COMMUTING DISTANCE SENSITIVITY BY RACE AND SOCIO-ECONOMIC STATUS

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ABSTRACT

Previous research has shown that households are sensitive to commuting distance. A model of the responses to work-residence separation showed that the probability of moving closer to the job was a function of increasing distance from the work place. In particular, households beyond a threshold distance moved closer to the job when they changed residence. The question which is central in this paper is how race affects the probability of moving closer to the job when households change residence. Using a specialized data set the research shows that the commuting behaviors of relatively affluent minority and white households are consistent with the overall hypothesis that households minimize their commuting distance whenever possible. Thus, when we hold socio-economic status constant, there are negligible differences in the responses of white and minority households. Both household types are likely to move closer to their work locations with greater distances from the work location.

INTRODUCTION

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. A straightforward model of a household’s response to commuting distance shows 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 when socio-economic status is held constant. Do minority households respond in the same manner as white households, to the separation of work and residence?

A great deal of the literature which has considered black commuting distances and work-residence separation for black households has been couched within the general framework of the "spatial mismatch" hypothesis. In general this research has tended to argue that black households commute longer distances because jobs are not available near their residential locations. Even though some recent investigations have questioned the applicability of the mismatch hypothesis (Taylor and Ong, 1995), others conclude that there is a commute penalty for African Americans regardless of their skill level (Stoll, 2000) or gender and race (Press, 2000). Whatever the current debates about the spatial mis-match hypothesis, we still do not have a good understanding of how minority households respond to work-residence separation. Do minority households respond in the same way as white households to greater work residence separation when we control for socio-economic status?

This analysis uses a specialized sample of households in the Atlanta metropolitan region to examine the responses of individual households to the pattern of work locations in the Atlanta region. The interest in using this specialized sample is threefold. First, the data set, by its nature (it is a sample of teachers and schools) controls for socio-economic status, including both income and educational dimensions. Second, the use of a dispersed set of work locations, schools, enables us to examine the extent to which the previous models of behavioral response to workplace residence separation is applicable to non central city work locations. Third, by implication, the data set raises the issue of the greater concentration of African American households and the impacts of those concentrations on commuting distances.

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, 1998; and Rouwendal, 1999) 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.

Theoretically, van Ommeren et al (1996, 2000) make the 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 (van Ommeren, 2000). 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. In addition, Zax and Kain (1991) link commuting distance to the propensity to quit a job or to change residence. Clearly, these studies provide a context which emphasizes the importance of behavioral responses to the separation between work and residence.

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, 2002). 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 to 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. The work that has examined this question has usually been couched in the context of the "spatial mis-match hypothesis", which suggests that the disjunction between the location of jobs and residences for blacks and Latinos (Holzer, 1991), is related to the lack of employment opportunities for black households that are near to their concentrated residential areas (Ihlanfeldt, 1998). In the initial versions of the spatial mismatch hypothesis the lack of jobs near black residential areas was responsible for generating longer commutes for African American households. More recent work has questioned the spatial mismatch hypothesis, as commutes of blacks and Latinos have been found to be somewhat shorter than for comparable whites (Taylor and Ong, 1995). However, Stoll (2000) provides a counter argument in which racial discrimination is used to explain the shorter commutes. Even so, much of this work is focused on low skill black workers and in general is focused on the aggregate behavior of black households rather than (a) individual minority households, (b) more affluent minority households and (c) dispersed job locations. Although the major focus in this study is not on the spatial mismatch hypothesis per se, the findings from the research will inform the debate about the spatial mismatch hypothesis.

Clearly, the previous research suggests that spending additional time commuting is undesirable, and there is a tendency to reduce that commute (Press, 2000). At the same time that African Americans may not be able to do so is a measure of the extent to which employed blacks are constrained from living in close proximity to their place of employment, *whether they are high skilled or low skilled* (Press, 2000). The analysis in this paper can test directly the issue of whether “relatively skilled" African Americans are impacted differentially by workplace residential separation. Are they able to choose residences that reduce the commute in the same manner as white households? By implication, the research is asking whether greater segregation of African American households influences their workplace residence separation.

