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The Effect of Residential Accessibility to Employment on Mens and Womens Travel

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THE EFFECT OF RESIDENTIAL ACCESSIBILITY TO EMPLOYMENT ON MEN S AND WOMEN S TRAVEL

ABSTRACT

This research explores the effect of residential gravity accessibility by automobile to all employment in the Atlanta metropolitan region on the quantity and nature of travel by men and women. The literature suggests that greater accessibility of residential locations is associated with more, but shorter trips, resulting in less travel. Using the Atlanta Regional Commission's 1990 Household Travel Survey, I evaluated household and personal travel behavior and found: (1) individuals and households who live in more accessible portions of the metropolitan area spend significantly fewer minutes in travel; (2) among individuals this effect is seen primarily for employed men; (3) residential accessibility's effect on numbers of motorized trips is ambiguous and often insignificant, though students who were not employed and lived in more accessible locations made significantly fewer home-based school trips by motorized vehicle.

These results demonstrate that residential accessibility does affect travel, reinforcing the belief that land use policy and physical planning to improve accessibility may provide means of manipulating travel demand to achieve higher quality of life, enhanced economic development and more efficient transportation. However, some planning policies aimed at least partly at increasing accessibility (zoning for higher densities, fostering mixed uses, achieving jobs-housing balance) can be costly, unpopular, or both. This research also demonstrates that residential accessibility's effects on travel, though significant, do not affect everyone, suggesting they may not be worth large sacrifices. Finally, though these effects are significant, and gravity measures of accessibility may help transportation planners predict the results of planned and unplanned changes when used with other information, they do not predict travel behavior well when used alone.

INTRODUCTION

Much of planners' and urban designers' strong recent interest in the connection between transportation and land use stems from believing that travel behavior is affected by the physical environment. (Crane, 1996a) Yet this paper is one of very few which test whether this is true, and in particular, whether this is true (1) on a scale broader than the neighborhood or community, (2) in the recent past, (3) in a large and growing U.S. metropolitan area, (4) for more travel than just commutation (5) considering travel using our most common means of transportation, the private car, and (6) distinguishing between men and women, and those who are employed and not employed.

In order to test for significance, a quantifiable indicator of a key dimension of the physical environment is required. The measure used here, a gravity measure of accessibility to all employment in the metropolitan region, is calculated for census tracts, and is intended to measure the physical potential of alternative residential locations for desired interaction, thus operationalizing the concept of physical accessibility at the scale of the metropolitan region. (Helling, 1996a) The effects of this physical attribute on the travel of different groups are then compared using the results of an extensive household travel survey.

REVIEW OF THE LITERATURE

ACCESSIBILITY

Everyone (including individuals, groups and businesses) values the ability to accomplish interactions of interest or importance to them. Though theoretically such interactions might be achieved through either travel or communication, this paper concerns itself exclusively with transport, allowing me to define accessibility as *the potential ease with which destinations can physically be reached for desired interaction*.

The large literature on physical accessibility identifies a number of possible means of measuring it, most of which are at least somewhat congruent with the concept outlined above, although not all are equally good at explaining variation in empirical phenomena. (Helling, 1996c) The detailed operational definition I provide later attempts to quantify a common-sense understanding of "accessibility," and has a number of other advantages, including relative ease of calculation from available data, predictive power, a firm theoretical foundation and a long history of both scholarly and applied use. However, it has the following weaknesses: (1) it is based on aggregate rather than individual or household data, implying that all individuals in the given area have the same accessibility, (2) it has no temporal dimension, implying that accessibility does not vary, for example, by time or day or day of the week, and (3) it is better suited to comparing the accessibility of different locations via the same mode than of those locations via different modes. Nonetheless, it has proven itself capable of explaining observable differences in my previous research in Atlanta. (Helling, 1992; 1996a, 1996b)

TRAVEL AND ACCESSIBILITY

Crane (1996b) has recently posed again the question of what effects the physical environment has on numbers of trips, overall vehicle miles of travel (VMT) and mode split. He uses comparative statics to infer consequences from the design precepts of the new urbanism; shorter travel distances due to streets built on a grid system, slower travel speeds due to traffic calming measures, and enhanced destination attractiveness due to mixed and intensified uses. However this approach doesn't yield a definitive prediction of the direction of the combined effects of these popular policies on car trips, VMT or mode split. I argue that by incorporating travel time and destination weights, a gravity measure of accessibility can function as a simple, straightforward indicator of the combined effects of these three dimensions (proximity, speed and destination attractiveness). Hence this paper contains a method for obtaining an empirical answer to Crane's question, though I have not focused solely on neo-traditional neighborhoods.

