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Driving to Opportunity:

Understanding the Links among Transportation Access, Residential Outcomes, and Economic Opportunity for Housing Voucher Recipients

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Executive Summary

In the 1990s and early 2000s, the Department of Housing and Urban Development (HUD) sponsored two major experiments to test whether housing choice vouchers propelled low-income households into greater economic security. The first of these was the Moving to Opportunity (MTO) for Fair Housing program, which was designed to move low-income families from high- to lower-poverty neighborhoods. The other was a tenant-based housing voucher program, the Welfare to Work Voucher program (WTW), initiated in 1999 to help families currently receiving or eligible to receive welfare transition from public assistance into the labor market.

Although slightly different, the two voucher programs' purpose was to assess whether low-income families benefitted from living in lower-poverty neighborhoods—either through improved neighborhood conditions or better economic and health outcomes. Research shows that households receiving vouchers choose to live in a wider range of neighborhoods than public housing residents and unassisted renters. However, voucher users still face hurdles when trying to secure housing in high-opportunity neighborhoods.

There is growing evidence that transportation—particularly access to automobiles—plays an important role in shaping the residential location choices and economic outcomes of low-income households. Automobiles and high-quality public transit services can enable participants to better search for housing as well as provide access to potential employment, services, and other opportunities within a reasonable travel time. To date, however, transportation has not been a major focus of the research related to housing voucher participants.

This study fills this gap. We examine the relationship between transportation, residential location, and employment outcomes. More specifically, our research focuses on three areas: (1) the sorting of housing choice voucher recipients into different neighborhoods and variation in neighborhood sorting by automobile ownership, (2) the role of transportation in voucher users' residential choices, and (3) how transportation access and residential location choice influence economic opportunity.

Overall, the findings from this study underscore the positive role of automobiles in outcomes for housing voucher participants. The following bullet points list our key findings in the three research areas.

- Neighborhood sorting
    - Families with access to cars found housing in neighborhoods where environmental and social quality consistently and significantly exceeded that of the neighborhoods of households without cars. Especially noteworthy, families with car access felt safer in their neighborhoods and were less likely to live in neighborhoods with high crime rates than those without car access.
    - Low-income households did make trade-offs with respect to neighborhood conditions. MTO households with cars lived in neighborhoods that were more spread out—with lower density of aggregate income and housing and less diverse housing stock—and with worse measured school performance than transit-dependent households. (School performance measures improved, however, by the final survey, as noted below.)
    - While most neighborhoods are not distressed, practically none with housing prices affordable to most families offers mostly positive attributes and few disadvantages.
    - Only a small minority of tracts in US metropolitan areas have crushing crime rates, failing schools, high levels of environmental degradation, and deep poverty; these distressed tracts also number among the most conveniently situated places in a nation.

    - The two sets of metropolitan areas offer important contrasts with one another on one important dimension. The MTO metropolitan areas—Boston, Baltimore, Chicago, New York, and Los Angeles—offer many transit choices. The WTW metropolitan areas—Atlanta, Houston, Augusta, Spokane, and Fresno—have less-developed transit systems than the MTO areas.
- Transportation and residential location choice
    - Over time, households with automobiles experience less exposure to poverty and are less likely to return to high-poverty neighborhoods than those without car access.
    - Among those relocating from their baseline neighborhoods, program participants with access to automobiles moved to areas with lower concentrations of poverty, higher concentrations of employed adults, higher median rents, more owner-occupied housing, lower vacancy rates, greater access to open space, and lower levels of cancer risk.
    - When we control for other factors influencing residential mobility, program participants with access to automobiles move to neighborhoods with higher levels of school performance by the time of the final survey.
    - Access to vehicles positively influences neighborhood satisfaction, particularly in neighborhoods with low levels of transit.
    - Program participants with automobiles live in neighborhoods with lower levels of transit and in environments less conducive to walking.
- Effect of transportation access and residential location choice on economic opportunity
    - The neighborhoods where carless voucher users live offer access to larger numbers of jobs than those where driving voucher users live. However, voucher users with cars more than compensate for this by living in neighborhoods where fewer low-income people compete for available jobs.
    - Keeping or gaining access to automobiles is positively related to the likelihood of employment.
    - Improved access to public transit is positively associated with maintaining employment but not with transitions to employment.
    - On earnings, both cars and transit access have a positive effect, though the effect for auto ownership is considerably greater.

Our analyses point to many implications for future research and data collection efforts, voucher-enhanced mobility programs, and strategies for coordinating housing and transportation policies in ways that enhance economic opportunity for low-income households:

- All levels of government, philanthropy, and the private sector should continue to pursue efforts to strengthen coordination of transportation and housing programs.
- Policymakers should rethink vehicle asset limitations and state-level policies that limit the value of the cars that participants in safety-net programs may own.
- Combining rental vouchers with subsidies for automobile purchases may be one possible approach to expanding the location choices available to low-income households.
- Short-term car rental services such as ZipCar and Car2Go have the potential to address the travel needs of some low-income adults at a lower cost, because users pay only for the transportation that they use.
- Housing search services should be tailored to the transportation needs of households receiving assistance.
- Voucher recipients would benefit from greater coordination of housing voucher assistance and nonprofit car donation and rideshare services.
- HUD would be well-advised to collect data on assisted tenants and their access to working

automobiles.

- Because the importance of automobile access may also reflect the inadequacy of public transportation, policies to enable households to move to transit-rich neighborhoods can also help participants retain employment.

HUD's Sustainable Communities Initiative helps communities and regions improve their economic competitiveness by connecting housing with good jobs, quality schools, and transportation.[1] Given their numerous negative environmental externalities, automobiles tend to be ignored in these planning efforts. Yet, as our research shows, automobiles are important to achieving many elements of the sustainability agenda because they are associated with improved access to high-opportunity and more livable neighborhoods. In other words, pursuit of the broader sustainability agenda may require some difficult trade-offs in the types of neighborhoods in which families live and in the means (the travel mode) by which they access opportunities.

[1] "Sustainable Communities Initiative." US Department of Housing and Urban Development, accessed February 10, 2014, http://portal.hud.gov/hudportal/HUD?src=/hudprograms/sci.

Introduction and Overview

In the 1990s and early 2000s the Department of Housing and Urban Development (HUD) sponsored two major experiments to test whether housing choice vouchers propelled low-income households into greater economic security. The first of these was the Moving to Opportunity (MTO) for Fair Housing program. Authorized by Congress in 1992, MTO was a tenant-based housing voucher program that, coupled with housing and counseling services, was designed to move low-income families from high- to lower-poverty neighborhoods, neighborhoods with poverty rates under 10 percent in 1990. The other was a tenant-based housing voucher program, the Welfare to Work Voucher program, (WTW) initiated in 1999 to help families currently receiving or eligible to receive welfare transition from public assistance into the labor market. Combined, these two programs produced experimental data (treatment and control) for voucher participants in 10 major US metropolitan areas: New York, Los Angeles, Chicago, Boston and Baltimore (from MTO); and Atlanta, Spokane, Augusta, Houston and Fresno (from WTW).[2]

Although slightly different, the two voucher programs' purpose was to assess whether low-income families benefitted from living in lower-poverty neighborhoods—either through improved neighborhood conditions or better economic and health outcomes.[3] Research on the linkages between tenant-based housing assistance and residential outcomes suggests that households receiving vouchers choose to live in a wider range of neighborhoods than public housing residents and unassisted renters (Schwartz, 2010). However, over the long term, they still face hurdles when trying to secure housing in high-opportunity neighborhoods (Turner et al. 2011). Among other characteristics, high-opportunity neighborhoods have low poverty and high labor force participation rates, quality public services (schools, public transit, and other services), access to employment opportunities within a reasonable travel time, and are safe and healthy environments in which to live.

There is growing evidence that transportation—particularly access to automobiles—plays an important role in shaping the residential location choices and economic outcomes of low-income households. Automobiles and high-quality public transit services can enable participants to better search for housing as well as provide access to potential employment, services, and other opportunities within a reasonable travel time. Participants in both voucher experiments were asked questions about their transportation resources and use. Depending on the survey, they reported whether they had a driver's license, their access to automobiles, their commute mode, and their proximity to public transit. To date, however, transportation has not been a major focus of the research related to housing voucher participants.

This study aims to fill this gap. In a series of papers currently under consideration or in preparation for peer review, we have examined the following three general topics: (1) the sorting of housing choice voucher recipients into different neighborhoods and variation in neighborhood sorting by automobile ownership, (2) the role of transportation in voucher users' residential choices, and (3) how transportation access and residential location choice influence economic opportunity. (In this report, we summarize our findings from this body of research.)

Our findings underscore the positive role of automobiles in outcomes for housing voucher participants. Automobiles increase the likelihood that voucher participants will live and remain in high-

[2] While Los Angeles also hosted a WTW demonstration, there were no follow-up data collected there, so we exclude it from our experimental sample.

[3] For more information on both programs, see Briggs et al. (2010), Orr et al. (2003), Patterson et al. (2004), and Sanbonmatsu et al. (2011).

opportunity neighborhoods—neighborhoods with lower poverty rates, higher social status, stronger housing markets, and lower health risks than neighborhoods in which those without cars live. Cars are also associated with improved neighborhood satisfaction and better employment outcomes. The importance of automobiles arises not because of the inherent superiority of the mode, but because public transit systems in most metropolitan areas are slow, inconvenient, and lack sufficient metropolitan-wide coverage to rival the automobile.

HUD's Sustainable Communities Initiative intends to help communities and regions improve their economic competitiveness by connecting housing with good jobs, quality schools, and transportation.[4] Given their many negative environmental externalities, automobiles tend to be ignored in these planning efforts. For example, the listing of FY2011 Sustainable Communities Grantees includes many references to transportation, particularly efforts to improve the linkage between affordable housing and public transit.[5] Not a single grantee lists efforts to increase low-income households' access to automobiles. Yet, as our research shows, automobiles are important to achieving many elements of the sustainability agenda because they are associated with improved access to high-opportunity, more livable neighborhoods. In other words, pursuit of a sustainability agenda may require some difficult trade-offs.

Background

In this section, we briefly discuss the academic literature relevant to our study. We emphasize two major strands of literature: (1) theoretical and empirical works that examine the linkages among transportation, residential location decisions, and economic outcomes for low-income households, and (2) studies that focus specifically on those receiving federal housing assistance, emphasizing the role that HUD subsidies play in helping households secure housing in neighborhoods that provide access to social and economic opportunities.

Residential Location, Transportation, and the Poor

It is widely acknowledged that transportation plays an important role in shaping the residential location and economic outcomes of low-income households. Muth (1969) and Alonso (1964) were the first to examine the role that transportation costs play in household location decisions. These authors argue that utility-maximizing households will make trade-offs between housing costs and intra-regional accessibility, with more centrally located locations offering higher accessibility to employment and more suburban locations offering lower housing prices, all things else equal. If the income elasticity of demand for housing exceeds the income elasticity of demand for savings in commuting costs, higher-income households will choose more distant locations to consume a larger housing bundle, while lower-income households will choose smaller housing in more accessible central-city locations. LeRoy and Sonstelie (1983) expand upon this model to argue that the availability of a public transportation system may also induce centralization of low-income populations, if the costs of owning and operating an automobile are prohibitively high and public transportation is only accessible within more centrally located areas.

While subsequent research offers only mixed support for these initial models, many studies still find a relationship between transportation, housing search, and residential location choice (Abraham and Hunt

[4] "Sustainable Communities Initiative," US Department of Housing and Urban Development, accessed February 14, 2014, http://portal.hud.gov/hudportal/HUD?src=/hudprograms/sci.

[5] "HUD FY2011 Sustainable Communities Grantees" US Department of Housing and Urban Development, accessed February 14, 2014, http://portal.hud.gov/hudportal/documents/huddoc?id=FY2011RegGrantees_noDist.pdf.

