Title
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BLACK AND WHITE COMMUTING BEHAVIOR IN A LARGE SEGREGATED CITY: EVIDENCE FROM ATLANTA*

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ABSTRACT

Previous research has shown that households are sensitive to commuting distance. In particular, households beyond a threshold distance move closer to the job when they change residence. The questions which motivate this paper are--how does race affect the probability of moving closer to the job when households change residence, and is there a trade off between commuting distance and neighborhood composition? Using a specialized data set the research shows that the commuting behaviors of minority and white households are consistent with the overall hypothesis that households minimize their commuting distance whenever possible. The research also shows that there is a tendency for both white and black households to choose slightly more integrated settings after changing residences. Yet, black households have to juggle the trade-off between neighborhoods with high socio-economic status and commute distance and those who choose higher socio-economic status neighborhoods have longer commutes.

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There is now substantial evidence that shows that households are sensitive to commuting distance. This is expected from theory that emphasizes the trade-off of commuting costs and housing costs. Models of household responses to commuting distance show that the probability of decreasing the journey to work increases with the length of the commute between work and residence. The question which is addressed in this paper is whether the sensitivity to the commute distance is affected by race (we have few specific studies of the commuting behavior of African American households), and whether there is a trade off between commuting behavior and the choice of residential neighborhood composition.

The literature which has considered black commuting distances and work-residence separation for black households suggests that there is a commute penalty for African Americans regardless of their skill level or gender (Press, 2000, Stoll, 2000). Most of this research has been couched within the framework of the spatial mis-match hypothesis that African Americans are penalized by the location of jobs. Instead of setting the debate in the context of the spatial pattern of jobs, we want in this paper to examine the trade off between commuting and the selection of neighborhood racial composition. We know that both black and white households have distinct preferences for particular combinations of residents of their own race (Clark, 1992, Farley, 1978). How do households exercise these choices in the context of commuting distance?

This analysis uses a specialized sample of households in the Atlanta metropolitan region to examine the responses of individuals to the pattern of work locations in the Atlanta region. By using a sample of teachers and schools we remove some of the issues of job concentration as schools are distributed across the residential landscape and offer work opportunities at various sites, close to, and far from, particular teaching households. The data set, by its nature also

controls for socio-economic status, including both income and educational dimensions, and allows us to examine the interrelated nature of residential choices and commuting behavior holding socio-economic status constant. Because the African American community is spatially segregated we can examine the impact of this separation on commuting behavior.

BACKGROUND

The trade-off between commuting costs and housing costs has always been central to models of residential location (Alonso, 1964; Muth 1969). Households evaluate the benefits of particular housing locations and the costs of commuting between these locations and their workplaces. But while economic models have established the formality of a linkage between the work place and residence, much of that work has focused on the aggregate patterns of housing costs and distance between central work locations and dispersed residences. Moreover, most of the research has not been focused on how responsive households are to increasing separation between residence and workplace.

Until recently, few studies had examined the complex intersection of residential location, job location and commuting in a dynamic context. Levinson (1997) attempted to unravel the complexity of the job-commute-residence nexus by focusing on job duration and residence duration. Levinson argued that individuals who have recently changed their jobs or residence should have shorter than average commutes, if indeed these relocations are induced by the desire to reduce commuting distance or time. Similarly, individuals with a long duration of employment and residence should have shorter than average commutes since these households have remained spatially stable. Thus, he establishes the necessary behavioral interdependence of workplace and residential location, unlike research that continues to treat workplace and residence choice as exogenous.

Related work in a series of Dutch papers (van Ommeran, Rietveld and Nijkamp, 1996; Rouwendal and Rietveld, 1994) also take up the issue of the residence-commuting link by examining job *search* behavior and job locations. Using a search model framework they ask how residential changes and job changes are interrelated. These studies develop a sophisticated theoretical framework to show that an increase in commuting distance increases the probability of accepting an alternative job offer or a residential offer. In essence these studies find that households are quite susceptible to separation between work and residence and deal with that separation by adjusting their job or their residence location to shorten the commute.

Although not all transport theorists agree, van Ommeren et al (1996, 2000) make a strong argument that job moves precede and trigger residential moves. Thus, persons accept jobs first and then move their residences closer to the new work location. The later notion is consistent with our behavioral model which predicts that, ceteris paribus, households do want to minimize the commuting distance. Waddell (1993) and Linneman and Graves (1983) also found that the sequence of workplace and residence choices were linked. At the same time Clark and Withers (1999) find that residence changes within the city often lead to job changes so the inter-connections are far from simple. Even if we cannot be sure of the causal linkage we can be sure that there are actions and reactions to the separation between work and residence.

Increasingly, commuting studies are also set within discussions of the impact of urban structure. Several studies have shown that suburban work locations may reduce commutes (Cervero and Wu, 1997; Cervero and Landis, 1992) and others have emphasized the role of the jobs-housing balance in shortening commutes (Cervero, 1989). Clearly, polycentric cities do have effects on commuting patterns as O'Kelly and Mikelbank (1999) show in their discussion of commuting behavior in the Columbus, Ohio region. These thoughts are extended in a series of discussions of "excess" commuting. Horner and Murray

(2002) and Horner (2002) draw attention to the way in which large Tm values (maximum average commute miles) increase with more decentralized employment and residences on average. Just how these findings can be balanced with the general notion that suburban job locations reduce commutes have yet to be spelled out. Nevertheless, the patterns of work places are an integral part of understanding how commuting varies across space.

Two empirical studies of the behavioral response to separation between work and residence clearly establish that households are sensitive to the separation between work and residence (Clark and Burt, 1980, Clark, Huang and Withers, 2003). That work, in two different residential contexts, Milwaukee and Seattle, and over two different time periods, documents that as separation between work and residence increased households were more likely to adjust their residences by moving closer to work. These studies were also able to provide statistical evidence of a threshold beyond which households were very likely to make adjustments that shortened their commute distances.