Previous research, using several different measures of accessibility, has found that greater accessibility increases rates of trip generation (numbers of trips) (Morris, Dumble and Wigan, 1979; Leake and Huzayyin, 1979; Koenig, 1980), and reduces trip length (Hanson, 1982; Ewing, 1995). Hanson found that when all trips, including walking trips, were recorded, higher densities of destination opportunities (establishments) in the immediate vicinity of home (1 km.) significantly increased the number of trips and significantly decreased their average distance from home for both workers and nonworkers. The effect of accessibility on trip length was negative and greater than the positive effect on trip generation, so that, "People living and/or working in high-density[1] environments make more trips and still manage to travel fewer kilometers," (Hanson, 1982, p. 196). As an explainer of individual travel, home-based accessibility has also been demonstrated to be more important than work-based accessibility. (Hanson and Schwab, 1987) However, it has been unclear whether these conclusions remain true, and whether they are relevant to the U.S. in spite of dissimilarities in culture, urban form and public policy from that in Europe, where Hanson and Koenig obtained their data.

Also, there is evidence that conclusions depend upon the individual and the type of travel. Previous work showed that residential opportunity accessibility to establishments significantly increased the number of discretionary trips taken by all working men and nonworking men with cars, but not by women. Higher values of opportunity accessibility to the place of residence also reduced the length of shopping and personal business trips, but not other discretionary "social" trips (Hanson and Schwab, 1987). Leake and Huzayyin also found that non-commuting trips were more elastic with respect to accessibility than commuting trips, and that measures of accessibility via transit improved prediction of transit trips more than accessibility via auto improved prediction of automobile trips. (Leake and Huzayyin, 1979)

Some oppose planners' attempts to use land use and locational policy to reduce travel, arguing that such intervention will impose new restrictions and costs, but be ineffective. For example, in the Los Angeles metropolitan area, improved jobs-housing balance and freeway capacity enhancements are projected to contribute only a fraction of reductions in vehicle miles and hours of travel needed to reduce future emissions of five major pollutants controlled by the Clean Air Act (Bae, 1993). Increasing residential density in developing areas around the periphery of existing metropolitan areas will have little effect on commuting distances if jobs are widely dispersed in these outer suburbs. (Downs, 1992) And though dispersed employment creates the potential for shorter commutes in Los Angeles, there is much less difference between actual commuting to concentrated employment centers and more accessible, dispersed employment than theoretically possible. Thus "attempts to alter the metropolitan-wide structure of urban land use via policy intervention are likely to have disappointing impacts on commuting patterns..." (Giuliano and Small, 1993, p. 1498)

Some of those who argue for attempting to affect travel through design and controls on the physical environment and location merely assert that their approach should work. Among these are proponents of the new urbanism, maintaining, for example that, "The proximity of daily destinations and the convenience of transit reduces the number and length of trips..." (Duany and Plater-Zyberk, 1994, p. xviii) However, accessibility is a richer and more useful concept than physical proximity and previous research indicates greater accessibility is likely to reduce the length, but not the number of trips, as noted above.

Others who favor using the physical environment as a policy tool draw conclusions based on empirical work rather than philosophical orientation. Cervero and Gorham (1995) conclude that older neighborhoods, which are more accessible by foot and transit because they have rectangular-street-grids and were initially built around rail transit, generate fewer drive-alone trips and more transit and pedestrian trips than the otherwise similar neighborhoods without these attributes in the San Francisco area. This is consistent with Hanson and Schwab's finding that greater accessibility has a significant effect on mode choice, with higher accessibility associated with a greater proportion of trips using non-motorized means of travel (foot or bicycle). (Hanson and Schwab, 1987) Interestingly, Gorham and Cervero found the situation to be less clear in Los Angeles, which they attribute to the overall automobile accessibility of the Los Angeles region, although they are not able to test this hypothesis. "Having transit-oriented neighborhoods in a region strongly dominated by the automobile may very well be of negligible importance." (Cervero and Gorham, 1995, p. 221) This paper addresses this important, and previously untested question: does greater accessibility to an entire metropolitan area via car also reduce trip length and increase the number of trips, as accessibility at the smaller pedestrian/transit scale of the immediate neighborhood apparently does?

A middle position between those who see the physical environment as all-powerful and those who argue its near total irrelevance seems more reasonable than either extreme. We already know that accessibility depends upon individual circumstances and preferences; "the shape of the spatial environment is generally less influential on travel than are the personal and household characteristics of travelers." (Hanson and Schwab, 1987) Thus the hypothesis of this paper is not so much that physical accessibility alone will explain patterns of travel, as that it may add to an understanding which distinguishes among types of travelers and their travel.

TRAVEL AND GENDER

This study analyzes the effects of accessibility on travel behavior, broken down according to gender and employment status. Janelle, Goodchild and Klinkenberg (1988) compared the relative merits of using cluster analysis or grouping by personal attributes to obtain groups of sample survey respondents which were homogenous on how much time they spent in travel per day (as well as other travel variables). Their data, from a random sample of individuals in Halifax, Canada in the 1970s, indicated that cluster analysis created only marginally more homogenous groupings than separating the sample into men and women or all employed people versus those who were not employed.[2] Other binary categorizations of people (by marital status, the presence or absence of children in the household, homeownership status and automobile availability) were somewhat less helpful than gender and employment status at reducing variation in daily travel time within groupings. In general, they observed that "a priori groupings compared favorably with those based on cluster analysis." (Ibid., p. 904) This is in keeping with the following recent research.