1997; Levine 1998; Rodriguez et al. 2011). The literature on residential satisfaction also finds that various transportation-related factors, including measures of walkability and land use mix (Yang 2008), proximity to public transportation (Baum et al. 2009), access to walking and biking paths (Kearney 2006; Chapman and Lombard 2006), and more general measures of accessibility to jobs and social services (St. John and Clark 1984) are significant determinants of one's satisfaction with his or her residential environment. Schwanen and Mokhtarian (2004) find that automobile access interacts with geographic location in influencing the disparity between households' preferred and actual neighborhood choices.

Transportation also is a significant determinant of the economic outcomes of low-income families. Low-income, inner-city residents suffer from a "modal" mismatch, a drastic divergence in the relative advantage between those who have access to automobiles and those who do not (Blumenberg and Hess 2003; Blumenberg and Ong 2001; Grengs 2010; Kawabata 2003; Ong and Miller 2005; Shen 1998; Taylor and Ong 1995; Wyly 1998). In almost all metropolitan areas, individuals without reliable access to automobiles can reach far fewer opportunities within a reasonable travel time compared with those who travel by automobile (Benenson et al. 2010; Blumenberg and Ong 2001; Grengs 2010; Kawabata 2009; Kawabata and Shen 2006, 2007; Ong and Miller 2005; Shen 2001, 1998).

Given this access advantage, it is unsurprising that private automobiles are positively associated with employment outcomes for low-income and minority adults. Cars facilitate searching for and commuting to jobs and therefore increase the likelihood of finding and retaining employment. Conversely, employment can provide households with the necessary resources to purchase automobiles; income is one of the strongest correlates of automobile ownership (Blumenberg and Pierce 2012; Giuliano and Dargay 2006; Schimek 1996). The importance of automobiles to employment persists even in studies that control for the simultaneity of car ownership and employment decisions. In general, automobile ownership is associated with higher employment rates, weekly hours worked, and hourly earnings (Raphael and Rice 2002). Automobile ownership also reduces racial disparities in employment rates (Raphael and Stoll 2001) and unemployment duration (Dawkins et al. 2005).

Automobiles can be particularly important for low-income women who often juggle paid work with household-serving responsibilities and would benefit greatly from the flexibility offered by driving (Blumenberg 2004). Many studies have examined the effect of automobile ownership on outcomes for welfare participants—largely poor, female-headed households. These studies produce similar results: a positive association between household automobiles and employment rates, the likelihood of leaving welfare, and an increase in earned income (Baum 2009; Cervero et al. 2002; Gurley and Bruce 2005; Lucas and Nicholson 2003; Ong 2002; Sandoval et al. 2011).

For low-income households without access to automobiles, public transit is essential (Garrett and Taylor 1999), which is why many of them choose to live in dense, transit-rich urban neighborhoods (Glaeser et al. 2008). However, despite transit's importance, findings on the relationship between public transit and employment outcomes are mixed, likely because employment access by public transit—even in the transit-richest of urban areas—still pales in comparison to access by automobile. In their study of welfare recipients in six major US metropolitan areas, Sanchez and colleagues (2004) conclude that access to fixed-route transit and employment concentrations had virtually no association with welfare recipients' employment outcomes. Transit access appears to make a difference among households without cars. For this subset of the poor, transit-based employment accessibility can positively affect the probability of employment (Kawabata 2003; Yi 2006) and of working 30 hours or more per week (Kawabata 2003). Similarly, studies of welfare recipients show that higher levels of transit service increase the likelihood of finding jobs (Ong and Houston 2002) and reduce time on welfare (Alam 2009).

Residential Location, Transportation, and Subsidized Housing Residents

Despite this body of literature, few studies focus on the relationship among transportation resources, residential location, and employment outcomes of subsidized housing residents. Yet overcoming transportation barriers and improving access to employment were two of the underlying objectives of the voucher experiments. In part, vouchers were intended to facilitate families' moves to transit-rich neighborhoods in close proximity to employment and other destinations. For example, in early text about the WTW program, the authors wrote: "Search assistance can be an effective technique for educating families about and encouraging them to rent near high-employment areas, day care centers, public transportation, etc." (US Housing and Urban Development, 2000: 1-7.)

There are a few exceptions, largely using data from the MTO program. Both the interim and final MTO evaluations examine the effect of voucher access and living in a low-poverty neighborhood on "transportation access" (Orr et al. 2003 Sanbonmatsu et al. 2011). In these evaluations, transportation access is defined as the share of adults with a working car or the share that lives less than a 15-minute walk to public transit. Using this measure, almost everyone in both samples—95 percent of the interim sample and 94 percent of the final sample—had access to transportation. The combined measure conflates modes with very different characteristics. Thus, it is not surprising that the program at either point in time did not have a statistically significant effect on transportation access, perhaps because the measure was too broadly defined.

Transportation does not appear to factor into a family's decision to move. In the interim evaluation, participants were asked to state their most important reason for moving (Orr et al. 2003). Less than one percent (0.2%) of participants cited a desire to move to obtain "better transportation." Clampet-Lundquist and Massey (2008) find that access to automobiles did not influence the likelihood of using a voucher to move.

Once households decide to move, transportation can positively influence their successful use of a housing voucher. Shroder (2002) finds that access to a car or a driver's license increases the likelihood that MTO program participants successfully found and secured a lease using their housing voucher.

Transportation also affects the types of neighborhoods that participants considered and to which they moved. For example, Clampet-Lundquist (2004) studied households relocated from the DuBois HOPE VI project in Philadelphia and found that many were constrained in their housing search because of their lack of access to an automobile and their perception that suburban public transportation opportunities were limited (reviewed in Varady et al. 2010). Varady and Walker (2007) find that a major factor determining the location of moves is proximity to friends and relatives and the availability of public transportation. De Souza Briggs and colleagues (2010) find that families who relocated were also more likely to successfully lease up in a low-poverty neighborhood if, among other factors, they had consistent access to a car. Clampet-Lundquist and Massey (2008) find that households with automobiles were less likely to move to racially-integrated neighborhoods compared to households without cars.

Finally, two qualitative studies examined the relationship between lease-up locations and transit access. De Souza Briggs and colleagues (2010) used mixed research methods—interviews, ethnographic fieldwork and analysis of survey data—to produce the most extensive findings on the relationship between transportation resources and key outcomes for MTO participants. In Boston, New York, and Los Angeles, MTO participants who relocated tended to move from transit-rich inner cities to suburbs, which require the use of a car to take advantage of jobs and services. Moreover, about 15 percent of mothers interviewed by the authors identified giving up convenient access to transit as a price they had paid to live in safer neighborhoods. The lack of transit options in their new neighborhoods subsequently presented a major obstacle to those who had moved and did not have cars.

In their interviews with 67 MTO families in Baltimore, Turney and colleagues (2006) find similar results. MTO participants who relocated often lived further away from their jobs and in neighborhoods with less dense transportation networks. Turney's (2006) study also provides evidence suggestive of the importance of car ownership for capitalizing on economic opportunities. Half of those who were employed among those assigned to the experimental group—those obligated to move to a lower-poverty neighborhood in order to lease up—owned a car, as opposed to only one unemployed respondent in this subgroup. Still, the links between transportation assets and employment are few and indirect in studies utilizing MTO data.

Data

In this section, we describe the primary databases used to perform the analyses outlined in this report. In the 1990s and early 2000s HUD sponsored two major experiments to test whether housing choice vouchers propelled low-income households into greater economic security. These programs, Moving to Opportunity for Fair Housing (MTO) and Welfare to Work Vouchers (WTW), each produced a rich dataset describing households with housing vouchers. While both studies were experimental in nature—providing some households with a housing voucher while keeping others in a nonvoucher control group—there were key differences between the experiments and therefore the nature of the data they produced. This section provides a brief background on these two experiments and describes the datasets used to complete our analyses.

The purpose of MTO was explicitly to test whether poor public housing households with children benefitted from living in low-poverty neighborhoods. (For more information about MTO, see Sanbonmatsu et al. 2011; Orr et al. 2003; and Briggs et al. 2010.) At the outset of the experiment, project guidelines stipulated that all households have at least one child present. In particular, HUD hypothesized that relieving part of a household's housing burden and requiring lease-up in a neighborhood with a poverty rate below 10 percent as of 1990 would improve many of the household's social and economic outcomes. Between 1994 and 1998, eligible (and willing) households in five metropolitan areas were randomly assigned into three groups. The MTO Treatment Group received Section 8 housing vouchers only useable in areas of less than 10 percent poverty as measured by the 1990 census. The Section 8 Comparison Group received identical Section 8 vouchers, but faced no geographic restrictions. The Control Group remained in project-based public housing. The use of three groups allowed causal analysis of the effect of vouchers versus no vouchers—that is, mobility choice versus no mobility choice—as well as the effect of moving into low-poverty neighborhoods.

Three MTO surveys were conducted. Between 1994 and 1998, baseline data were collected on 4,604 families when they were randomized into one of the three groups. An interim survey was conducted in 2002 including 4,252 of these households; the survey excluded 356 families in Los Angeles whose randomization occurred between December 1997 and the end of randomization in July 1998. A third and final survey was conducted in 2008, 10 to 15 years after randomization, on all the families randomly assigned in the MTO demonstration. Our analyses make use of data from the baseline survey, interim survey, and final surveys, along with a "residential spell file" that provides geocoded information linking each household to their residential location at baseline and following each residential relocation.

The WTW experiment targeted low-income households to learn the effect of receiving housing assistance on households' neighborhood locations, obtaining and retaining employment, and welfare dependency. (For more information on WTW, see Patterson et al. 2004.) All the recipients of WTW vouchers had already applied for housing vouchers from local public housing agencies but had been placed on the waiting list. The use of mobility vouchers was appealing because in theory, families could choose to move into neighborhoods that optimized their ability to find or maintain employment. Another distinction between the experiments was that WTW households were not required to use their vouchers in low-poverty neighborhoods. For the most part, the housing agencies that implemented WTW did not provide counseling on mobility, housing search, or employment to experimental households beyond the level normally provided to their tenants (Patterson et al. 2004, 33).

Baseline WTW data were gathered in 2000 and 2001 at the time of the randomization in which 7,684 households were assigned to one of two groups: the treatment group that received housing vouchers and the control group that did not. Like MTO, WTW treatment and control group households came from five (non-MTO) metropolitan areas. The random assignment allows researchers to analyze WTW data to infer the effects of receiving a voucher on location choice, employment, and welfare dependency.

Together, there are voucher treatment and control data for people who began the experiments in 10 major US metropolitan areas: New York, Los Angeles, Chicago, Boston, and Baltimore (from MTO); and Atlanta, Spokane, Augusta, Houston, and Fresno (from WTW). While Los Angeles also hosted a WTW demonstration, there were no follow-up data collected there, so we exclude it from our analyses. (Participants in these experiments could move to other metropolitan areas; we did not include any households in our analysis that moved to locations outside the 10 case study regions.)

We also use Form HUD-50058 data describing housing choice voucher tenants as a comparison point to the voucher data. The housing choice voucher tenant data are gathered by housing agencies who report on households participating in public housing or Section 8 rental subsidy programs. Housing agencies collect and electronically submit information to provide HUD with a picture of people who participate in subsidized rental housing. We obtained an extract of 50058 data from HUD's Office of Policy Development and Research. This data concerned households with tenant-based vouchers for 2000 and 2002 for all the counties in all 10 of the metropolitan areas in which the MTO and WTW experiments took place. This allows us to describe the location of all voucher holders in these 10 metropolitan areas in relation to the households involved in the experiments.