Although there is now a substantial research literature on commuting in general, most of that research has not directly addressed the issue of commuting by minority households, nor has that work focused on the interrelated issue of residential segregation and work residence separation. Although early work on the commutes of minorities suggested that they had longer commutes than whites, recent work has suggested that the commutes of blacks and Latinos are in fact shorter than for comparable whites (Taylor and Ong, 1995). Stoll (2000) suggests an explanation in terms of racial discrimination to explain the shorter commutes. In his conceptualization, employment discrimination against blacks in non-minority areas could prevent blacks getting jobs in areas distant from their residence. Thus far, the research tends to be focused on low skill black workers and the aggregate behavior of black households rather than (a) individual minority households, (b) more affluent minority households and (c) dispersed job locations.

Hence, the research here will expand our understanding of both the commute response and the response to neighborhood composition.[1]

Does the tendency to segregation in the urban mosaic influence the commute? In other words does living in a segregated or integrated setting increase or decrease the commute? Is there a commute penalty for African Americans regardless of their skill level (Press, 2000)? Thus, a central concern of this paper is to test whether "relatively skilled" African Americans are able to choose residences that reduce the commute and chose integrated neighborhoods. Recall that there is substantial research that documents the overall demand for integrated neighborhoods on the part of black households. The study sets commuting squarely within the urban structure. We examine commuting within a dispersed job structure (school locations) and within the context of residential separation (Figure 1). In sum, the study expands the more common central city/suburban node approach to a set of dispersed locations and examines the potential impacts of residential separation as well.

The review serves to reiterate that separation is a critical component of residence change and job location, and that there are important gaps in understanding the behavior of sub-populations of commuters. By examining the behavioral links in decision-making between these spheres we focus on a major element of the commuting process and on the nature of the linkage itself. The study will provide answers to the question of how sensitive households of different types, are to the separation within a local labor market and how they juggle the interaction of the residential composition of their neighborhood and the distance to work.

[1] We recognize that we do not have specific measures of discrimination and can examine only the outcomes of choices about neighborhood composition to infer the effects of racial concentration on commuting.

PREVIOUS RESEARCH ON MODELING WORKPLACE RESIDENCE SEPARATION

The problem of separation between workplace and residence and the effect of a change in residence is laid out in a simple figure of the potential links between workplace and residence (Figure 2). The figure outlines a vector structure of an initial location (R_1) and initial work-residence separation s_0, followed by a new residential location (R_2), and the corresponding new work-residence separation following the move s. The relationship of distance and direction in figure 1 can be modeled as a two parameter model in which the move is a vector that has length and direction. The distribution of moves can be defined as a joint distribution of move lengths and move directions. The change of residence generates two separate distances from work for the locations before and after a move, and an angle of change between the old and new distances.

A model which allows us to calculate the probability of decreasing distance to work with a change in residence is:

$$P(s < s_0) = \frac{1}{pI_0(k)} \int_0^1 \frac{1}{\sqrt{1-t^2}} e^{kt} (1 - e^{-2as_0 t}) dt \qquad (1)$$

The model[2] can been solved to evaluate $P(s < s_0)$ for selected values of s_0
In the model, k is a measure of the degree to which movers are attracted to the work location. The larger the k is, the stronger the attraction to the workplace. Setting k=0 is thus a test of the null hypothesis of no work attraction. By computing k values for different groups we can assess the strength of the workplace attraction and provide a contextual relationship for the analysis of work residence separation.

[2] The formal model is outlined in the appendix and elaborated in Clark and Burt (1980) and Clark Huang and Withers (2003). The model assumes consistent with empirical findings (Quigley and Weinberg , 1977; Clark and Burt, 1980) that move distances are distributed exponentially, that move directions follow a von Mises distribution with a mean direction of zero (Gaile and Burt, 1976), and that move distances and move directions are independent.

We will use this model to examine the nature of workplace residence separation for minorities and whites in the Atlanta metropolitan region. We will conduct both tests of the model and computations of the before and after move distances. The analysis is extended by examining the changes in neighborhood residential composition contingent on the residential relocation and the combined effect of changing commute distance and neighborhood composition.

RESEARCH QUESTIONS, DATA AND ANALYSES

A special data set of the locations of households (teachers) in the Atlanta metropolitan region and workplaces (schools) in Fulton County, Georgia, is used to test empirically the extent to which changes in residence impact the commuting distances of white and minority households. The data set includes all teachers in the school system and those who moved between 1999 and 2000. The data is geo coded for both households and school locations.[3]

The first analysis describes pre- and post- move commuting distances and the changing proportion of households who commute varying distances. The second analysis re-tests the model of behavioral responses to residence workplace separation. It is a test of what we believe is an important new way of quantitatively assessing the behavioral links between workplace and residence. The research asks about the differences and similarities in the behavioral responses of African American to residence work place separation. The values of s and s_0 and k are computed for white and minority households. The working hypothesis is that holding socio economic status constant, commuting distances will be similar, *and despite the relatively high levels of spatial separation of black*

A discussion of the assumptions can be found in Clark, Huang and Withers (2003). A substantial body of empirical evidence supports the assumptions (Clark and Dieleman, 1996).

[3] Unfortunately this data set does not provide the workplace locations of both workers in any two worker households and other work has shown that two worker households try and balance the two workplaces (Clark, Huang and Withers, 2003).

households, they will behave in a similar fashion to white households and where possible reduce their commute distances and increase their integration.