Rosenbloom (1995) argued that gender, employment status and presence and ages of children are very important to explaining variations in travel behavior in 1990. Gender and employment status have special importance. According to the 1990 Nationwide Personal Transportation Survey (NPTS), women aged 16 to 64 made more trips than men of the same age in 1990, though because these trips were shorter, they covered fewer miles in vehicles than men on average. (Rosenbloom, 1995) Although women's trips have historically been shorter than men's, as recently as 1983 men and women made approximately equal numbers of trips. (Pisarski, 1992) This relationship is the same among working men and women. Employed women make more trips than working men, on average, and working women in urban areas travel fewer miles than their male counterparts. Employed people take more trips and travel further, on average, than those who don't work, but the differences are greater among women than among men. (Rosenbloom, 1995)

"The most salient fact today is that most women, and most women with children, are in the labor force, generally retaining substantial childcare and domestic obligations in addition to their jobs. At the same time, a growing number have also assumed duties for aging parents and in-laws. These compound responsibilities have important transportation implications: they create the need for multiple trips in addition to any work trips, they create the incentive to link trips, and they reduce the ability to use alternative modes, like transit, which are inflexible and time consuming. All of these needs are intensified by the low density suburban development of jobs and homes." (Rosenbloom, 1995, p. 2-9) Thus not only are there great time pressures on people, particularly women, with travel critical to carrying out these many responsibilities, but the physical arrangement of residences and work and other destinations potentially play an important role in how successfully these challenges can be negotiated.

Any measure of accessibility to the residence, such as the one used in this study, can be expected to do a poorer job predicting travel for groups who have less home-based travel. Because working women are more likely to form complex work-related trip chains (Dueker, Strathman and Davis, 1994) this suggests that as a group their travel might be less sensitive to the accessibility of home. Although Dueker, Strathman and Davis found home-to-work distance and workplace and residence variables insignificant in their model predicting work commute trip chaining, such trip chaining theoretically holds greater benefits for people who live in inaccessible locations. Thus it seems possible that accessibility might do a poorer job of explaining travel behavior for residents of such locations.

EMPIRICAL ANALYSIS

THE GRAVITY MEASURE OF ACCESSIBILITY

The gravity measure of Atlanta census tracts' accessibility to employment in 1990 used here ($ACCESS^{90}$) is based on modelled peak-hour street and highway network travel times obtained from the Atlanta Regional Commission (ARC). Because the travel times used to calculate this measure assume travel by car, not walking, bicycling or mass transit, it does not measure accessibility via other modes. The 1990 Census demonstrates that this is appropriate for the vast majority of Atlanta workers, since approximately ninety-one percent of the workers over age 16 in the Atlanta MSA commuted to work in a privately-owned motorized vehicle in 1990. Under five percent of all workers in the MSA commuted to work via public transportation, while a little over two percent worked at home and under two percent walked or bicycled to work. (Rossetti and Eversole, 1993)

The measure used in this analysis is defined as:

$$ACCESS_i^{90} = \sum_{j=1}^{n} W_j^{90} * (t_{ij}^{90})^{-b}$$

where:

$ACCESS_i^{90}$ is the gravity accessibility of tract i to 1990 employment,

W_j^{90} is the number of jobs in tract j in 1990,

$(t_{ij}^{90})^{-b}$ is impedance; a function of the separation in peak travel time (t) in 1990 between tracts i and j, and

n is the number of tracts in the study area.

An accessibility score was calculated for each census tract in the study area using this measure.[3] Higher values mean a tract is more accessible to all employment in the study area. The form of the impedance function causes nearby employment to increase a tract's accessibility score far more than do more distant jobs. Recent work has demonstrated that gravity measures of accessibility are more accurate at predicting residential density, with which they have a well-defined theoretical relationship, than any other type of accessibility measures, including opportunity measures, which count the numbers of destination opportunities within a specified radius. (Song, 1996; Helling, 1992, 1996a)

Many destinations, including those visited for school, shopping, personal business and some types of recreation are also employment locations, although the ratio of trip attractions to employment varies widely by activity type. Thus this measure of accessibility to all employment is intended to represent accessibility to any and all desired destinations in the metropolitan area, with the amount of employment indicating a general attractiveness to trips, whether for errands, leisure or work. When Atlanta lost over 26,000 jobs in a single year between the first quarters of 1990 and 1991, it had the effect of shuffling the destinations of many thousands of households, reaffirming the importance of accessibility to the entire employment base rather than just a portion of it. Additionally, the nineties have seen strong growth in firms providing temporary employees to many different industries. Since "temps" by definition lack a permanent employment destination, the growth of this segment of the employment base also suggests that the importance of accessibility of residential areas to all employment locations will remain important. Although it might be natural to think in terms of the locational match-up between an individual and his or her current job, an individual's accessibility to *all* employment recognizes that individuals' destinations may change at any time, and in any case are not limited to the workplace.