The housing choice voucher tenant data provide basic demographic variables: age, race, household composition, and income. They also include a "project-based" flag, indicating that the household's subsidy is tied to a particular location. We exclude these from our sample in order to compare only voucher-eligible (mobile) households across the datasets. Throughout, we compare housing choice voucher tenant data and experimental data only from the same metropolitan areas.

In addition to these data sources, we rely on publicly available data provided for census tracts from many sources to characterize the sustainability dimensions of neighborhoods. We describe these data in more detail in a subsequent section of the report.

Research Questions

Using the data described above, we examine three primary research questions. Each question is informed by many separate analyses.

- *How do Housing Choice Voucher recipients sort into different neighborhoods?* Answers to this question extend work by Pendall (2000), Been and colleagues (2010), and Galvez (2010), identifying (1) the array of neighborhood social and built environments that HUD voucher recipients inhabit, (2) how the neighborhood characteristics of HUD voucher recipients compare to those of other HUD-assisted households, and (3) differences among HUD voucher recipients in their neighborhood environments. Information about current residential choices across a range of metropolitan contexts (small to large, weak to strong economies, transit-rich to auto-dependent) provide valuable baseline information for ongoing and future Sustainable Communities research, planning, and policy efforts. To address this question, we (1) characterize the neighborhoods inhabited by MTO and WTW participants in terms of their sustainability dimensions, and (2) examine patterns of sorting across each of these dimensions, paying particular attention to the differences in sorting patterns between those with and without access to vehicles.

- *What role does transportation play in voucher users' residential choices?* Answers to this question identify the effect of transportation assets on the residential location decisions of HUD households, and for which households transportation appears to be most important. This research also contributes to Sustainable Communities efforts by enhancing our understanding of housing and transportation connections and how they vary across metropolitan areas. It also contributes to HUD's responsibility to affirmatively further fair housing by identifying transportation-related barriers to the integration of minority voucher users. To answer this question, we examine the influence of transportation access on three dimensions of location choice: (1) locational attainment, (2) neighborhood satisfaction, and (3) dynamic patterns of residential mobility. Each analysis, with the exception of the neighborhood satisfaction analysis, is conducted for a sample of MTO and WTW households.
- *How do transportation access and residential location choice influence economic opportunity?* As part of the Sustainable Communities agenda, HUD has funded initiatives intended to "enrich the social and economic health" of communities.[6] Thus, it is important to understand not only the residential location choices of program participants, but also the effect of these choices on specific outcome measures. To address the above question, we examine the influence of transportation access on employment and earnings. For MTO participants, we examine the exposure of households to "access opportunity neighborhoods," which we define as census tracts in the top quartile of their metropolitan area for employment and public transit availability. Then we examine the influence of transportation access on employment transitions for those in the MTO and WTW program. We conclude with an analysis of the joint relationships among automobile ownership, residential location in transit-rich neighborhoods, and earnings for MTO participants.

The next several sections provide summaries of our findings, organized according to the three research questions posed above.

How Do Housing Choice Voucher Recipients Sort into Different Neighborhoods?

To answer the first research question we undertook two operations. First, we created a new multidimensional definition of neighborhood sustainability, applying it to the 10 metropolitan areas in the two experiments. Second, we analyzed the differences in neighborhood attainment between the experimental households that had access to cars and those who did not.

Defining Neighborhood Sustainability

In this section, we operationalize neighborhood sustainability with reference to six major dimensions: natural environment, functional environment, social environment, economic vitality, security, and access

[6] See the announcement of the Sustainable Communities Research Grant program, "Transformation Initiative: Sustainable Communities Research Grant program," Grants.gov, accessed February 14, 2014, http://www.grants.gov/web/grants/view-opportunity.html?oppId=230694.

to opportunity. We assemble relevant indicators from available local and national data and construct measures that reflect key conceptual components of our dimensions, which we refer to as subdimensions. We then apply these dimensions to the 10 metropolitan areas in which the MTO and WTW experiments were carried out, showing important variations within and among metropolitan areas in desirable neighborhood characteristics.

Dimensions and Subdimensions of Neighborhood Sustainability

The task of measuring and classifying neighborhood sustainability began with defining six major dimensions of sustainability: natural environment, functional environment, social environment, economic vitality, security, and access to opportunity. We identified these dimensions based on a review of the neighborhood opportunity, livability, and sustainability indicator literature, grouping these into sets of characteristics that provide for a series of basic needs. Using these dimensions, we built a comprehensive database of neighborhood indicators, which we created by assembling a range of measures related to each dimension. We were able to develop indicators related to five of the six dimensions using national data; for the sixth, security, we collected data from local sources, but were able to obtain data only for central cities of most of the 10 metropolitan areas in our study area. The data sources included the 2000 US census, the National Land Cover Database, and indices produced by other organizations. Table 1 summarizes the various dimensions around which we assembled the data.

Table 1. Dimensions and Subdimensions of Neighborhood Sustainability

Dimension	Subdimension
Natural environment	• urbanization • highway proximity • health outcomes • environmental hazards
Functional environment	• housing market strength • housing diversity • transit access
Social environment	• level of household distress • socioeconomic status of residents
Economic vitality	• level of household distress • housing market strength • presence of neighborhood work opportunities • density of income
Security	• incidence of violent and property crime • public perceptions of safety
Access to opportunity	• access to high-quality elementary schools • job access

Source: Authors' data.

To reduce the list to a more manageable number for analysis and to assess underlying concepts, we followed two procedures. First, we produced correlation matrices of the indicators within each dimension. Where multiple indicators were clearly important for capturing the dimension and appeared largely independent of one another, we created subdimensions. Some sets of indicators were highly correlated and could be replaced by a single representative indicator. For others that were strongly related but not easily represented by a single measure, we used principal components factor analysis to produce a single factor score from all the component indicators within a subdimension. Each dimension includes between two and four subdimensions.

In some instances, subdimensions can be a component of more than one dimension. The calculation of these subdimensions is the same across dimensions. Categorizing a subdimension within more than one dimension does not mean that a set of indicators is weighted more heavily in our analysis, but that we interpret any findings related to that subdimension through the lens of more than one broader dimension. For example, we do not weight our index for housing market strength more heavily than the other subdimension measures, but we consider what its relationship to other neighborhood characteristics and voucher household patterns suggests about functional environment and economic vitality.

Each neighborhood consists of a mix of these six dimensions, each of which will have different importance for different residents. Neighborhoods differ from one another in part because different kinds of households want and need different things from their residential environments. Young singles often want to live in lively places where they can meet each other and get easy access to work and nightlife. Families with kids usually value parks, playgrounds, good-quality schools, and convenient shopping. Everyone wants "security," but people's thresholds for what feels secure vary by age, gender, and other characteristics, and there is sometimes a trade-off between safety and liveliness. For these reasons, a single scale for neighborhood sustainability, livability, or opportunity may not apply to all households. Instead, it makes sense to develop scales for the different dimensions of neighborhood characteristics that people balance in different ways when they decide where to live.

We describe the indicators used to capture each of these dimensions below:

Natural Environment

Here, we consider both the amenity aspects of a neighborhood's natural environment—access to nature and open space, most importantly—and the threats posed by the neighborhood environment from pollution and noise. We divided the natural environment dimension into four subdimensions. Three measures reflect environmental hazards of different kinds that are not well correlated with one another: percent of the tract's area within one mile of a facility listed on the EPA's 2000 Toxic Release Inventory (TRI);[7] an index of cancer risk from the 2002 National-Scale Air Toxics Assessment;[8] and proximity to major highways, calculated as the percent of land in a census tract lying within 200 meters of major highways as georeferenced in the 2000 Census TIGER files.[9] The weak empirical relationship among these hazards was expected, given the many factors that may be associated with neighborhoods' elevated cancer risk, proximity to highways, and proximity to registered toxic facilities. We include all of them in our analysis because there is a clear conceptual relationship among them, and each can have serious implications for a neighborhood's livability and sustainability. In all three cases, a higher score indicates a living environment most people would consider lower-quality. While access to highways may represent opportunity for some households, exposure to a major highway within 200 meters has noise and air pollution impacts that can impair health, especially for children.

For the urbanization subdimension, the key indicators were percent of census tract that is open space,

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[7] Environmental Protection Agency. "2000 Toxics Release Inventory (TRI) Public Data Release Report: Executive Summary," Environmental Protection Agency, last modified February 17, 2014, http://www2.epa.gov/toxics-release-inventory-tri-program/2000-toxics-release-inventory-tri-public-data-release-report.

[8] Environmental Protection Agency. "2002 National-Scale Air Toxics Assessment (NATA)," EPA, accessed March 10, 2014, http://www.epa.gov/nata2002/.

[9] US Census Bureau. "Census 2000 Tiger/Line Shapefiles," US Department of Commerce, accessed March 10, 2014, http://www.census.gov/geo/maps-data/data/tiger-line.html.

percent of tract that is water, and percent of tract that is developed for urban uses, calculated from the 2001 National Land Cover Database.[10] Percent of urban developed land was strongly correlated with the other indicators, and most fully represents the concept of urbanization, so we use that indicator alone as our measure of urbanization. We do not infer a clear relationship between level of urbanization and quality of life, though a higher score would indicate a more urbanized environment and a lower score a more suburban or rural one.

Functional Environment

This set of characteristics conveys those features of the neighborhood's built environment that make it livable for residents, even if they have financial, mobility, and other limitations. We consider three subdimensions of functional environment: housing market strength, housing diversity, and transit access. Our initial list also included a walkability subdimension, but we dropped walkability due to data availability constraints.

We group together vacancy rate, percent owner-occupied housing units, and median gross rent as indicators of neighborhood housing market strength. All three measures are from the 2000 decennial census summary file 3.[11] To control for variation in the rental market across our sites, we standardized median gross rent by metropolitan area and used the resulting z-score as the indicator. The standardization process means that the resulting indicator reflects a given neighborhood's median rent relative to other neighborhoods in that metropolitan area. Each indicator reflects a unique aspect of housing market strength and we thus relied on factor analysis to construct that subdimension. As expected, vacancy rate had a negative coefficient (meaning higher vacancy rates suggest lower sustainability), while the other two indicators had positive coefficients. Thus, a higher score on the housing market strength dimension indicates a stronger housing market and usually a more attractive or appealing neighborhood. See appendix A for more details on the factor analysis.

We used a similar process to create a single measure of housing diversity, composed of diversity of residential structure type, average of residential density, and percent of very old and very new housing. We again relied on factor analysis, and the resulting score serves as our measure (see appendix A for more details on the factor analysis). A higher score on the housing diversity dimension indicates a more diverse housing stock. As discussed in the background chapter, housing diversity is valued strongly by some contemporary urban designers and city planners. Individual satisfaction levels are somewhat higher, however, in exclusively single-family neighborhoods than in neighborhoods with diverse housing stock even after adjusting for individual and housing-unit characteristics. We thus do not associate this dimension with either a more or a less desirable outcome.

We examined transit access as a unique subdimension of functional environment. Our single indicator of transit access is the FHEA (Fair Housing Equity Assessment) transit access index created by HUD.[12] This index used data from public transit agencies to assess relative accessibility to amenities

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[10] Multi-Resolution Land Characteristics Consortium. "National Land Cover Database 2001 (NLCD2001)," Multi-Resolution Land Characteristics Consortium, accessed March 10, 2014, http://www.mrlc.gov/nlcd2001.php.

[11] US Census 2000, "Summary File 3," US Census Bureau, last modified October 13, 2011, http://www.census.gov/census2000/sumfile3.html.

[12] In 2012, HUD created a database to support grantees of the Sustainable Communities Regional Planning Grant program in the preparation of their FHEAs. The data file included indicators for a wide array of neighborhood conditions at the block-group level, using 2010 census tract boundaries. HUD provided a readable version of the national file to the research team for use in this project. We imputed

within metropolitan areas. Higher values indicate greater access to transit; values of one indicate no transit availability. Because of uniformly low index values for almost all tracts in three of the five WTW metropolitan areas (Atlanta, Augusta, and Spokane), we chose not to use this indicator for the neighborhood analysis for the WTW group.