ANALYSIS AND RESULTS

The commuting patterns of African American and white households are quite similar although African American commutes tend to have a peak at 4-8 miles while white households are concentrated in the 8-12 mile range. (Table 1). The slightly lower peak in commute distances for African American households reflects the fact that a significant proportion of those teachers are living in black residential areas in the southern parts of the Atlanta metropolitan region and teach in predominantly black schools within the black community.

Almost 55 percent of the sample maintain or reduce their commute when they move residences. At a descriptive level the data support the general hypothesis that households tend to reduce their commute distances when they move. That average finding can be elaborated by analyzing the commute distance after a move by pre-commute distances. At shorter distances a larger number of the total sample, both African American and white commuters, are more likely to increase than decrease their commutes after moving. However, somewhere in the pre-commute range of 12-16 miles there is a distinct shift to shorter commutes after the move. For the sample as a whole and for white commuters the break point is closer to 12 miles, while for African American commuters the break point ranges up to 20 miles. At the highest pre-move commutes there is a very high likelihood of reducing the commute. If average commutes are small the adjusted commutes are more likely to increase for African Americans. In this instance we have tentative evidence that black households who want to teach outside of their community face longer distance commutes, or if they relocate to more integrated settings, face longer commutes to their existing schools. It is true that the sample sizes are small for long distance commutes and thus preclude formal tests of the difference between the two distributions. As a reviewer presciently remarked,

clearly, commutes increase if the commute distance is below the peak of the distribution, and the adjusted R square values of the probability of increasing the commute distance as a function of the pre move distance are .67 for whites and .79 for blacks. Thus, *overall* both blacks and whites are likely to increase commute distance. But, it is the threshold that is of major concern in this analysis and that analysis requires the estimation of the k values from the model. As we will show, both outcomes are possible – overall a probability of increasing the commute distance, but beyond a threshold, a very high likelihood of decreasing commute distance. [4]

A plot of the proportion of commutes which increase, by the pre-move commute distance, provides a further justification for the argument above. The proportion that increases their commutes decreases consistently across the range of distances (Figure 3). For the sample as a whole and for whites the proportion who increase their commute distance falls under 50 percent by the 8-12 mile pre-commute distance but not until the 16-20 mile range for African American commutes.[5]

Testing a model of commuting responses

The model requires the calculation of the resultant vector of move directions, and the k value which measures the fit of the probability curve of shortening the distance to work, that is ($P(s<s_0)$). As assumed in the model the observed and expected move distances are similar (Figure 4). The observed values of s climb rapidly with increasing pre-move commute distances. The curves for plotted values of k= .672 are good fits to the observed values (Figure 4).

For the total sample the mean move direction q_R is 356.66 in degrees and the mean length of resultant vector $\overline{R}$ is 0.32 and k=0.672. The model is

[4] We would like to thank the reviewer for taking the time and trouble to suggest the regression analysis of the overall probability of changing the commute distance.

significant and the findings confirm that, overall, there is a bias towards the workplace with increasing distance (Table 2). The results are further confirmation of the value of the model as an explanation of the behavioral responses of households to work residence separation.

The k values are .687 for white households and .641 for African American households and are significant in both cases, that is both African American and white commuters are sensitive to commuting distances, and they both tend to move closer to workplace when change residence. We also find that we cannot reject the hypothesis of no difference (G=0.299)[6]. Thus, we conclude that the commute responses are not different across the two groups. The results certainly argue against the notion of a commute penalty for "more affluent" minority workers; how the penalty varies by class cannot be examined with the current data but is clearly an important topic for further study.

Neighborhood choice and commuting

How do the patterns of neighborhood choice differ for white and black households? Who chooses which neighborhood compositions? Are households choosing to integrate, maintain their separate status or move towards a greater own race composition? Are households moving to neighborhoods with higher socio-economic status? And how is their commute affect by their neighborhood choice?

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[5] The largest concentration of school age children and thus of schools is in North Fulton County.

[6] According to Mardia (1972), we use the statistics G to test the difference in work attractions between blacks and whites. The Statistics G is normally distributed with mean zero and variance unit. The calculation of G is based on the value of $\overline{R}$. When $\overline{R} < 0.45$,

$G=\frac{2}{\sqrt{3}}\left|\sin^{-1}(1.22474\overline{R_1}) - \sin^{-1}(1.22474\overline{R_2})\right| \Big/ \left|(n_1-4)^{-1}+(n_2-4)^{-1}\right|^{1/2}$. In this case, $\overline{R}$ for blacks is 0.31 and $\overline{R}$ for white is 0.32, and the number of observations n for blacks is 147 and n for whites is 369. So G=0.299, smaller than the critical value at 95% level of 1.96. So we accept the null hypothesis that k for whites is the same as k for blacks.

The results of neighborhood choice for blacks and whites are more similar than different. First, both blacks and whites are in general positively integrative in their move outcomes. We classify neighborhoods into own race preference or segregative (>75% own race), mixed (25-75%), other race preference or integrative (<25%). Overall, blacks in integrated settings (<25% black) before a move are nearly uniformly likely to opt for integrative settings (Table 3). Blacks in segregated settings (>75% black) are equally likely to choose integrated or segregate settings. In combination with those in integrated settings the overall response is to increase, rather than decrease, inter-racial exposure. Whites are more likely to choose the settings in which they already live (note the diagonal). At the same time, if we examine the overall outcome, more whites choose integrated settings than not. Nearly all households who are in integrative settings before a move, choose the same structure after a move. Similarly those in integrated settings either choose the same setting or a setting in which they are less than a majority presence (Table 3). And more than one third of those in segregated settings moved to integrative settings. Overall, there are significantly more households who increase their living in integrated settings than the alternative. These findings must be set within the greater Atlanta levels of segregation. Overall, the region has a dissimilarity index of .66. The tracts in which the sample are resident, is similar in index level before and after their moves (.60). That is the sample population, in the aggregate, are more integrated than the population as a whole. Both white and black teachers are more likely to live in integrated settings than the population as a whole. This is consistent with arguments about class effects on integration (Clark and Ware, 1997).