THE TRAVEL SURVEY

The travel survey which is the source of the trip data reported here was undertaken by Barton-Aschman Associates and NuStats Inc. for the Atlanta Regional Commission in the fall of 1991[4]. Although the survey covered eleven counties, this paper reports data only for those surveyed households residing within the study area shown in Figure 1. This area is made up of the seven counties comprising the central portion of the 18-county Atlanta Metropolitan Statistical Area (MSA). It contained about 2.4 million people in 1990, nearly 84 percent of the MSA population, and about 1.4 million jobs.[5] A sample of 2,433 households, containing 6,351 persons, was drawn from those having telephones in the eleven-county area. After eliminating households living in the four counties outside the study area, households not reporting a residence location and households not reporting income, 2,351 of these households (6,192 persons) remained and are included in the data reported here for the smaller area covered by this study.

The survey consisted of contacting each household to verify basic information and secure their agreement to participate, mailing each household a travel diary and related information, and interviewing each household by telephone to obtain the information recorded in the travel diary within 72 hours of the agreed-upon travel day. The data thus obtained were then edited, coded and entered into a database. The procedures used in conducting the survey are documented in an Atlanta Regional Commission publication titled "1990 Household Travel Study: Final Report." (ARC, 1993)

The ARC travel survey omitted two types of travel. Only trips by persons five years old and older were recorded, which is not likely to be important here. More significantly, only trips in motorized vehicles were recorded except for walking or biking trips to work, of which there were only 19 out of a total of 23,308 trip records. Thus for all practical purposes this survey describes only motorized trips. This means that the hypothesis that accessibility increases the number of trips, but increases the proportion accomplished via foot or bicycle to reduce travel overall, cannot be tested. This may not represent a large loss to this analysis, which hypothesizes the importance of a measure which relates to the whole metropolitan region, and relies on data collected at too coarse a scale to likely be useful at explaining pedestrian trips. However, this lack does reduce the potential for understanding and for effective holistic transportation planning which would recognize pedestrian and bicycle travel as a substitute for and compliment to people's motorized travel.

The seven travel variables listed in Table 1 were assembled from the travel survey data. The individuals reported on were members of the surveyed households and their out-of-the-area visitors staying with them who were five years old or older. Each household was asked to record a variety of information about each trip made on the assigned travel day. Trips were counted two ways; unlinked (each stop defines the beginning of a new trip) and linked (the trips before and after brief stops to serve or drop off a passenger or to change to transit are counted together as one trip). The number of unlinked trips for a person or household is always equal to or greater than the number of linked trips. Trips in private cars exclude trips via vanpools, carpools, taxis, Metropolitan Atlanta Rapid Transit Authority (MARTA) train, bus, school bus, social service or special bus or by walking or biking. Home-based trips include only trips for which the person's home is either origin or destination. Work or school trips included trips to or from work and school and trips which were work-related, omitting personal, shopping, social/recreational, "eat meal" and "other" trips. Minutes spent traveling sums the elapsed time between when trips were reported to begin and end for all trips by an individual or household.

FINDINGS

GENDER DIFFERENCES IN MEANS FOR TRAVEL VARIABLES

Table 1 indicates that women surveyed made significantly more trips in motorized vehicles that did men. The difference was more significant when all trips were counted separately rather than being linked, meaning women made more short stops to connect to transit, drop off a passenger or allow a passenger to run an errand as well as more trips overall. Women also made significantly more home-based trips. Though women also appeared to make more private car trips, the difference from men is not significant. The most significant difference in means for the travel variables considered is between men's and women's numbers of work and school trips, with men making more. Men also spend significantly more minutes in travel than do women.

If earlier research results for miles of travel can correctly be assumed to approximately parallel what I obtained here for time spent travelling, these results confirm that the men and women that participated in the ARC travel survey were not unusual, as these patterns mirror those observed in the 1990 Nationwide Personal Transportation Survey, as described earlier. This is important primarily because, if Atlanta's travel is reasonably similar to that in other large U.S. metropolitan areas, the effects of accessibility on Atlantans' travel may be generalizable as well.

THE EFFECTS OF ACCESSIBILITY ON INDIVIDUALS TRAVEL

Table 2 indicates that accessibility significantly reduces the time men spend travelling, though this effect is not seen for women. These results are made more specific in Table 3, where minutes spent travelling are significantly reduced by accessibility only for employed men. Thus it appears that, at least for this measure of accessibility, men are the chief beneficiaries of household decisions to pay more for locations which are accessible to all employment. These time savings are not small, though there is clearly much variation which accessibility cannot explain. The coefficient on accessibility suggests that an employed man living in highly accessible location A (near a regional shopping center and a few minutes down Interstate 85 from Atlanta's Hartsfield International Airport) saves about 34 minutes of travel time per day over his counterpart living in location B, where the accessibility index is about 1,000 points lower (a historic in-town neighborhood).