Social Environment

These characteristics express important aspects of the social and demographic makeup of the neighborhood, including the level of household distress and the socioeconomic status of residents. Our measures for this dimension all came from the 2000 decennial census summary file 3.[13]

Our conception of social environment includes two subdimensions: household distress and social status. We selected four measures to indicate household distress: labor market participation rate, number of households on public assistance, poverty rate, and median household income (converted to z-scores within each metropolitan area to account for variation among metropolitan areas). These were all highly correlated with one another. We chose poverty rate as a single measure of this subdimension because it has the strongest relationship with the other indicators and is most clearly associated with household distress in the literature.

We considered social status a conceptually separate subdimension of the social environment. We collected three indicators of social status. The first is a single variable meant to encapsulate the variation of racial composition: the percent of white households, standardized by metropolitan area to control for variations in racial composition across our sites. The second indicator is the percent of population age 25 and over with a high school diploma. The third is the percent of female-headed households. We performed a factor analysis because we believed each was relevant to social status. All three indicators were positively associated with the resulting factor score, in which higher values associate with higher levels of social status. See appendix A for more details on the factor analysis.

We placed racial composition in this social status subdimension rather than the household distress subdimension because although mostly black and mostly Latino neighborhoods continue to have high levels of household distress, the correspondence between race and distress is complex. Neighborhoods with higher percentages of whites, college-educated residents, and two-parent households usually have low levels of household distress. Conversely, however, neighborhoods with low socioeconomic status are not always seriously distressed. We decided not to consider racial composition separately so as to highlight the aspects of racial composition that associate with social status and to separate it from those that correlate with household distress.

Economic Vitality

A neighborhood's economic vitality comes from a composite of characteristics that include both the presence of work opportunities in the neighborhood and the density of population and income in that area. Our best available measures for this dimension come from the 2000 decennial census Summary File 3.[14]

For the dimension of economic vitality, we include two previously considered subdimensions, household distress and housing market strength, as well as economic activity and income density. The additional subdimensions are each represented by a single indicator. For economic activity, we calculated

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these values to 2000 Census Tract boundaries.

[13] US Census 2000, "Summary File 3."

[14] Ibid.

job density as total jobs per square mile, as reported in the 2000 Census Transportation Planning Package.[15] We also included aggregate income density, computed using the estimated aggregate income from Summary File 3 of the 2000 census,[16] and then standardized the results by metropolitan area to control for differences among sites.

Security

A neighborhood's sense of security is measured by the incidence of violent and property crime and public perceptions of safety in the neighborhood. Reported crime data are unavailable for full metropolitan areas, because each county or city individually decides whether or not to make data available to the public. Where data are available, they may not be available for the time periods needed. Finally, jurisdictions that do report data apply different standards for the crime records to be included, the information to be reported, and how the crimes are reported, making aggregation and comparison difficult.

We collected crime data in various ways in each of the case-study areas. For Atlanta, Baltimore, and Chicago, we utilized publicly available point-level crime records for varying years. Each crime incident contained address or coordinates that we then mapped to 2000 census tract boundaries. We calculated the number of violent crime incidents in a given year for each census tract and divided by the estimated population of the tract in the year the crime data was collected, using a linear interpolation between 2000 and 2010 census population figures to create a measure of number of violent crimes per 100,000 inhabitants on the census tract level. Finally, within each metropolitan statistical area, we ranked the census tracts by violent crime rate and categorized them by quartile to establish low, low to moderate, moderate to high, and high crime neighborhoods. For three other sites of our study (Boston, Houston, Los Angeles), we used data from the National Neighborhood Crime Study (Peterson and Krivo 2010). The study provided census tract-level statistics for these three sites, including the sum of violent crimes over 1999–2001. We used this figure and 2000 census population statistics to create a violent crime rank and quartile categories consistent with the assignments for the sites with public crime records. We were unable to secure reliable crime data for the central cities of the other four metropolitan areas or for suburban areas of these six metropolitan areas.

To gauge perceptions of neighborhood safety, we used questions from the interim and final surveys for MTO and WTW, respectively. Like the crime data, the survey data were available for only some of the tracts in the metropolitan area; unlike the crime data, however, survey responses were available beyond the central cities and in all 10 metropolitan areas.

Access to Opportunity

The neighborhood's access to opportunity, unlike the other dimensions, is a function mainly of what the neighborhood is close to rather than what it contains. The availability of jobs is important here, as is access to high-quality elementary schools. Access to opportunity is characterized by the availability, proximity, and quality of educational and employment opportunities and critical public service functions. We include only one subdimension for this dimension, school quality, as represented by HUD's FHEA school quality index. The school quality index uses elementary school data on the performance of students in state exams to produce a score for each tract, based on the closest elementary schools. Job access is a second critically important measure of access to opportunity. We were unable to obtain reliable data on this measure for all metropolitan areas and therefore do not include it in this report.

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[15] Federal Highway Administration. "Census Transportation Planning Products 2000 Data Products," US Department of Transportation, accessed March 10, 2014, http://www.fhwa.dot.gov/planning/census_issues/ctpp/data_products/2000dataprod.cfm.

[16] US Census 2000, "Summary File 3."

Neighborhood Sustainability Dimensions for MTO and WTW Metropolitan Areas

The MTO and WTW metropolitan areas differ in a series of important ways that stand out when reviewing the sustainability dimensions (table 2). First, the MTO metros have many more tracts than the WTW metropolitans. Three of the MTO metropolitan areas—Chicago, LA, and New York—each have more tracts than the 1,893 tracts in all five WTW metros combined. The diversity within these large metropolitan areas is also substantial, but a full review of that diversity is beyond the scope of this report. The smallest WTW metropolitan areas, Augusta and Spokane, have only 95 and 104 tracts respectively, and the largest, Houston, has fewer tracts than all but the smallest MTO metropolitan area, Baltimore.

Table 2. Mean Levels of Sustainability Subdimensions and Their Factor-Score Contributors, Moving to Opportunity and Welfare to Work, 2000–2001

	MTO					WTW				
	Baltimore	Boston	Chicago	LA	NYC	Atlanta	Augusta	Fresno	Houston	Spokane
Number of tracts	601	832	1,958	2,564	4,307	675	94	154	864	104
Natural environment										
Land within buffer of TRI site (%)	16.6%	64.6%	65.5%	24.2%	57.3%	28.9%	24.9%	26.2%	38.4%	37.2%
Log of cancer risk score	3.8	3.8	3.8	4.1	4	3.8	3.4	3.5	3.7	3.5
Land within 200m of major highway (%)	27.5%	24.0%	17.5%	13.4%	22.7%	17.30%	16.9%	10.30%	11.0%	10.2%
Land developed as urban uses (%)	68.6%	72.4%	87.7%	93.2%	87.5%	57.20%	45.9%	66.90%	75.3%	71.4%
Functional environment										
Housing market strength factor	0.1	0.1	0.1	0	-0.1	0.1	-0.1	0	-0.1	0.1
Vacancy rate (%)	7.9	4	6.4	4	5.4	5.9	10.2	6.1	7.9	6.6
Owner-occupied housing units (%)	66.8%	59.9%	61.6%	52.7%	51.2%	66.1%	69.1%	57.7%	62.5%	67.7%
Median gross rent ($)	669	803	700	857	836	727	505	572	637	582
Housing diversity factor	-0.3	0.2	-0.1	-0.3	0.2	-0.1	-0.2	0.1	0.1	0.2
Diversity index of structure type	0.5	0.6	0.6	0.6	0.6	0.4	0.4	0.5	0.4	0.4
Housing density (dwellings/acre)	7.9	8.8	9.3	8.2	21.2	3	2.3	3.3	3.9	3.4
Housing 50+ years old (%)	12.4	7.6	10.2	7.9	6.3	25.5	20.3	17.5	17.5	16.9
Housing <11 years old (%)	30.6	45.5	36.3	21.5	42.8	10.4	13.6	15.2	10.5	27.4
FHEA transit index	45.4	41.2	52.6	49.4	32.8	1.8	1.0	1.0	36.2	44.2
Social environment										
Poverty rate	12	10	13.5	16.2	14.5	12.1	17.9	22.5	14.9	13.1
Social status factor	0.02	0.09	0.02	-0.05	-0.01	0.02	-0.06	-0.11	-0.01	0.15
Non-Hispanic white (%)	63.4	78.4	52.9	36.6	50.8	56.3	58.2	41.1	46.9	89.4
Female-headed households (%)	34.5	31.7	32.9	28.4	33.4	31.4	33.7	28.2	27.5	28.9
Adults with college degree (%)	25.9	36.1	26.3	24.7	27.6	28.6	19.3	16.9	23.9	24.4
Economic vitality										
Aggregate income/square mile (in millions of dollars)	113	194.6	218	195.7	629.3	51.1	21.8	52.9	75.1	50.2
Nat log of job density/sq mi	6.65	7.19	7.25	7.5	7.9	5.84	4.99	6.1	6.25	5.98
Job density per square mile	2,570	4,179	4,188	3,521	12,403	1,754	951	1,460	1,726	1,631
Access to opportunity										
FHEA school performance index	48.6	50.2	44.2	49.7	49.1	50.3	43.8	39.6	51.4	54

Source: Authors' calculations. For details on variable construction, see appendix A.

Notes: TRI is Toxic Release Inventory. FHEA is Fair Housing Equity Assessment.

Of the natural environment indicators, the WTW metropolitan areas stand out for being generally less urban than the MTO metropolitan areas. Boston, Chicago, and New York also have high exposure to TRI sites, while Los Angeles has a level closer to that of the WTW metropolitan areas, and Houston has a relatively high level of exposure to TRI sites (a function of its large oil and gas sector). MTO metropolitan areas also have higher cancer-risk scores, average shares of their tracts within 200 meters of a major highway, and average shares of their tracts developed with urban uses.

The functional environment indicators also show important differences between the MTO and WTW metropolitan areas. Two of the three subdimensions we developed for this dimension—housing market strength and housing diversity—are factor scores, each of which is the product of three variables. (Because the factor scores were developed separately for the two datasets, once for MTO and once for WTW, the scores can be usefully compared among metropolitan areas in the same dataset but not across the two datasets.) The MTO metropolitan areas generally have lower vacancy rates and homeownership rates and higher gross rents than the WTW metropolitan areas, with the exception of Baltimore. The MTO metropolitan areas also score higher on average housing diversity and density in their tracts. While New York stands out for density, it resembles Los Angeles and Boston in its level of structure-type diversity and Boston in its median housing age. The oldest average housing stock in the WTW metropolitan areas, about 47 years in Spokane, is younger than any of the MTO metropolitan areas. Finally, the FHEA transit index—which shows relative accessibility to amenities through public transit—also generally is higher in the MTO metropolitan areas than in the WTW areas. Atlanta, Augusta, and Fresno all have average scores around 1.0 because the vast majority of tracts within these sites were deemed inaccessible by HUD's definition of the FHEA transit index. New York's average FHEA transit index of only 32.8 is lower than we expected, and is similarly attributable to its many outlying census tracts receiving a value of one.