Second, while black teachers usually live in neighborhoods at lower quintiles and whites live in neighborhoods at higher quintile in terms of median household income and education level (% of college), they both move between neighborhoods with similar status. According to Table 4, only 15.4% (before move) and 13.5% (after move) of blacks live in the top quintile neighborhoods in median household income, while 44.6% (before move) and 49.4% (after move) of

whites live in top quintile neighborhoods. There is a similar pattern in education level. Yet, if we compare neighborhoods before and after move, most households, both blacks and whites, move between neighborhoods in the same quintile, indicated by larger numbers at the diagonal. Overall, blacks tend to move slightly downward on the neighborhood hierarchy, while whites tend to move upward in respect of income but slightly downward in education.

Now, how does neighborhood choice affect commuting distance? Are there differences between black and white households? We use the same categories of racial composition, household income and education quintile that we used in the above analysis. For households who move to more segregated or similar racial composition neighborhoods, the commuting distances were almost equally divided between increases and decreases (Table 5). In contrast, among households who move to more integrative settings, about two thirds (60.9% blacks and 64.8% whites) have a shorter commuting distance than before. That is, households who chose more integrative settings were also able to reduce their commutes. We find for both black and white households, the after-move distance commutes are substantially less than the pre-move distance commutes. Black households commuted on average 14.2 miles before the move and 11.3 miles after the move, and white households, 13.2 miles before the move and 9.6 miles after the move. Clearly, to the extent that black or white households make integrative moves they can also decrease their commutes. By extension, the extent to which black households cannot affect integrative moves they are likely to have longer commutes. The overall pattern of residential separation does have impacts on the commuting distances of black households. Even those who are relatively more able to access integrated residential communities still have longer after move commutes than whites.

Moving between neighborhoods with different income and education status also affects commuting distance; yet, its effect is quite different for blacks and whites. Among households who moved upward in neighborhood hierarchy in

both income and education, more than two thirds of black households have longer commutes after the move, while more than two thirds of white households (66.7% for income, 80.5% for education) have shorter commutes. In other words, blacks are penalized in commute if they move to neighborhoods with higher income and education status, while whites benefit if they make the same moves. At the same time, among those who moved down the hierarchy, blacks are more likely to reduce than increase their commutes (55.6% vs. 44.4%) while most whites actually increase their commutes (61.11%). Much of this has to do with African Americans working (teaching) in their own community or not. If blacks choose to teach in the black community their neighborhoods by and large are likely to be in lower quintiles of the income education scale. Clearly, for blacks, there is a trade-off between neighborhood status and commute distance, which may make blacks' relocation more difficult. Yet, for whites, the decision seems to be easier, that is, to move to neighborhoods with higher status and reduce their commutes. Three conflicting processes are at work. The desire for shorter commutes, for higher status neighborhoods, and for blacks in particular, integrated residential settings. Satisfying these three aims is clearly difficult as the research shows. [7]

CONCLUSION

There is no question that households continue to struggle with the commute, especially in large metropolitan areas. The discussions of congestion and the surveys which document the increasing problems surrounding the daily commute, are the surface manifestation of one of the difficulties of living and working in large urban areas. The research from this paper documents the finding that households do focus on work residence separation and are particularly responsive to large commute distances.

[7] With a very large data set it would be possible to examine all three dimensions, commute distance, neighborhood composition and neighborhood quality. The data set here is not sufficiently detailed.

Using a special data set of teachers in the Atlanta metropolitan region, we examined households' response to work-residence separation in a large metropolitan area with scattered job locations. Although overall, households tend to increase their commute when they move, most of these increases are what we could call inconsequential. That is they are small in time or distance. Consistent with our previous research in two different regions, and two different time periods, our subset of households in Atlanta do tend to move toward their work places to shorten their commutes but only when a distance threshold is crossed. The probability of shortening the commute is much higher when the commute distances are relatively long. The probability of this occurring is measured with the k value which is similar for both black and white households.

Commuting occurs within a residential structure and by examining the changes in commuting in the context of changes in neighborhood residential composition the research sheds light on the interaction between work residence separation and the choice of neighborhood. Not unexpectedly, both white and black households tend to move within neighborhoods with similar compositions and status. At the same time, when white and black households do move to more racially integrated neighborhoods they have clear gains in decreased commutes. Of course, we cannot distinguish, based on this study, whether these teachers were attracted to integrated neighborhoods, or they want to reduce commutes in a large metropolitan area and have no choice but to move to neighborhoods with a small percentage of their own race. At the same time black households have to make a trade-off between a neighborhoods' socio-economic status and commute distance. Black households who move to neighborhoods with higher income and education status are likely to suffer longer commutes, while white households making the same move can actually benefit from decreased commutes.

The study reiterates that the continued racial separation does influence commuting and that when households can or do choose more integrated settings there are gains in decreased commutes. Class does matter, the study finds,

contrary to some other suggestions. High skill black workers are able to decrease their commute distances in a manner similar to whites. At the same time, neighborhoods matter too, especially for blacks, who have to struggle between neighborhoods status and commute distance.