Table 1
Differences of Means Among Travel Variables by Gender

Travel Variables	Women N=3.164	Men N=3.028	Diff. of Means[1] (t)
Individuals'[2] linked[3] trips in motorized vehicles	3.65	3.52	1.88*
Individuals'[2] unlinked[3] trips in motorized vehicles	3.89	3.70	2.82***
Individuals'[2] linked[3] trips in private cars[4]	3.37	3.27	1.50
Individuals'[2] linked[3], home-based trips in motorized vehicles	2.64	2.57	1.74*
Individuals'[2] linked[3], home-based, work and school trips in motorized vehicles	1.10	1.35	-9.82****
Minutes individuals[2] spent traveling in motorized vehicles	70.63	83.57	-6.93****

* Significant at the .1 level ** Significant at the .05 level *** Significant at the .01 level
**** Significant at the .001 level

[1] Using a two-tailed significance test and assuming unequal variances. A negative result indicates than the mean for men was greater than that for women.
[2] Trips were recorded only for persons aged 5 and older.
[3] When trips are linked, two types are combined with others; (1) those in which once traveler "makes a trips to serve the needs of another traveler," such as dropping a child off at school, unless it is part of a "serve passenger tour" or the stop at the passenger's destination lasts longer than six minutes, and (2) those which provide access to a different travel mode, such as a car trip to a transit station. Unlinked trips count all trips, including these types, separately.
[4] Travel in private cars includes drivers and passengers, but not self-identified members of carpools or vanpools.

By contrast, it appears that the gravity accessibility of a man's or woman's residence has no significant effect on the number of linked or unlinked, motorized trips they make. The signs of the coefficients on residential accessibility are sometimes positive and sometimes negative for the first five travel variables in Table 2, reinforcing the idea that accessibility's effect on the number of motorized trips is uncertain. This is consistent with the conclusion that "the individual's location within the city plays a relatively minor role in explaining travel frequency but plays a more important role in explaining travel distances" (presuming the latter correspond approximately to travel time). (Hanson, 1982, p. 197) And it is not necessarily inconsistent with previous findings of increased numbers of trips, since non-motorized trips, which were not included in the survey, may be higher among those who live in more accessible locations.

Table 2
The Effects of Home-based Gravity Accessibility on Travel Variables by Gender

Travel Variables	All N=6,192	Women N=3,164	Men N=3,028
Individuals'[2] linked[3] trips in motorized vehicles	0.000129 (0.73) r = 0.01	0.000080 (0.30) r = 0.00	0.000171 (0.73) r = 0.01
Individuals'[2] unlinked[3] trips in motorized vehicles	0.000227 (1.20) r = 0.02	0.000220 (0.77) r = 0.01	0.000228 (0.92) r = 0.02
Individuals'[2] linked[3] trips in private cars[4]	0.000156 (0.85) r = 0.01	0.000078 (0.28) r = 0.01	0.000228 (0.93) r = 0.02
Individuals'[2] linked[3], home-based trips in motorized vehicles	0.000022 (0.19) r = 0.00	-0.000026 (-0.14) r = -0.00	0.000066 (0.42) r = 0.01
Individuals'[2] linked[3], home-based, work and school trips in motorized vehicles	-0.000100 (-1.45) r = -0.02	-0.000056 (-0.55) r = -0.01	-0.000140 (-1.45) r = -0.3
Minutes individuals[2] spent travelling in motorized vehicles	-0.01671 (-3.27)*** r = -0.04	-0.006690 (-0.99) r = 0.02	-0.025760 (-3.41)**** r = -0.06

* Significant at the .1 level ** Significant at the .05 level *** Significant at the .01 level
**** Significant at the .001 level

[1] Regression coefficients on the gravity measure of accessibility to employment when it predicts listed travel variables, followed by t scores in parentheses, and correlation coefficients.
[2] Trips were recorded only for persons aged 5 and older.
[3] When trips are linked, two types are combined with others; (1) those in which once traveler "makes a trips to serve the needs of another traveler," such as dropping a child off at school, unless it is part of a "serve passenger tour" or the stop at the passenger's destination lasts longer than six minutes, and (2) those which provide access to a different travel mode, such as a car trip to a transit station. Unlinked trips count all trips, including these types, separately.
[4] Travel in private cars includes drivers and passengers, but not self-identified members of carpools or vanpools.