This study sets commuting squarely within the urban structure as both residences and work locations (schools) are scattered throughout the metropolitan region. In this context it is also relevant to recall that Cervero and Wu's (1997) study of commuting and residential location in the policentric San Francisco Bay Area found evidence that *suburban employment* tends to generate shorter commute times than central city employment. Other studies which also examined commuting times and distances for workers commuting to suburban locations provided similar findings (Doorn and van Rietbergen,1990; Cervero and Landis, 1992; Wachs et al. 1993). Thus, the spatial patterns of jobs does have an important role to play in creating the changes in residence work place separation. This study expands the central city or suburban node approach to a set of dispersed locations and so is a further test of the relevance of the behavioral response to work residence separation. [1]

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

[1] Beyond the issues of race and urban structure there has been a concern with gender differences in the journey to work. Within this voluminous literature most studies compare men and women in the aggregate and consistently find that women tend to commute shorter distances and travel less time than men (Blumen, 1994; Turner and Niemeier, 1997; Wyly, 1998). The difference is frequently explained by women's low wages, their need to balance the dual role of mother and worker, and a relatively even spatial distribution of jobs (MacDonald, 1999). Singell and Lillydahl (1986) found that in two-earner married households it was the male's job location that propelled residential location decisions. Moreover, they found a residence change increased female commute times. The seemingly contradictory findings may well be due to the various spatial and temporal scales of analysis, but it is clear that there is much more that we need to know about the mechanics of these processes of commuting and residential mobility for women in addition to minorities.

answers to the question of how sensitive households of different types, are to the separation within a local labor market.

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 1). 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 the figure 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 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 $$h(x,q) = \frac{a}{2pI_0(k)} e^{k\cos q - ax}, \quad x > 0, \; -p < q \le p$$

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[2] has been 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).

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. 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

[2] The formal model is elaborated in Clark and Burt (1980) and Clark Huang and Withers (2002). The presentation of the model here draws on those papers. 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. A discussion of the assumptions can be found in Clark, Huang and Withers (2002).

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.

With these background studies we can set out the main dimensions of the present study. The analysis will use the basic model to examine the nature of workplace residence separation for minorities and whites in the Atlanta metropolitan region. The research has two broad sections, one on commuting distances and a second on the fit of the model.

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 has geo codes for both households and school locations.

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 - thus it is a validation of what we believe is an important new way of quantitatively assessing the behavioral links between workplace and residence. In effect, does the model work when the jobs are not centrally located but are in dispersed locations. Third, 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 households, they will behave in a similar fashion to white households.

To investigate the basic question of commute distances we will use the basic model outlined earlier and analyze the actual patterns of commutes by ethnicity. As the work locations are fixed (schools) we can examine the pattern of residence choices, and the commuting outcomes, as a set of vectors of distance and direction. The k values are summary measures of the probabilistic responses of different groups.

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 somewhat more evenly spread across commute distances (Figure 2). The spike in relatively short commutes for African Americans 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 in southern Fulton County.

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 is expanded by tabulating the commute distance after a move by pre-commute distances (Table 1). At shorter distances a larger number of the total sample and 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 commuters 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 seems to range up to 20 miles. At the highest pre-move commutes there is a very high likelihood of reducing the commute.

A plot of the proportion of commutes which increase, by the pre-move commute distance, is an alternate way of examining the effect of workplace residence separation. 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. This suggests a constraining impact of the concentrated residential concentration of black residential areas because of residential preferences for mixed, rather than all white neighborhoods (Clark, 1997), such as are common in North Fulton County.[3]

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 5).

For the total sample q_R is 356.66 in degrees and $\overline{R}$ is 0.32 and k=0.672. The model is 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. We

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

also find that we cannot reject the hypothesis of no difference (G=0.299)[4]. Thus, we conclude that the commute responses are not different across the two groups and we accept the working hypothesis that when we control for socio economic status that race is not a factor in the responses to work residence separation.

CONCLUSION

There is no question that households continue to struggle with the commute, especially in large metropolitan areas. The discussions of congestion especially in Atlanta, 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. Using a special data set of teachers in the Atlanta metropolitan region, we examine households' response to work-residence separation in a large metropolitan area with scattered job

[4] 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= $\frac{2}{\sqrt{3}}\left|\sin^{-1}(1.22474\overline{R_1}) - \sin^{-1}(1.22474\overline{R_2})\right| \bigg/ \left|(n_1-4)^{-1} + (n_2-4)^{-1}\right|^{1/2}$. 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 locations. Consistent with our previous research in two different regions, and two different time periods, our subset of households in Atlanta also tend to move toward their work places to shorten their commutes.

We also test the effect of race and socio-economic status on the sensitivity to work-residence separation. As teachers, they are educated and relatively well paid (middle class households), who show the same tendency of shortening commuting distance by moving closer to workplaces. The sensitivity to commuting distance seems to be universal to all strata of the population.

Furthermore, we find that middle class blacks present the same sensitivity to work-residence separation as whites. Race by itself seems to be less relevant in households' response to commuting distance. This finding is contrary to the suggestion that high skill black workers may not be able to adjust their commute distances. Clearly they can and do, and so behave similarly to their equivalent white cohort.

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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.

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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

*** accept the hypothesis that k for whites is the same as the k for blacks

FIGURES