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APPENDIX

A model of the likelihood of a person moving to a finite area is defined by two distances (x_1, x_2) and two angles (q_1, q_2), such that:

$$P(x_1 < x < x_2, q_1 < q < q_2) = \int_{x_1}^{x_2} \int_{q_1}^{q_2} h(x,q)\,dq\,dx \qquad (1)$$

where $h(x,q) = \frac{a}{2pI_0(k)} e^{k\cos q - ax}$, $x > 0$, $-p < q \le p$

Integrating equation (1) over the region where $s < s_0$ and after transformations and integration by parts, the above equation can be restated as:

$$P(s < s_0) = \frac{1}{pI_0(k)} \int_0^1 \frac{1}{\sqrt{1-t^2}} e^{kt}(1 - e^{-2as_0 t})\,dt \qquad (2)$$

The model can be solved to evaluate $P(s < s_0)$ for selected values of s_0. Solving numerically in Milwaukee and Seattle we found k values which provide clear evidence of "work place attraction" and a bias towards the work place when households adjust residences (Clark Huang and Withers, 2002).

If the assumptions in the model are incorrect and there is interaction between direction and distance the fit between the expected and observed distributions will be lower. The basic point is that dependence rather than independence can only reduce the fit between the observed and the expected distribution from the model. Thus, if the fit between observed and expected is good, we are confident of the results of the model.

Even if the workplace has no effect on the move, movers having a long pre-move trip will experience a higher probability of moving closer to work than those who are already close to work simply because of the effect of the urban

structure. Thus, for any value of k, the value $P(s < s_0)$ is an increasing function of s_0. To illustrate, imagine the case of no bias. As s_0 increases the circular region corresponding to $s < s_0$ grows larger, approaching the half plane in the limit. Even if the workplace has no effect on the move, movers having a long pre-move trip will experience a higher probability of moving closer to the workplace than those who are already close to work. Thus, the fact that $P(s < s_0)$ increases with s_0, does not in and of itself indicate workplace attraction. What we must do is to compare an observed curve of $P(s < s_0)$ with one generated from the null hypothesis of k=0.

Two parameters are critical in evaluating the model - q_R, the mean direction, and R, the length of the resultant vector. The mean direction of the resultant vector

$$q_R = \tan^{-1} \frac{1/n \sum \sin q_i}{1/n \sum \cos q_i} \qquad (3)$$

is a measure of centrality for a set of move directions just as the arithmetic mean is a measure of centrality. The value R reflects the degree of clustering in the sample, and can be compared to the variance in non-directional data set. Perfectly opposing vectors will sum to zero. R is standardized by n to yield an index between zero and one.

$$\overline{R} = R/n = \frac{1}{n}\sqrt{(\sum \sin q_i)^2 + (\sum \cos q_i)^2} \qquad (4)$$

It is related to the concentration parameter k by:

$$\overline{R} = I_1(\hat{k}) / I_0(\hat{k}) \qquad (5)$$

where I_0 is a modified Bessel function of the first kind and zero order.

For the study of Seattle, q_R is 5.56 in degrees and $\overline{R}$ is 0.318 and k=0.668. The findings confirm that, overall, there is a bias towards the workplace with

increasing distance. That analysis also showed that at very large values of s_0 the values of $P(s < s_0)$ are even greater than the probabilities indicated by curve with k value of 0.668. Thus, at very large distances the bias towards workplace is greater than that evaluated by the constant k.

Table 1: Commuting Change after a Residential Move, for All and by Race

Pre move	All		White		Black	
Commute(miles)	Less/same	More	Less/same	More	Less/same	More
< 4.0	8.92	22.69	10.47	25.42	5.48	17.11
4.1-8.0	15.61	30.38	12.57	28.81	21.92	34.21
8.1-12.0	19.33	18.46	20.94	16.38	13.70	21.05
12.1-16.0	16.36	14.23	17.80	15.25	10.96	11.84
16.1-20.0	16.36	8.85	18.32	8.47	12.33	10.53
20.1-24.0	13.01	1.15	10.99	0.56	21.92	2.63
24.1-28.0	4.09	1.54	4.19	2.26	4.11	0.00
28.1+	6.32	2.69	4.71	2.82	9.59	2.63
Total %	100.00	100.00	100.00	100.00	100.00	100.00
Total N	269	260	191	177	73	76

Table 2 Parameter Estimates for All and by Race

	All	Whites	Blacks
Mean distance moved $\overline{X}$ (miles)	10.21	9.60	12.01
Pre-move commute (miles)	12.02	11.97	12.36
Post-move commute (miles)	12.00	11.70	12.99
Mean length of resultant vector $\overline{R}$	0.32	0.32	0.31
$2n\overline{R}^2$	107.54 *	77.52 *	27.40 *
Mean move direction (degree)	356.66	355.56	0.51
Confidence interval for move direction (degree)	0 ± 10.54 **	0 ± 12.40 **	0 ± 20.93 **
k	0.672	0.687	0.641
G			0.299 ***

* reject the hypothesis of no bias

** accept the hypothesis that move directions are centered around the workplace

Table 3 Neighborhood Racial Composition before and after a Move

		After Move		
Blacks		<25% black	25-75% black	75%+ black
	<25% black	47 (45.19)	-	9 (8.65)
Before	25-75% black		-	
Move	75%+ black	25 (24.04)		23 (22.12)

		After Move		
Whites		<25% white	25-75% white	75%+ white
	<25% white	109 (33.75)	6 (1.86)	22 (6.81)
Before	25-75% white	30 (9.29)	38 (11.76)	10 (3.10)
Move	75%+ white	37 (11.46)	8 (2.48)	63 (19.50)

Note: percentages in parenthesis.