This appears likely for one result in Table 2 in particular. The numbers of motorized home-based work and school trips men made were reduced by living in an accessible location, though not significantly. The effect for women was much smaller. It seems possible that non-motorized trips, particularly to school, may have taken the place of some of those car trips for men and boys who live in accessible areas. This is reinforced in Table 3, where women and men are further broken down into those who are employed at least part time and those who are not. Among the latter group of both men and women, accessibility significantly reduces the numbers of home-based trips to work and school. Since nonworking people do not make trips to work, this means that accessibility reduces the number of motorized trips to school for both males and females. Although it is certainly possible that students in accessible areas make fewer school trips, perhaps because they have a different demographic or economic profile, such as being older, with greater discretion and fewer classes, it is also possible that they make an equal number or more, replacing motorized trips with non-motorized trips. Rosenbloom has noted that lower numbers of motorized trips by children may have negative consequences if it means they have fewer opportunities, or are unsafe travelling alone on foot or bicycle. (Rosenbloom, 1988)

Table 3
The Effects of Home-based Gravity Accessibility on Travel Variables by Gender and Employment Status

Travel Variables	Women Employed N=1,696	Women Not employed N=1,468	Men Employed N=2,018	Men Not employed N=1,010
Individuals'[2] linked[3] trips in motorized vehicles	0.000127 (0.36) r = 0.01	-0.000300 (-0.78) r = -0.02	0.000449 (1.53) r = 0.03	-0.000460 (-1.26) r = -0.04
Individuals'[2] unlinked[3] trips in motorized vehicles	0.000290 (0.76) r = 0.02	-0.000230 (-0.55) r = -0.01	0.000500 (1.62) r = 0.04	-0.000400 (-1.01) r = -0.03
Individuals'[2] linked[3] trips in private cars[4]	-0.000074 (-0.21) r = -0.01	-0.000170 (-0.41) r = -0.01	0.000341 (1.15) r = 0.03	-0.000150 (-0.37) r = -0.01
Individuals'[2] linked[3]. home-based trips in motorized vehicles	-0.000012 (-0.06) r = -0.00	-0.00015 (-0.52) r = -0.01	0.000240 (1.31) r = 0.03	-0.000280 (-0.96) r = -0.03
Individuals'[2] linked[3]. home-based work and school trips in motorized vehicles	.000000 (0.00) r = 0.00	-0.00032 (-2.22)** r = -0.06	-0.000015 (-0.14) r = -0.00	-0.000420 (-2.58)** r = -0.08
Minutes individuals[2] spent travelling in motorized vehicles	-0.008700 (-1.03) r = -0.03	-0.011500 (-1.08) r = -0.03	-0.033980 (-3.38)**** r = -0.08	-0.013410 (-1.49) r = -0.05

* Significant at the .1 level ** Significant at the .05 level *** Significant at the .01 level **** Significant at the .001 level

[1] Regression coefficients on the gravity measure of accessibility to employment when it predicts listed travel variables, followed by t scores in parentheses, and correlation coefficients.
[2] Trips were recorded only for persons aged 5 and older.
[3] When trips are linked, two types are combined with others; (1) those in which once traveler "makes a trips to serve the needs of another traveler," such as dropping a child off at school, unless it is part of a "serve passenger tour" or the stop at the passenger's destination lasts longer than six minutes, and (2) those which provide access to a different travel mode, such as a car trip to a transit station. Unlinked trips count all trips, including these types, separately.

THE EFFECTS OF ACCESSIBILITY ON HOUSEHOLDS TRAVEL

Table 4 shows that when aggregated into households, those who live in more accessible areas spend significantly fewer minutes per day in travel, as was true for individuals. Thus the savings to men are not, as a rule, offset by increased travel by women in the same household. This is important because the household is commonly taken as the unit of analysis in transportation planning. Households are usually viewed as decision-making units, capable of saving travel time for one member by increasing the amount of travel another undertakes. This view is reinforced by these findings. Urban economics has traditionally linked residential location decisions to commutation costs (Muth, 1969) and has proposed a variety of theoretical models for how households might trade off accessibility to the employment location of more than one worker. This study's results for Atlanta in 1990 support the simpler, older view that residential location is most commonly used to reduce the length of trips by working men, rather than accommodating other members of the household.

Table 4
The Effects of Home-based Gravity Accessibility on Travel Variables at the Household Level

Travel Variables	All Households N=2,351
Unlinked[3] trips households[2] made in motorized vehicles	-0.003760 (-4.78)**** r = -0.10
Unlinked[3] trips per adult households[2] made in motorized vehicles	0.000253 (1.06) r = 0.02
Minutes households[2] spent travelling in motorized vehicles	-0.125950 (-7.01)**** r = -0.14
Minutes per adult households[2] spent travelling in motorized vehicles	-0.901070 (-1.82)** r = -0.10

* Significant at the .1 level ** Significant at the .05 level *** Significant at the .01 level
**** Significant at the .001 level

[1] Regression coefficients on the gravity measure of accessibility to employment when it predicts listed travel variables, followed by t scores in parentheses, and correlation coefficients.
[2] Trips were recorded only for persons aged 5 and older.
[3] When trips are linked, two types are combined with others; (1) those in which once traveler "makes a trips to serve the needs of another traveler," such as dropping a child off at school, unless it is part of a "serve passenger tour" or the stop at the passenger's destination lasts longer than six minutes, and (2) those which provide access to a different travel mode, such as a car trip to a transit station. Unlinked trips count all trips, including these types, separately.

