This variable was judged an acceptable instrument since it is highly correlated with the distance the worker's job is located from the CBD and is expected to be uncorrelated with the disturbance. The OLS and IV estimates were compared for selected groups of workers and were not found to be statistically different. The null hypothesis of no misspecification could therefore not be rejected.

5 A number of variables known to affect earnings (e.g., achievement motivation) are not provided by the PUMS data. This may bias estimates of the wage gradient if workers possessing more of a particular unobservable earnings characteristic tend to select jobs that are located at only certain distances from the CBD. For example, if more motivated workers self-select jobs located within the central city, the estimated coefficient on $D_i$ will be biased downward. Some evidence on this issue has been provided by Ihlanfeldt (1988), which suggests that this type of potential bias is not a major concern. PUMS data for the Atlanta metropolitan area were employed to test for selectivity bias using the two-step procedure outlined by Heckman (1976). In the first step, maximum likelihood probit models were estimated for each race, where the dependent variable equalled one if the individual worked in the central city and zero if the work location was the suburbs. In the second step, the sample was stratified by race, occupational class, and work location to form twelve subsamples. For each subsample, a separate earnings equation was estimated which included a selectivity
variable predicted from the probit results. If the estimated coefficient on this variable is not significantly different from zero, the null hypothesis that sample selection is an unimportant phenomenon can be accepted. In ten of the twelve regressions, the results indicated that self-selection of work location is an unimportant phenomenon. In the other two cases the results suggested that self-selection may cause the steepness of the wage gradient to be underestimated.

6To allow those functional forms that logarithmically transform D_i, one mile was added to all estimated values of D_i.

7The estimated coefficients on the X_ij variables were generally significant and of the anticipated sign in the equations estimated for the twenty-three different groups. To conserve space, these results are not reported.

8The "too-large sample size problem" may exist in the case of white private-sector workers, since six of the seven samples contained over 3,000 observations. Leamer (1978) has suggested that the significance level be adjusted downward as the sample size grows to improve the interpretation of the data against a null hypothesis. A one-percent rather than the conventional five-percent level of significance is therefore used for white private-sector workers.
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