Table 4 Neighborhood Quality before and after a Move

	BLACKS	After Move					
Median household income		1st quintile	2nd	3rd	4th	5th	Subtotal (%)
	1st quintile (N)	11	1	3	0	0	14.42
Before	2nd (N)	2	24	3	7	1	35.58
Move	3rd (N)	1	3	7	2	0	12.5
	4th (N)	0	5	2	14	2	22.12
	5th (N)	0	2	1	2	11	15.38
	Subtotal (%)	13.46	33.65	15.38	24.04	13.46	100.00
Education (%college)							
	1st quintile	6	2	3	0	0	10.58
Before	2nd	1	20	3	1	0	24.04
Move	3rd	3	9	18	2	0	30.77
	4th	0	2	2	9	1	13.46
	5th	0	3	1	2	16	21.15
	Subtotal (%)	9.62	34.62	25.96	13.46	16.35	100.00

	WHITES	After Move					
Median household income		1st quintile	2nd	3rd	4th	5th	Subtotal (%)
	1st quintile	14	1	1	1	1	5.61
Before	2nd	1	30	2	3	7	13.4
Move	3rd	1	0	25	1	14	12.77
	4th	0	1	6	47	22	23.68
	5th	1	3	7	17	115	44.55
	Subtotal (%)	5.28	11.18	12.73	21.43	49.38	100.00
Education (%college)							
	1st quintile	10	1	1	0	0	3.74
Before	2nd	1	22	4	3	4	10.59
Move	3rd	1	1	35	7	11	17.13
	4th	1	3	5	26	10	14.02
	5th	1	8	15	18	133	54.52
	Subtotal (%)	4.35	10.87	18.63	17.08	49.07	100.00

Table 5 The Interaction between Moves, Neighborhood Change and Commute Distance

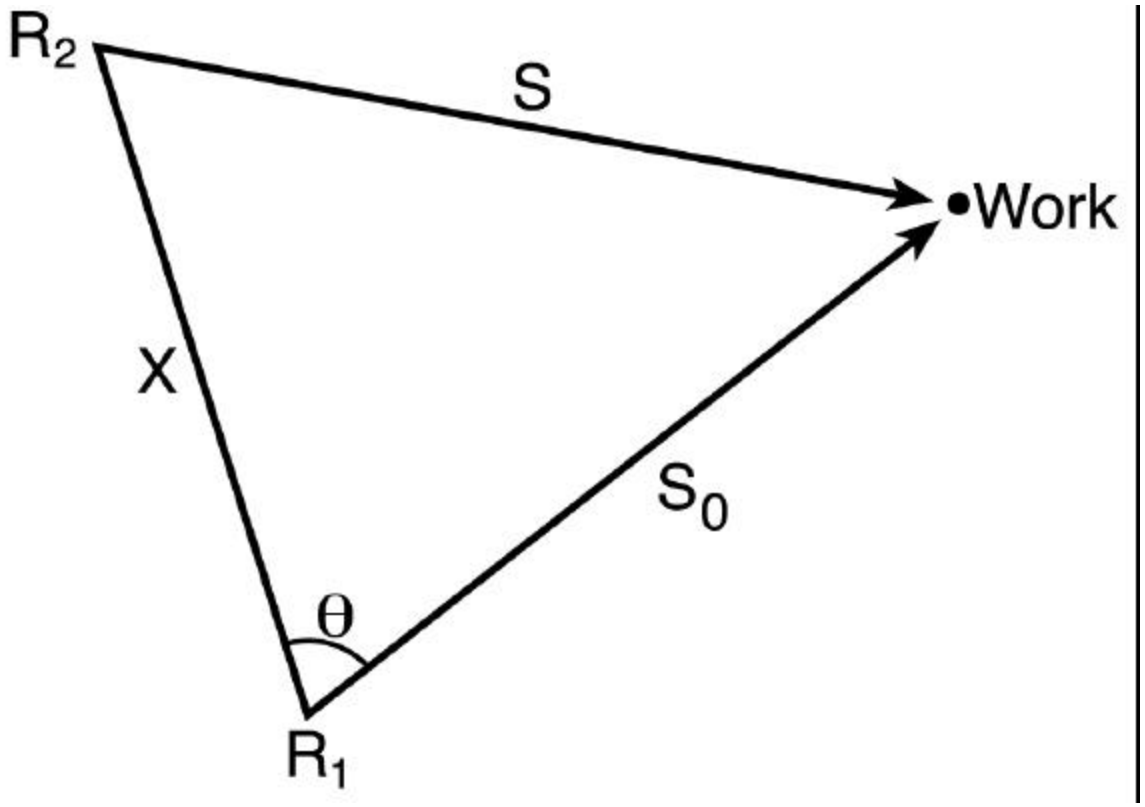
	Blacks			Whites		
	Commute Distance			Commute Distance		
	Less/same (%)	More (%)	Total N	Less/same	More	Total N
Racial Composition						
More segregate	53.13	46.88	32	50.54	49.46	93
Neutral	43.48	56.52	46	48.23	51.77	141
More integrate	60.87	39.13	23	64.79	35.21	71
Household Income Quintile						
Move down	55.56	44.44	18	38.89	61.11	36
Same	53.85	46.15	65	53.33	46.67	225
Move up	33.33	66.67	18	66.67	33.33	51
Education (% college) Quintile						
Move down	30.43	69.57	23	32.69	67.31	52
Same	60.61	39.39	66	53.88	46.12	219
Move up	33.33	66.67	12	80.49	19.51	41