Households in more accessible areas also appear to make significantly fewer motorized trips, as indicated by Table 4. This is potentially consistent with earlier findings that both numbers of trips and the proportion of non-motorized trips are higher in more accessible areas. However, further analysis casts doubt on accessibility's ability to reduce the number of motorized trips. In Atlanta, accessibility is positively correlated with two other factors known to be important to household trip generation rates; household size (r = .60) and number of motorized vehicles available (r = .30) both rise along with accessibility. Removing most of the effect of household size by calculating each household's "trips per adult" (the second travel variable in Table 4) reduces the effects of accessibility on household trip generation to insignificance, as was the case for individuals. Making the same adjustment for minutes households spent travelling yields "minutes per adult households spent travelling," which is still significantly reduced by greater residential accessibility, as it was for individuals.

RESULTS IN COMBINATION WITH OTHER EXPLANATORY VARIABLES

Table 5 illustrates the results when household size, vehicles available, gravity accessibility to employment and household income were used to predict trips in motorized vehicles and minutes spent travelling for individuals by gender and employment status and for households. Table 5 makes it quite clear that accessibility has relatively little power to explain numbers of trips or minutes spent travelling, in spite of the significance of its regression coefficients. The best models are those for households, explaining about 37 percent of the variation in numbers of trips and about 23 percent of the variation in minutes households spent in travel, and far less of the variation in the travel of individuals, even individuals of the same sex and employment status. Nonetheless, the patterns in Table 5 are illuminating.

First, the effect of income on these travel variables is weak and ambiguous. This is consistent with Rosenbloom's findings (1995) and not surprising, since though higher income individuals minimize travel time because of its value to them in other pursuits, the high-income earner's other household members may have fewer time demands and hence less need to minimize travel. These countervailing effects within a single household leave the predicted sign of income's effect in doubt, and Table 5 shows both positive and negative coefficients on income, though all of the significant effects are negative. Significant results were obtained only for numbers of trips by employed individuals, men, and employed men. That employed people would make fewer trips matches the logic suggested above, since they are more likely to have competing uses for their time. However, this alone does not explain the result that this is more true for men than women.

As noted earlier, the positive effects of household size and number of vehicles available on trip-making have long been used to predict trip generation rates. Table 5 illustrates how trips by households increase significantly with increasing household size and the number of vehicles available, with income held constant. Household size and the number of vehicles available also significantly increase the minutes households spend travelling. Thus each additional member adds about 3 trips or 52 minutes of travel time to the household total per day. Interestingly, however, men's trips and minutes spent in travel are significantly diminished by increasing household size. This could happen if men undertook little travel to serve other members of the household and passed off to others travel responsibilities they would have undertaken themselves if they lived alone. Alternatively, perhaps family responsibilities cause men with larger households to minimize travel, by working, recreating and running errands closer to home than men with few or no dependents. The effect of household size on women's travel was to significantly increase the number of trips made, while having no significant effect on minutes spent travelling, so neither of the hypotheses proposed to explain the results for men would serve to explain the results for women. Meanwhile, Table 5 shows that employed women travel less, the more vehicles are available to the household, a possibility if employed women make fewer trips to serve others in the household when those others have vehicles of their own. Table 5 (following page) shows that more vehicles mean significantly more trips for men, a more common result.

Although multicollinearity with these other powerful explanatory variables, household size and number of vehicles available is clearly potentially troublesome, accessibility appears to have significant effects on travel for several of the groups. In predicting minutes spent travelling, the coefficient on accessibility is negative and significant for all individuals, men, employed men and households even after variation due to household size and number of vehicles available is separated out. In fact, accessibility's effects on minutes spent travelling is negative in every case in Table 5, though many of these effects are not statistically significant. This is consistent with the earlier results, which showed accessibility reducing trip lengths, and reinforces the idea that households often allocate the travel savings from accessible residential location to their employed male members.

Table 5 also shows accessibility to have a significant positive effect on numbers of trips for all individuals, employed individuals and employed men when incorporated into a model with household size, vehicles available and income. All of accessibility's significant effects on numbers of trips are positive. This is a stronger result than obtained by evaluating accessibility's effect on trips by itself, when its coefficient was positive but insignificant for all individuals as well as employed women and men. As noted earlier, a complete picture of the effect of accessibility on number of trips cannot be determined from the travel survey, since non-motorized trips were, for the most part, not reported.

IMPLICATIONS AND CONCLUSIONS

Evidence from Atlanta demonstrates that intrametropolitan accessibility to employment does affect travel. Persons who live in locations which are more accessible spend significantly fewer minutes in travel overall than do those who live in less accessible locations, as do their households. This conclusion is consistent with previous empirical work, but extends it to a metropolitan scale in the U.S. for a recent year, while providing detail on gender and work status. Confirming that metropolitan accessibility and time spent travelling are inversely related is very important for planning, as it suggests that policy which increases the overall accessibility of residence to all employment will reduce travel.