The metropolitan areas do not fall as cleanly into MTO versus WTW groups in their average social environments. The poverty rate, which we use as a proxy for overall neighborhood distress, is highest on average in Fresno (22.5 percent average across tracts) and Augusta (17.9 percent), but Atlanta and Spokane have poverty rates at the low end of the range (12.1 percent and 13.1 percent, respectively). Boston's 10.0 percent average poverty rate is less than half of Fresno's. The social status factor does not vary much across the metropolitan areas because we constructed it as two separate factor scores (one for each dataset), the exceptions being Spokane, with an average of 0.153, and Fresno, where the average was -0.11. The components of social status do vary substantially among the metropolitan areas, but again not in ways that distinguish MTO and WTW systematically. The California metropolitan areas and Houston all have average percent white non-Hispanic populations below 50 percent; Spokane's tracts are predominantly white, with an average of almost 90 percent. Among the other metropolitan areas, only Boston is more than 70 percent white on average. The range of female headed households is more restricted, from Houston's 27.5 percent to Baltimore's 34.5 percent average. But the share of college graduates is more varied, with as few as 16.9 percent in Fresno on average and as many as 36.1 percent in Boston. (The MTO metropolitan areas uniformly have higher levels of college completion than the WTW metropolitan areas.)

We express the economic vitality of the tracts (i.e., what is happening inside the neighborhood rather than near it) through density of income of residents and of jobs (which can be held by people outside or inside the tract). Here again, the MTO metropolitan areas stand out because they are larger, older, and denser than the WTW metropolitans, starting with New York—the clear outlier, with an average of nearly $630 million in household income per square mile in 1999 and over 12,400 jobs per square mile in 2000. Even excluding New York, however, the income density and job density in the MTO metropolitan areas is consistently higher than in the WTW metropolitan areas. Augusta's average income density of only $21 million per square mile, and its average job density of fewer than 1,000 jobs per square mile, identify it as a different place than most of the other metropolitan areas even in the WTW dataset (where Atlanta, Spokane, and Fresno have roughly comparable averages on both income and job density).

The sole access to opportunity metric we consider here is the FHEA school index. This index was computed such that it has an average score of 50. It is unclear why Fresno's average FHEA school index would be less than 40. Clarification of HUD's methods for constructing this index is pending. Other important considerations of accessibility are discussed in a subsequent chapter of this report, as are considerations of exposure to crime.

Neighborhood Typology

Our final analytic step was to develop a neighborhood typology incorporating all of the subdimensions we created except crime rates, which were available only for the central cities. For this step, we used cluster analysis to group tracts into sets based on their relative similarity to one another as measured by the indicators. We use a hierarchical cluster analysis using average linkage between groups based on squared Euclidean distances, which produces a series of potential clusters in stages, dividing previous clusters into new clusters at each stage. A measure of the average distance between cluster members serves as an indicator of the relative strength of each cluster solution. Choosing the optimal number of clusters is an experimental process in which we look for the strongest cluster solutions and examine the average values of the component indicators for each cluster both for plausibility of the solution (i.e., the analysis has produced neighborhood types with recognizable features) and for usefulness (e.g., a solution that does not lump all the tracts that are likely voucher destinations into a single cluster). Subdimensions which appear under more than one dimension enter the cluster analysis only once.

Because of the extreme range of values in two of our selected indicators, job density and aggregate income density, we performed two variable transformations. For job density, we use the natural log of the indicator, and for aggregate income density we use the natural log standardized by metropolitan area (i.e., the measure used is the z-score of the natural log). These changes caused distributions in the variables that more closely approximated a normal curve, eliminating dramatic skewing effects of extreme values on the construction of clusters.

Analysis of the MTO sites produced 4, 6, 8, 10, 12, and 15 cluster solutions. Comparing the cluster averages for our indicators and the distribution of tracts and MTO households across the clusters, we decided that the 15-member cluster solution provided the most convincing and useful grouping of neighborhood types. This solution consisted of a mix of identifiable neighborhood types, with poverty and relative affluence being important sorting factors but demonstrating variations based on our other dimensions. An initial analysis of the WTW sites revealed that over 70 percent of census tracts in Atlanta, Augusta, and Fresno had an FHEA transit index value of one, which is assigned to tracts located more than three quarters of a mile from either a bus or transit stop. We elected to omit this transit indicator from the WTW cluster analysis to avoid disproportionately weighting the tracts in these sites to group together because of their identical values. With this slightly reduced set of indicators for WTW sites, we identified solutions of 5, 6, 10 and 13 members. We concentrate our analysis on the 13-cluster solution, which performed the best in allocating tracts into recognizable groupings with members in each metropolitan area.

To simplify the interpretation of the large number of clusters produced, we divided the census tracts into groups based on the average poverty rate of the cluster to which they are assigned, creating low-, medium- and high-poverty bands. This method also addresses the problem that cluster analysis produces several clusters with very low tract counts, which can be analyzed more efficiently in combination with broadly similar clusters.

In broad terms, the clusters with the lowest average poverty levels rate favorably on other factors, while those with the highest average poverty levels have many other deficits. The poor neighborhoods are densely developed areas with little open space, weak economic activity, and occupied mainly by highly distressed households; the low-poverty neighborhoods are less dense spaces with stronger commercial and economic growth and better-performing schools.

For the WTW sites, there are two low-poverty, four medium-poverty, and seven high-poverty clusters. Tables 3 and 4 display the clusters and average dimension values for clusters in the WTW and MTO sites. The two low-poverty clusters include a total of 893 tracts in which, compared with tracts in other clusters, less of the neighborhood’s land area is urban, less is within 200 meters of a highway, schools have higher test scores, and social status is higher than in the average neighborhood. The great majority of the land area of the WTW metropolitan areas is in low-poverty tracts, but they account for about 47 percent of the tracts we classified into clusters. In all five WTW metropolitan areas, the low-poverty tracts cluster at the “macro” level (i.e., a level that is evident when viewing a map of the entire metropolitan area). In Atlanta, the large majority of tracts north of Interstate 20 are low-poverty tracts, especially those outside the I-285 beltway. Augusta’s low-poverty tracts occupy a band running from northwest to southeast, with more disadvantaged tracts lying at the northeast and southwest fringes of the CBSA and on Augusta city’s south side. Almost all of Fresno’s low-poverty tracts occupy land northwest of SH 99, the main thoroughfare of the Central Valley. In Houston, I-45 is an important dividing line, with most low-poverty tracts sitting west of this main route between Galveston, Houston, and Dallas; this is true inside the city’s two beltways as well, with a significant number of low-poverty tracts occupying a wedge on the city’s west side. In Spokane, smallest of the five WTW metro areas, most of the low-poverty areas are south of I-90 or north of the city limits.

Table 3. Cluster-Factor Average Values, WTW Clusters

WTW Cluster	**L1**	**L2**	**M1**	**M2**	**M3**	**M4**	**H1**	**H2**	**H3**	**H4**	**H5**	**H6**	**H7**	**Total**
Number of tracts	**443**	**450**	**183**	**328**	**228**	**11**	**71**	**109**	**40**	**3**	**15**	**6**	**4**	**1891**
Buffer of Toxics Release Inventory facilities (%)	.18	.25	.26	.35	.47	.66	.71	.57	.64	.91	.65	.72	.71	.33
Nat log of cancer risk	3.62	3.63	3.69	3.64	3.71	3.88	3.97	3.79	4.07	4.16	4.01	3.82	4.17	3.68
Buffer of major highways (%)	.09	.12	.16	.13	.14	.16	.23	.19	.24	.16	.37	.40	.13	.13
Land area that is developed as urban uses (%)	.59	.58	.68	.65	.73	.95	.91	.84	.92	.99	.88	.81	.92	.66
Housing market strength factor	.55	.19	-.14	-.06	-.35	-.50	-.64	-.77	-1.01	-1.25	-1.12	-1.32	-1.39	.00
Housing diversity factor	-.46	-.22	.18	.06	.30	.36	.66	.69	.82	1.00	.85	1.04	1.38	.00
Poverty rate	5.47	8.50	13.40	13.46	21.46	22.27	29.75	35.68	42.47	46.04	54.29	65.05	71.20	14.58
Social status factor	.84	.42	-.45	-.12	-.53	-.43	-1.12	-1.16	-1.41	-1.78	-1.65	-1.70	-1.90	.00
FHEA school performance index	83.49	57.71	12.36	28.95	42.62	90.22	67.65	13.09	40.05	97.00	24.62	7.92	46.77	49.79
Z-score of the natural log of aggregate income density, by MSA	.11	-.10	.16	-.14	-.11	.24	.27	.09	.20	.57	.09	.00	.15	.00
Nat log of job density per sq. mi.	5.73	5.69	6.01	5.79	6.26	7.69	7.29	6.74	7.66	7.44	7.31	6.53	7.36	6.01

Source: Authors' calculations using data from sources detailed in appendix A

Note: MSA is metropolitan statistical area. FHEA is Fair Housing Equity Assessment.

Table 4. Cluster-Factor Average Values, MTO Clusters

MTO Cluster	L1	L2	M1	M2	M3	M4	M5	H1	H2	H3	H4	H5	H6	H7	H8	Total
Number of tracts	**2,403**	**622**	**1,663**	**1,014**	**710**	**2,125**	**1,494**	**19**	**32**	**97**	**8**	**7**	**65**	**2**	**1**	**10,262**
Buffer of Toxics Release Inventory facilities (%)	.28	.29	.58	.50	.46	.59	.63	.50	.51	.84	.78	.08	.73	1.00	1.00	.49
Nat log of cancer risk	3.72	3.92	4.11	4.01	4.08	3.96	4.08	4.30	4.34	4.33	4.23	4.01	4.10	4.22	4.44	3.96
Buffer of major highways (%)	.15	.17	.23	.20	.23	.21	.21	.18	.17	.25	.49	.10	.20	.25	.95	.20
Land area that is developed as urban uses (%)	.66	.90	.96	.93	.97	.86	.98	.94	.96	.98	.98	.95	.99	1.00	.98	.87
Housing market strength factor	.55	.57	-.08	-.06	-.06	-.19	-.50	-.92	-1.10	-1.16	-1.31	-.45	-1.41	-.96	-.94	.00
Housing diversity factor	-.58	-.40	.37	-.08	.36	.11	.41	.31	.37	.24	.42	-.38	.22	.18	.71	.00
FHEA transit access index	4.65	46.47	82.08	46.22	86.59	3.00	87.50	54.31	68.74	2.53	35.84	77.67	92.64	1.00	1.00	42.13
Poverty rate	5.03	5.47	12.48	14.96	15.06	16.90	24.45	41.10	42.41	44.57	52.73	61.53	62.67	93.97	100.00	14.25
Social status factor	.79	.76	-.04	-.31	.08	-.22	-.89	-.93	-1.31	-1.40	-1.44	.18	-1.43	-2.02	-1.65	.00
FHEA school performance index	75.99	79.05	45.38	28.29	77.35	31.66	17.35	79.47	45.81	78.00	20.27	96.50	11.47	29.97	69.90	48.36
Z-score of the natural log of aggregate income density, by MSA	-.65	.08	.57	-.01	.61	-.16	.40	.12	.03	.33	.01	-.36	-.43	-3.08	-5.24	.01
Nat log of job density per sq. mi.	6.37	7.30	8.39	7.50	8.45	7.54	8.03	8.78	8.28	9.17	7.73	8.99	8.27	8.98	7.59	7.55

Source: Authors' calculations using data from sources detailed in appendix A.

Note: MSA is metropolitan statistical area. FHEA is Fair Housing Equity Assessment.

The high-poverty WTW clusters differ from the low-poverty clusters in several ways. They tend to have a higher than average share of urban developed land, very weak housing markets, much lower than average expected social status, and school performance that ranges from average to very poor. In Atlanta and Houston, most high-poverty tracts are close to the center of the region; metropolitan Atlanta's high-poverty neighborhoods are concentrated inside the I-285 beltway, and Houston's lie inside Beltway 8, its second loop road. Both metropolitan areas also have smaller cities (Marietta and Galveston, respectively) with a few tracts in high-poverty clusters. Spokane's high-poverty tracts also cluster in the center of the region. In Augusta and Fresno, by contrast, tracts in high-poverty clusters take two patterns: some line up along major highways while a few others are in outlying rural areas.