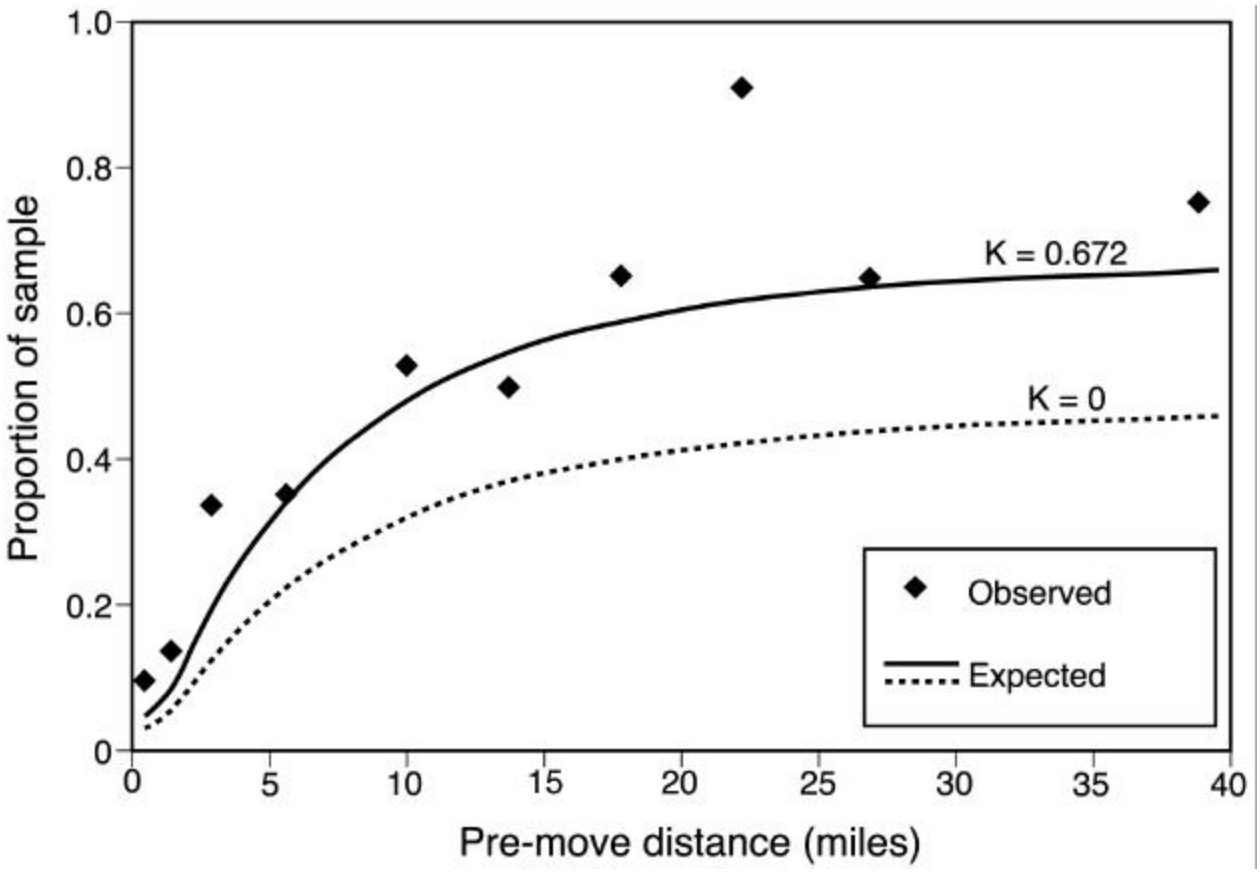
FIGURES

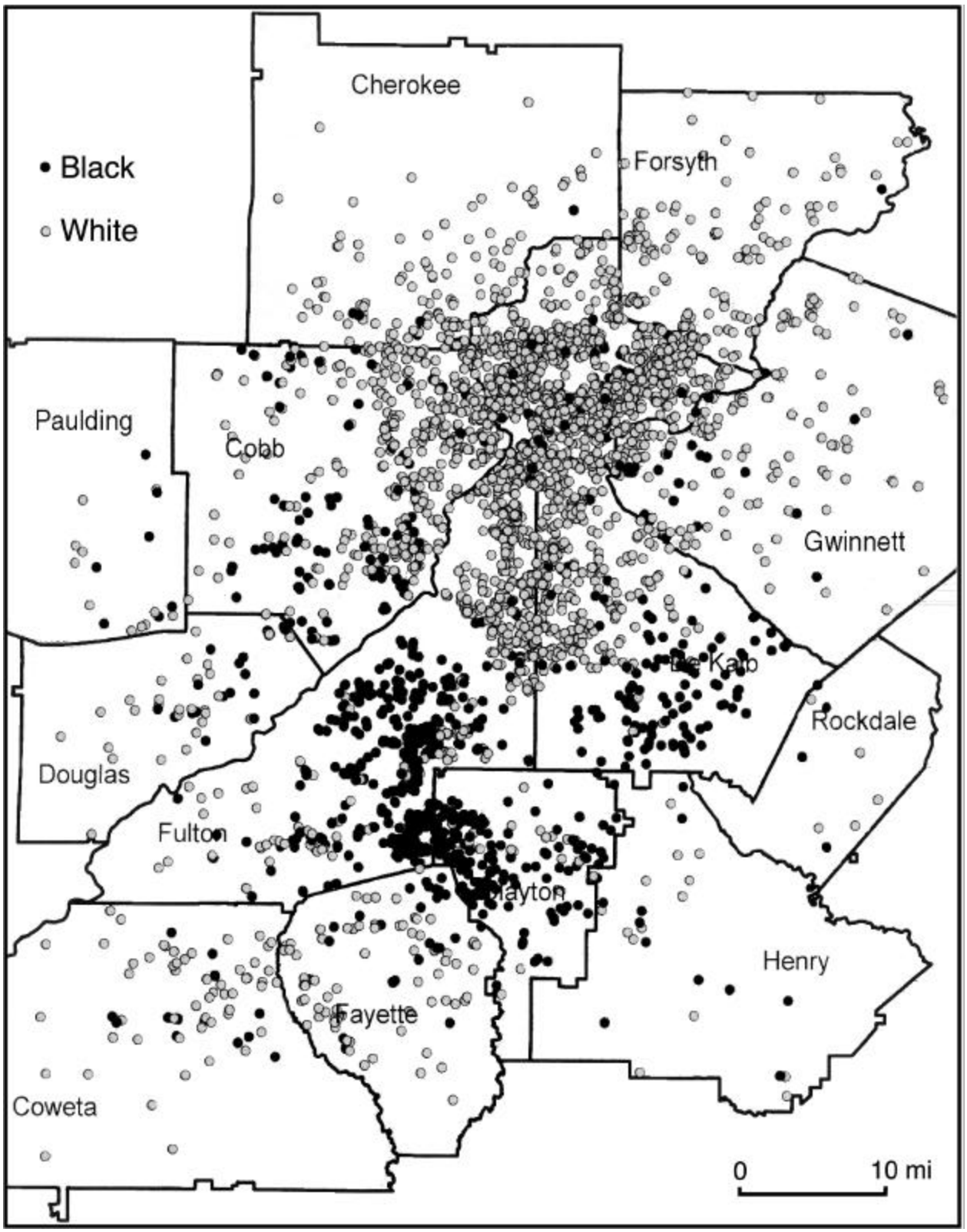
1. Residential locations of teachers who work in the Fulton County School District
2 . The vector structure of work-residence relationships.
3. Proportion of residential changes which increase commute distances.
4. Observed and expected probabilities of shortening the distance to work.