However, these effects are far from uniform among all persons. John Kain advocated testing the effects of accessibility to employment on males and females separately because, "there is reason to believe that differences in employment access would affect them differently." (Kain, 1992, p. 393) Women rely particularly heavily on travel to accomplish many responsibilities under very severe constraints on time and sometimes income and location. Yet this paper has demonstrated that the reduction in minutes spent travelling which appears to be such a robust result of greater residential accessibility accrues more to men than to women, and particularly to employed men. Thus policy aimed at improving accessibility ought to specifically consider that it may have fewer benefits for women than for men.

Exploring which other individual differences are important to accessibility's effects on travel is an obvious next step toward better understanding. Multi-worker households are increasing in number, and are particularly prevalent in low-density areas of large metropolitan areas. The number of workers

Table 5: Possible Models for Predicting Travel Variables Using Accessibility

Dependent Travel Variables	N	Household size	HH Income [1]	Vehicles avail.	Accessibility	Adjusted R2
Unlinked trips in motorized vehicles						
All individuals	6,192	0..3	0.09	0.0004	-0.01	.001
		(1.26)	(2.47)**	(1.90)*	(-0.94)	
Employed	3,714	0.17	-0.06	0.0006	-0.05	.008
		(4.73)****	(-1.28)	(2.26)**	(-2.48)**	
Not Employed	2, 478	0.07	0.11	-0.0001	0.01	.003
		(2.02)**	(1.94)*	(-0.43)	(0.50)	
Women	3,164	0.12	0.02	0.0004	0.01	.003
		(3.34)****	(0.28)	(1.27)	(0.41)	
Employed	1,696	0.37	-0.26	0.0004	-0.02	.023
		(6.40)****	(-3.38)****	(0.94)	(-0.78)	
Not employed	1,468	0.15	0.09	-0.0000	0.03	.009
		(3.22)***	(1.22)	(-0.05)	(1.15)	
Men	3,028	-0.07	0.17	0.0003	-0.04	.004
		(-2.00)**	(3.57)****	(1.37)	(-1.88)*	
Employed	2,018	0.03	0.10	0.0006	-0.06	.004
		(0.66)	(1.64)	(2.05)**	(-2.52)**	
Not employed	1,010	-0.05	0.12	-0.0003	-0.02	.000
		(-1.06)	(1.48)	(-0.73)	(-0.71)	
Households	2,351	3.11	0.62	0.0010	0.02	.367
		(31.93)****	(4.64)****	(1.54)	(0.34)	
Minutes spent travelling						
All individuals	6,192	-2.40	3.30	-0.0152	-0.34	.004
		(-3.63)****	(3.37)****	(-2.90)***	(-0.91)	
Employed	3,714	-0.12	0.36	-0.0233	-0.62	.003
		(-0.11)	(0.27)	(-3.35)	(-1.17)	
Not employed	2,478	0.42	1.75	-0.0100	-0.53	.001
		(0.50)	(1.28)	(-1.36)	(-1.06)	
Women	3,164	-0.82	1.32	-0.0058	-0.43	.000
		(-0.96)	(1.03)	(0.83)	(-0.88)	
Employed	1,696	0.98	-2.91	-0.01221	-0.36	.001
		(0.77)	(-1.71)*	(-1.37)	(-0.56)	
Not employed	1,468	1.60	2.32	-0.0078	-0.56	.001
		(1.36)	(1.20)	(-0.71)	(-0.79)	
Men	3,028	-4.00	4.62	-0.0248	-0.30	.010
		(-3.94)****	(3.14)***	(-3.22)***	(-0.52)	
Employed	2,018	-1.08	2.39	-0.0326	-0.95	.005
		(-0.73)	(1.21)	(-3.17)***	(-1.18)	
Not employed	1,010	-1.47	0.65	-0.0139	-0.44	.000
		(-1.32)	(0.35)	(-1.49)	(-0.67)	
Households	2,351	52.26	18.37	-0.0359	0.34	.233
		(21.15)****	(5.42)****	(-2.18)**	(0.28)	

*Significant at the .1 level ** Significant at the .05 level ***Significant at the .01 level **** Significant at the .001 level in a household may sometimes explain travel behavior better than does household size, the more traditional variable. But this has been studied relatively little empirically, and does not often figure into transportation demand models. (Soot, Sen, Marston and Thakuriah, 1995) Similarly, new operational definitions of household structure and person roles may prove useful to further research in this area because gender has been found to have a different effect on trip frequency for different person roles. (Al-Kazily, Barnes and Coontz, 1995)

The results reported here reinforce the belief that land use policy and physical planning to improve accessibility may provide means of manipulating travel demand to achieve higher quality of life, enhanced economic development and more efficient transportation. They indicate that greater accessibility benefits both individual households and society as a whole. Households benefit from greater residential accessibility because, though they retain great freedom to make their own travel decisions, they also get to devote less time to travel, while apparently making the same or greater numbers of trips. Meanwhile society benefits from shorter trips, reducing the acknowledged externalities of car travel. Yet residential accessibility's effects on travel, though significant, do not affect all individuals. Though metropolitan accessibility does have the hoped-for effect overall, it leaves much variation in travel behavior unexplained.

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