The middle-poverty group of WTW clusters includes a variety of environments that sorted into four main groups. The two largest clusters are M2 (328 tracts) and M3 (228 tracts). Compared with M3, M2 has lower poverty (13 percent versus 21 percent), exposure to TRI facilities, cancer risk, income density, job density, developed land, and housing diversity, as well as having lower average FHEA school performance scores. The average poverty rate of M1, with 183 tracts, is about the same as that of M2, but its social status is lower, its housing market is weaker and more diverse, its income and job density are higher, and its school performance is much worse. Cluster M4, the average poverty rate of which is highest in the group at 22 percent, includes only 11 tracts, all of them in either Atlanta or Houston. It is the most urban of these four clusters, with the highest exposure to TRI facilities, cancer risk, percent of land developed with urban uses, housing diversity, income density, and job density, as well as the lowest average housing market strength. Its social status factor, however, is not as low as those of either cluster M1 or cluster M3.

Anomalously, the average FHEA school performance index in this cluster is higher than that of any other cluster in the low- or medium-poverty band. Visual inspection of metropolitan-level maps does not readily resolve patterns of clustering of these neighborhoods other than that they often are interspersed in patches of medium-poverty areas surrounded by low-poverty neighborhoods and surrounding high-poverty tracts.

Out of fifteen clusters of the 10,262 MTO-metropolitan census tracts we analyzed, two clusters are low-poverty, five are medium-poverty, and eight are high-poverty, though half of the high-poverty clusters contain fewer than 10 tracts. The two low-poverty clusters account for 2,822 of the tracts we analyzed, 30 percent of the total. Like those in WTW, these tracts have high social status, strong housing markets, and above average school performance. They differ in their portion of urban developed land and in income and job density, however, suggesting that cluster L1 represents suburban and exurban wealthy neighborhoods, while cluster L2 represents wealthy urban areas. Like the low-poverty tracts in the WTW metropolitan areas, these neighborhoods cluster at the macro level. In Baltimore, the main macro-level dividing line is clearly the I-695 beltway; a small number of tracts in the low-poverty clusters lie at the northern and southernmost extents of the area inside the beltway, but the vast majority is beyond the beltway (many of them immediately outside I-695). Boston's Route 128 does not form this kind of dividing line; rather, low-poverty neighborhoods line either side of the beltway with fewer low-poverty tracts occurring inside a tier of neighborhoods two to three tracts deep. The Route 128 corridor's identity as a high-tech hub likely protects nearby neighborhoods from the decline that has reached Baltimore's beltway. Chicago, too, has few low-poverty neighborhoods close to its center, with even the relatively well-off north shore neighborhoods inside the central city limits classified into the medium-poverty tracts; broad expanses of the metropolitan area's suburban and exurban hinterland are in the low-poverty band, and Chicago's close-in northern suburbs (e.g., Evanston, Winnetka, and Highland Park) are low-poverty enclaves. Los Angeles and New York present patterns of low-poverty neighborhoods too complex to discern through visual inspection.

The high-poverty clusters include a total of 231 tracts, just 2.3 percent of the total. Contrasting sharply with the low-poverty clusters, these tracts are almost exclusively composed of dense, highly developed neighborhoods with weak housing markets and low social status. Four of the five medium-poverty MTO clusters have over 1,000 tracts, and M4 has over 2,000.

The fifth cluster, M3, has 710 tracts. Differences within these clusters could undoubtedly be discerned with further rounds of analysis, but for our purposes these main groupings present interesting contrasts. Their average level of urban developed land ranges from 86 percent to 96 percent, and all of them have job density near or above the average for all tracts. All of them have about the same average exposure to highways (20 to 23 percent of the land area, on average, is within 200 meters of a highway). M1, M2, M3, and M4 have very small differences in average poverty rates, ranging from 12.5 percent to 16.9 percent; M5 has average poverty of about 24 percent. M5 shares some traits with most of the high-poverty clusters, such as very low social status, poor school performance, a high portion of urban developed land, and weak housing markets. However, the lowest average poverty rate among the high-poverty clusters is 41.1 percent, well above that of M5, whose comparatively high income density and transit access also make it different from most of the high-poverty neighborhood clusters. The average income and job density of M5 are lower than those of either M1 or M3; its relatively high FHEA transit score is, however, comparable to those of M1 and M3. Few indices distinguish M1 and M3 from one another; these relatively densely developed (urban) neighborhoods have similar levels of social status, poverty, and job density, but M1 has lower FHEA school performance scores, higher TRI exposure, and slightly higher cancer risk. M2 and M4, meanwhile, are less urban medium-poverty clusters with low school performance indices, social status, and income and job density, with M4 distinguished from M2 mainly by its very low average score (3.0) on the FHEA transit index.

These medium-poverty clusters do appear in some unsurprising geographic patterns, with New York City constituting an exception. In the other four metropolitan areas, M5 tends to dominate the central cities, while M4 is located in more peripheral locations and M1, M2, and M3 are located in neighborhoods at the edges of the central city, in inner suburbs, and in outlying small cities (e.g., Columbia, Maryland; Quincy and Brockton, MA; Aurora, Elgin, and Joliet, IL). The patterns in metropolitan New York are too complex to describe here and contain a few anomalies that may be a consequence of the use of HUD's FHEA data that may not apply as well to New York as to some of the other metropolitan areas.

Crime and Neighborhood Clusters

In an additional step, we calculated the share of MTO or WTW households in each cluster that reported high perceived safety in their neighborhoods in the interim survey. Households in lower-poverty clusters tended to report feeling safer on their streets at night, not surprisingly. Among all WTW households, just under 50 percent felt safe at night. But in the lowest-poverty cluster, 70 percent felt safe, and in the highest-poverty cluster, only 27 percent felt safe. The relationship was similar, though less consistent, among MTO clusters. In particular, high-poverty MTO clusters varied substantially in their share of households that felt safe at night. Over half felt safe in clusters H2 and H6, but in clusters H1 and H3, only 41 and 32 percent, respectively, felt safe. Furthermore, the lowest-poverty MTO cluster had only a slightly higher share of households reporting feeling safe at night than did two of the medium-poverty clusters.

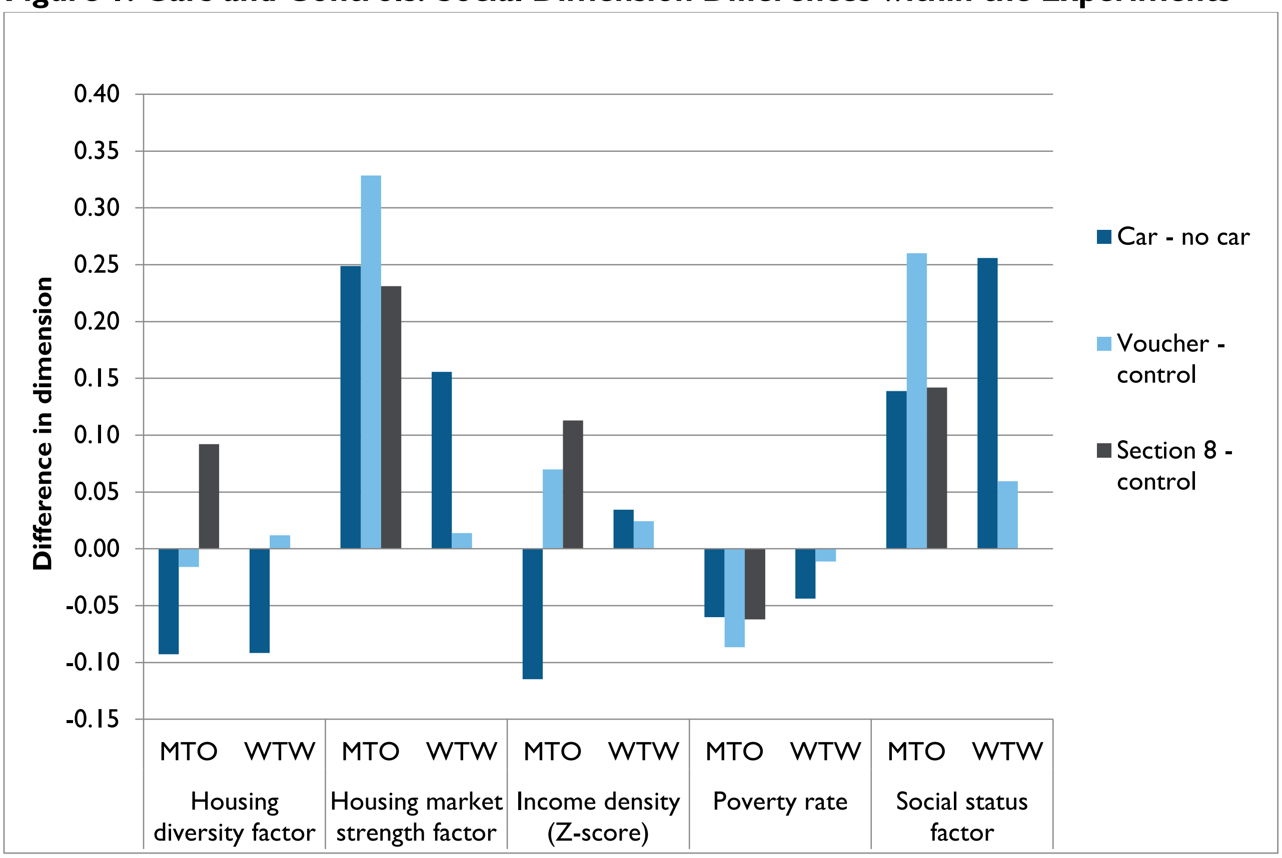
Car Ownership and Residential Sorting

This section documents the attainment of sustainable neighborhoods by tenants who participated in the MTO and WTW programs. Its principal question is: How do households differ in their neighborhood attainment based on whether or not they own a car?

In this section, we define households in which at least one member is both a licensed driver and has access to a running car as a "driving household." The questions about car access in the MTO surveys changed from the baseline to the interim survey to account for car ownership among household members other than the survey participant, from “Do you have a car that runs?” at baseline, to “Does anyone in your household own a car, van, or truck that runs?” in the interim survey. All WTW households were asked at baseline, “Do you have a car that runs?” Regrettably, the follow-up survey included a skip pattern in which only employed household heads were asked about cars and driver licenses. It is therefore impossible to ascertain precisely how access to cars changed between the baseline and follow-up surveys in WTW.

Figure 1 displays measures of the social environment, emphasizing comparisons between those with and without car access in addition to the experimental versus control group and Section 8 comparison versus control group. Access to a car clearly associates with access to better neighborhoods on most dimensions to which normative values can be ascribed. In both experiments, households with cars lived in neighborhoods with significantly lower poverty, higher social status, and stronger housing markets than those without cars. The relationship between driving and income density differs between MTO (in which the neighborhoods had generally higher population densities), where access to a car associated with lower income density, and WTW, where the reverse was true. These neighborhoods also had less-diverse housing stock than the neighborhoods of nondriving households. Combined with other information about neighborhood quality, this result reinforces the idea that while diverse housing stock may be favored by urban designers and planners, the neighborhoods with the most diverse housing in these 10 metropolitan areas may also have counterbalancing negative aspects that will need to be addressed before they work well for families.