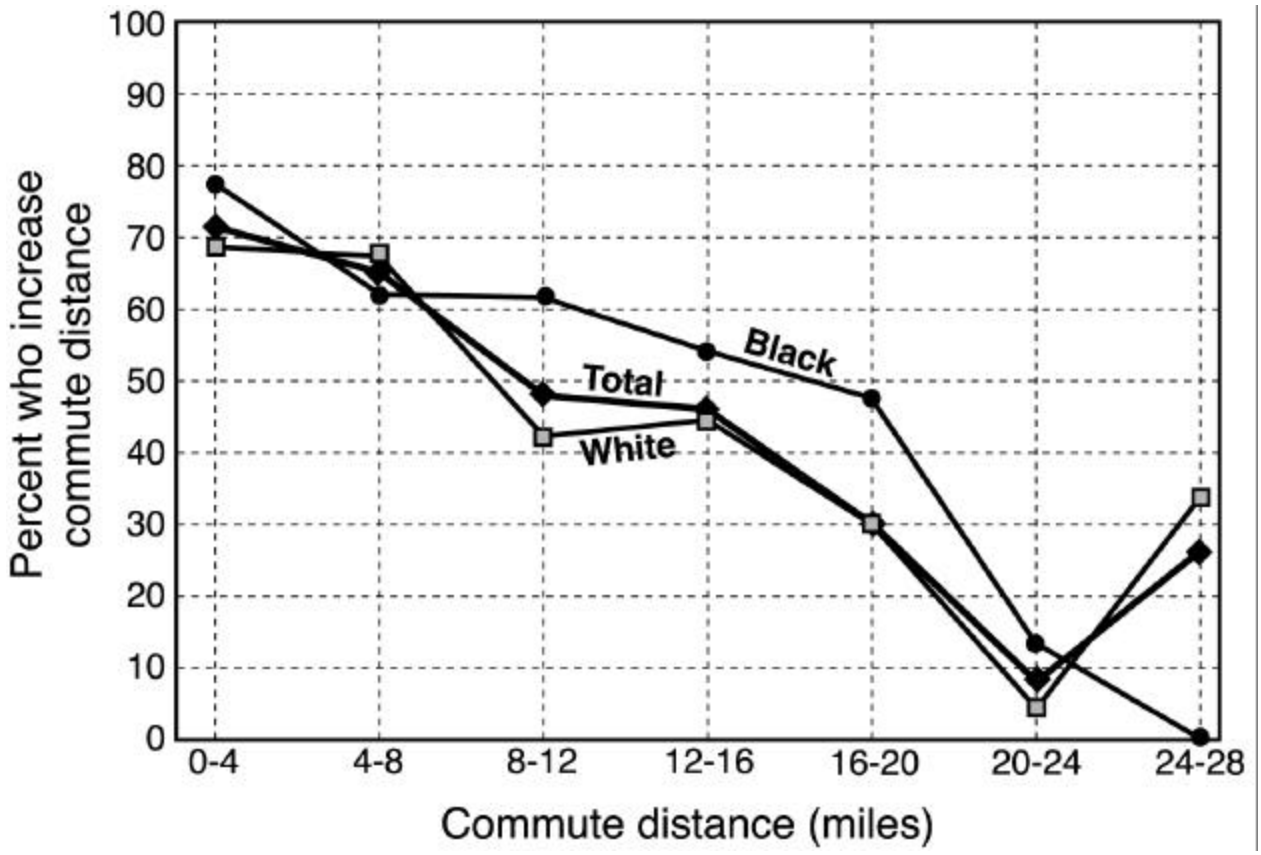
TABLES

1. Commuting distance after a residential move by race
2. Parameter estimates for commuting behavior
3. Neighborhood residential composition before and after a move
4. Neighborhood quality before and after a move
5. The interactions of moves, levels of segregation and commuting distance


R2
S
•Work
X
S0
θ
R1


1.0
0.8
0.6
0.4
0.2
0
Proportion of sample
K = 0.672
K = 0
Observed
Expected
0
5
10
15
20
25
30
35
40
Pre-move distance (miles)


• Black
◦ White
Cherokee
Forsyth
Paulding
Cobb
Gwinnett
DeKalb
Rockdale
Douglas
Fulton
Clayton
Henry
Fayette
Coweta
0
10 mi


Percent who increase commute distance
100
90
80
70
60
50
40
30
20
10
0
0-4
4-8
8-12
12-16
16-20
20-24
24-28
Commute distance (miles)
Black
Total
White