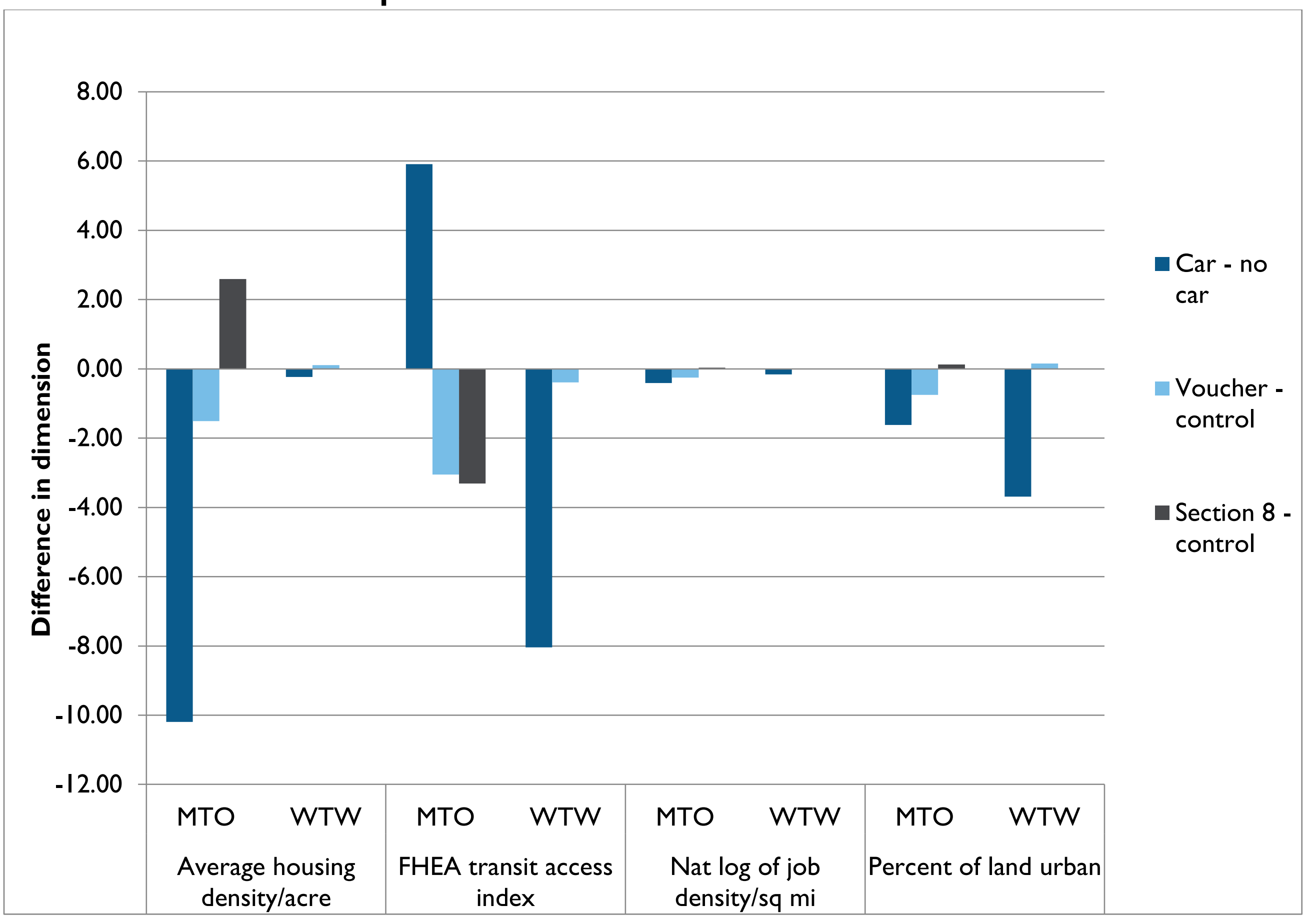
Figure 1. Cars and Controls: Social Dimension Differences within the Experiments



Source: Authors’ data.

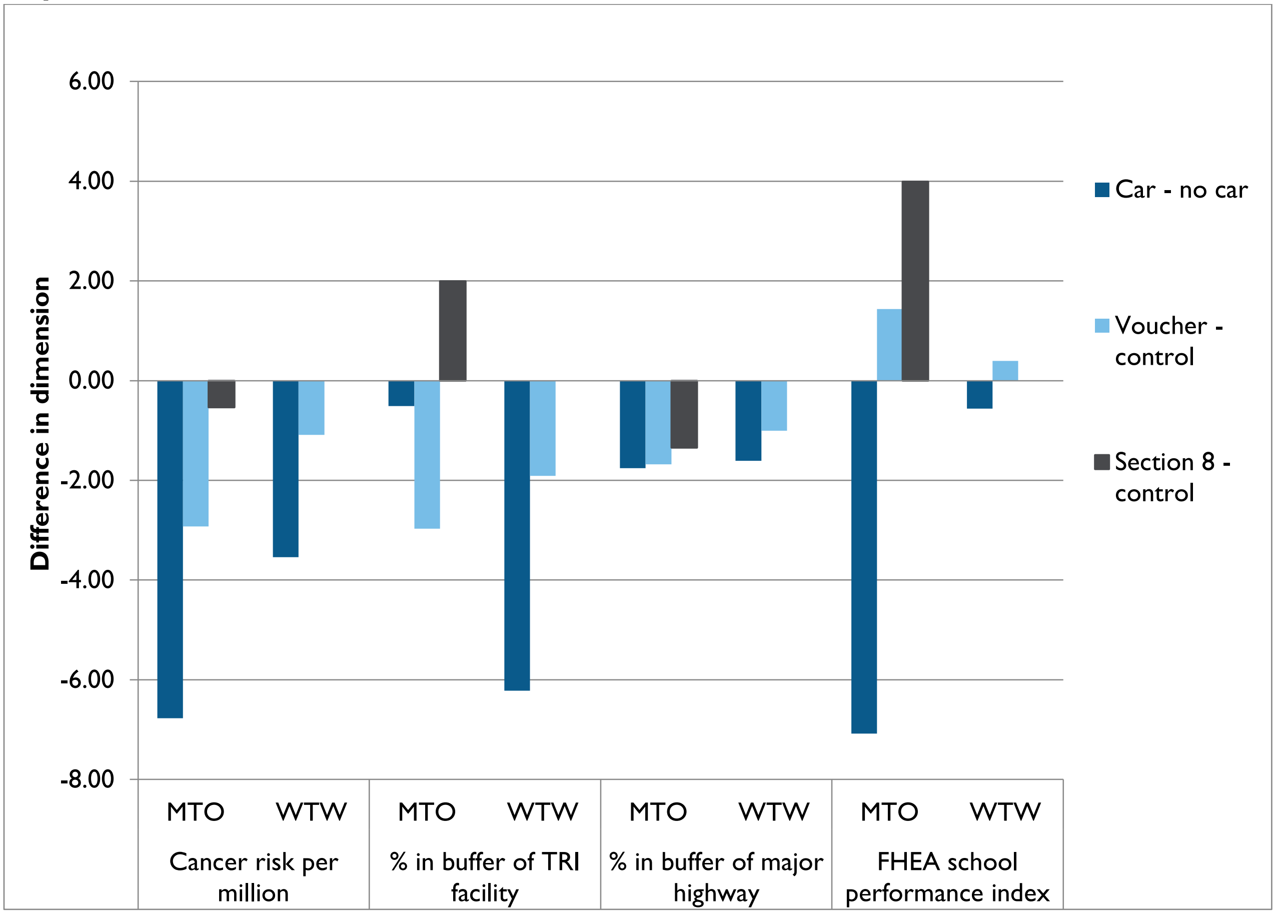
Figures 2 and 3 present the same comparisons for measures of the functional environment, natural environment, and school performance. Driving households in MTO lived in neighborhoods with much lower housing density than nondriving households, whereas the difference for WTW households was smaller (but still statistically significant) (figure 2). Neighborhood job density and percent urban land were also significantly lower for driving than for nondriving households. Curiously, driving households in MTO had better access to transit than nondriving households, opposite the result of the WTW experiment. The MTO metro areas have much better transit generally than the WTW metropolitan areas; it would be intriguing to learn that MTO households with cars could find neighborhoods that were more convenient for both their transit users and their drivers. Having a car also associated fairly consistently with lower exposure to neighborhood harms and hazards (figure 3). In both experiments, the average cancer risk was lower for driving households than for nondriving households, and in WTW driving households lived in neighborhoods that had less exposure to TRI facilities and highways.

Figure 2. Cars and Controls: Built Environment and Functional Dimension Differences within the Experiments



Source: Authors' data.
Note: FHEA is Fair Housing Equity Assessment.

Figure 3. Cars and Controls: Exposure and School Access Differences within the Experiments



Source: Authors' data.
Notes: TRI is Toxics Release Inventory. FHEA is Fair Housing Equity Assessment.

The neighborhoods of nondriving households outperformed those of driving households on only one dimension: nondriving households lived in neighborhoods with significantly better school quality than driving households. This result was statistically significant and large in the MTO experiment, but not large enough to be significant at conventional levels in WTW.

Neighborhood Sorting Among Clusters: MTO

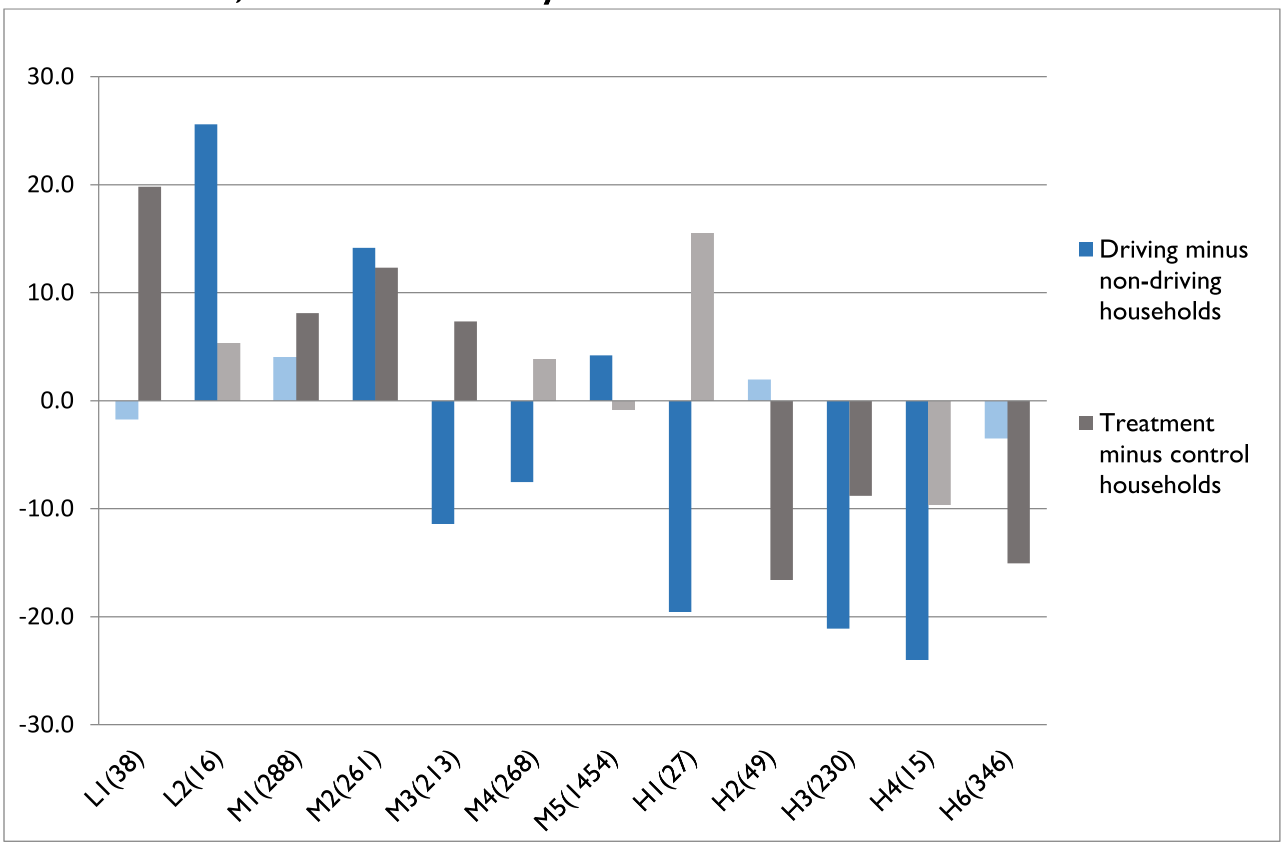
The cluster analysis procedure yielded 15 distinct clusters of neighborhoods (tracts) across MTO sites. Of those, 12 clusters contained tracts with experimental households in them. The three clusters in which there were no MTO households (from any of the three design groups) were all in the high-poverty band, and two of those clusters were the highest-poverty clusters (including a cluster with an average poverty rate of 100 percent). They also had extremely unfavorable ratings on several other factors including social status, proximity to highway and income density. Like many clusters, though, the picture was not uniformly negative; in two of those three clusters the schools had high FHEA indices, and they all had high job density.

Five of the 12 MTO-populated clusters had fewer than 50 households, but each of the remaining seven had more than 200. Of these, the majority—four clusters representing two-thirds of households—were in the medium-poverty band. Nearly 20 percent of households were also in high-poverty clusters.

Analysis of the sorting of MTO households across these clusters reinforces the conclusion that driving households and treatment households were significantly more likely to be located in low-poverty tracts (See figure 4). And, the difference between driving and nondriving households exceeded that between treatment and control households when it came to avoiding several of the highest-poverty clusters. But there were some important differences among the clusters that merit further discussion.

One medium-poverty band cluster, M5, had 1,454 MTO households, nearly half of the total. This cluster contains 1,494 tracts across the MTO sites and falls in the upper range of the medium-poverty band, with an average tract poverty rate of 24 percent. It is characterized by high-density urban tracts, with high average shares of land developed for urban uses, at 98 percent. M5 has relatively poorly performing schools and low social status factors. It has an average of 21 percent of its neighborhood area within 200 meters of a highway, near the middle of the range. M5 also has relatively high density of jobs and aggregate income, along with a mediocre housing market score. In other words, nearly half of MTO experimental households lived in dense, urban environments, with a range of socioeconomic statuses and access to opportunities. Some were likely better off than others, but on average these neighborhoods were at neither end of the spectrum with respect to sustainability and quality.

Figure 4. Percentage-Point Differences in Neighborhood Choice by Driving and Voucher Status, MTO Households by Cluster



Source: Authors' data.
Notes: Values represent the percentage-point difference from average in the household type's presence in the cluster. Dark colors represent differences that are statistically significant at the 5 percent or greater level. Light colors are not statistically significant. Horizontal axis labels are the cluster name and the number of MTO households in the cluster. For ease of representation, Treatment refers to Section 8 and Voucher households together, compared to Control households.

In general, the distribution of MTO households in this populous, medium-poverty cluster did not vary based on experimental voucher, Section 8 or control status of households. Voucher households were somewhat less likely to live in this cluster than control households, but those differences are statistically significant only at the 10 percent level. In contrast, driving households were more likely than nondriving households to live in this relatively high-quality cluster. That difference is statistically significant at the 1.0 percent level.

Nearly 600 MTO households lived in one of two high-poverty clusters, H3 and H6, with average neighborhood poverty rates of 45 and 63 percent, respectively. These clusters, containing a combined 162 tracts, comprised high-density neighborhoods with low social status factors. H6, with average poverty of 63 percent, had very poorly performing schools but high access to public transit and low proximity to highways. In contrast, H3 had comparatively good schools but poor transit access and high proximity to highways. That cluster also had the highest aggregate income density of the tracts. As with the households in M5, these 576 households lived in neighborhoods with a range of qualities, but tended to be more distressed.

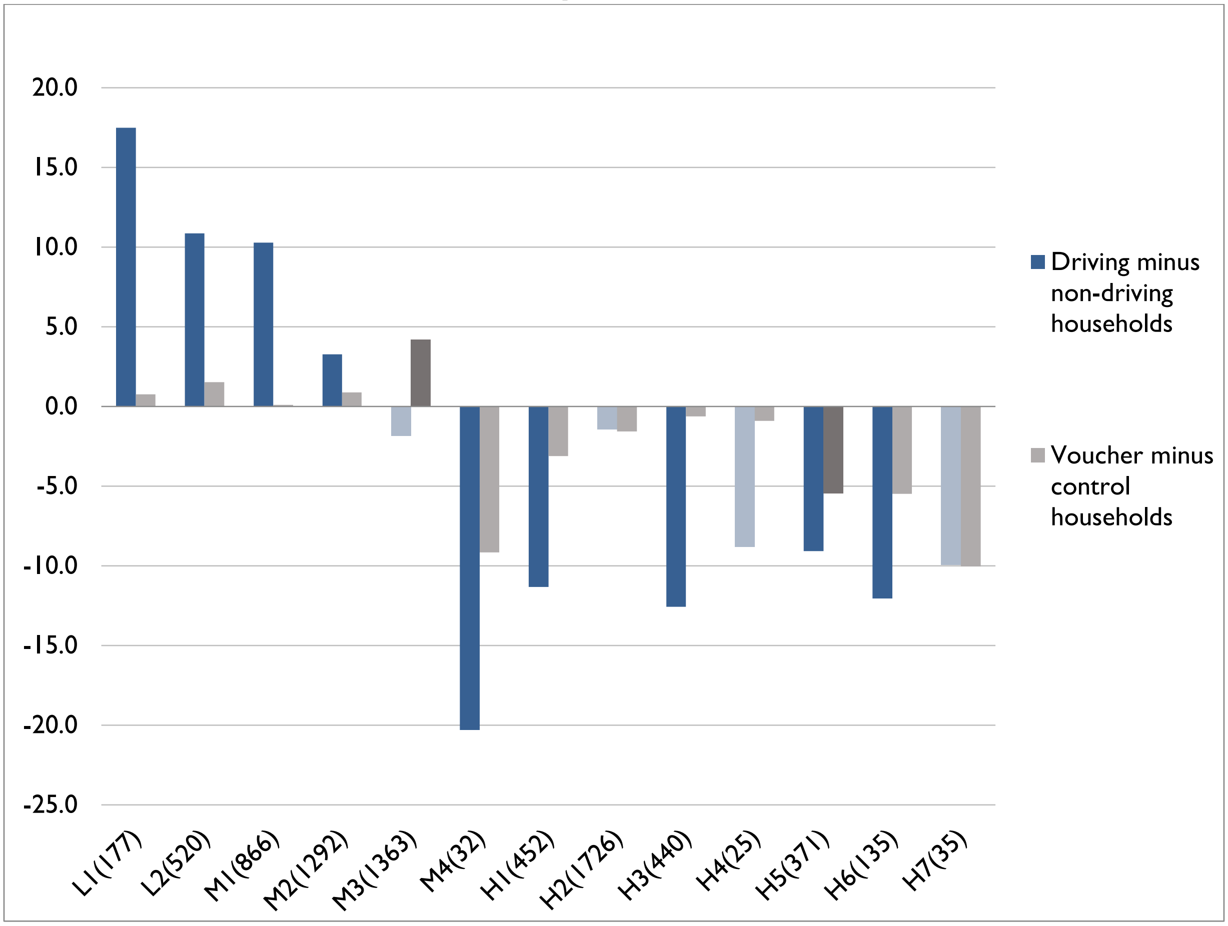
MTO experimental households with vouchers were less likely to live in these high-poverty clusters. The differences are especially pronounced in the higher-poverty cluster, with just half as many vouchers as a share of the cluster population as an even distribution would expect. Those differences are statistically significant at the 1.0 percent level. In contrast, control-group households were more likely to live in these neighborhoods, while there was not a clear pattern with Section 8 households. Similarly, driving households were much less likely than average to live in these clusters.

The remaining four clusters with more than 50 MTO households were characterized by neighborhood characteristics near the middle across the dimensions, with the exception of school quality; they tended to have poorly performing schools. The quality of schools emerged as a largely noncorrelated indicator; the highest-ranking tracts with respect to school quality were often in lower-quality neighborhoods. This is perhaps because of the temporal incongruity of that indicator, which was collected nearly a decade after randomization. There is therefore some evidence that "better-off" households—those with mobility in the form of housing choice vouchers and car access—lived in more sustainable neighborhoods, but the pattern was not universal across households or dimension of sustainability.

Neighborhood Sorting Among Clusters: WTW

The differences between driving and nondriving WTW households in attainment of low-poverty and higher-quality neighborhoods are even more consistent and pronounced than those in the MTO experiment. Whereas there are only two clusters in which voucher and control households had significant differences in sorting, there are nine in which driving and nondriving households had significant differences (figure 5). Again, important differences among the clusters merit further discussion.

Figure 5. Percentage-Point Differences in Neighborhood Choice by Driving and Voucher Status, WTW Households by Cluster



Source: Authors' data.
Notes: Values represent the percentage point difference from average in the household type's presence in the cluster. Dark colors represent differences that are statistically significant at the 5 percent or greater level. Light colors are not statistically significant. Horizontal axis labels are the cluster name and the number of WTW households in the cluster.

Compared to the MTO households, WTW households were more uniformly distributed across neighborhood types. Each neighborhood cluster had some WTW households, and only three had fewer than 50. Seven clusters had more than 400 households and three had more than 1,000. The cluster with the most WTW households contained 23 percent of the total, compared with the MTO cluster that contained nearly 50 percent of all MTO households. Further, 36 percent of WTW households—in three clusters representing nearly 1,000 tracts—were in clusters near the sustainable end of the neighborhood quality spectrum. These clusters are characterized by low to medium poverty levels—from 8 percent to 13 percent—relatively low shares of land developed for urban uses, low exposure to highways, and relatively high social status. In contrast, however, these clusters also had relatively poor schools and low density of jobs and aggregate income. In other words, neighborhoods in these clusters could be described as outside of the city center with low poverty and minor neighborhood streets.

These relatively sustainable neighborhoods were more heavily populated by WTW households that had cars at the baseline (See figure 5). In the three clusters, driving households were 3 to 10 percentage points more likely to live in these neighborhoods six quarters after randomization than nondriving households. These differences are statistically significant at the 1.0 percent level. In contrast, voucher-holding households were not more likely than control-group households to live in these clusters. Similarly, households with children were equally likely as households with no children or households with seniors to live in these clusters. These findings suggest that access to a car is a better predictor of whether a family will live in a high-quality neighborhood than either having access to a voucher or having children at home.

Another 18 percent of WTW households live in a cluster that closely represents the middle of the sustainability spectrum. This cluster of 228 tracts, M3, has medium to high average poverty, medium-quality schools, high share of land developed for urban uses, and low average social status. In other words, the 1,400 households in this cluster tend to live in fairly dense, urban neighborhoods with high poverty, decent schools and low average social status. These are not inner-city neighborhoods, but are likely found within the urban core. As with the more sustainable clusters, baseline driving-households were more likely to live in this cluster—with statistically significant differences at the 1.0 percent level—but treatment status and presence of children did not affect the likelihood of living in these neighborhoods after randomization.

The bad news for WTW households is that nearly a quarter—over 1,700 households—lived in a cluster with high-poverty, high-density, low social status neighborhoods, H2. These 109 tracts have poor schools and low income and job density. It is these neighborhoods that most closely represent traditionally understood inner-city, unsustainable neighborhoods. Voucher households and those with access to cars were marginally less likely to live in these neighborhoods after randomization. The differences are only a percentage point away from the expected distribution however, and do not represent meaningful sorting. The 5 percent level of statistical significance is likely because of the high explanatory power of the significance test resulting from a large number of households in this cluster.

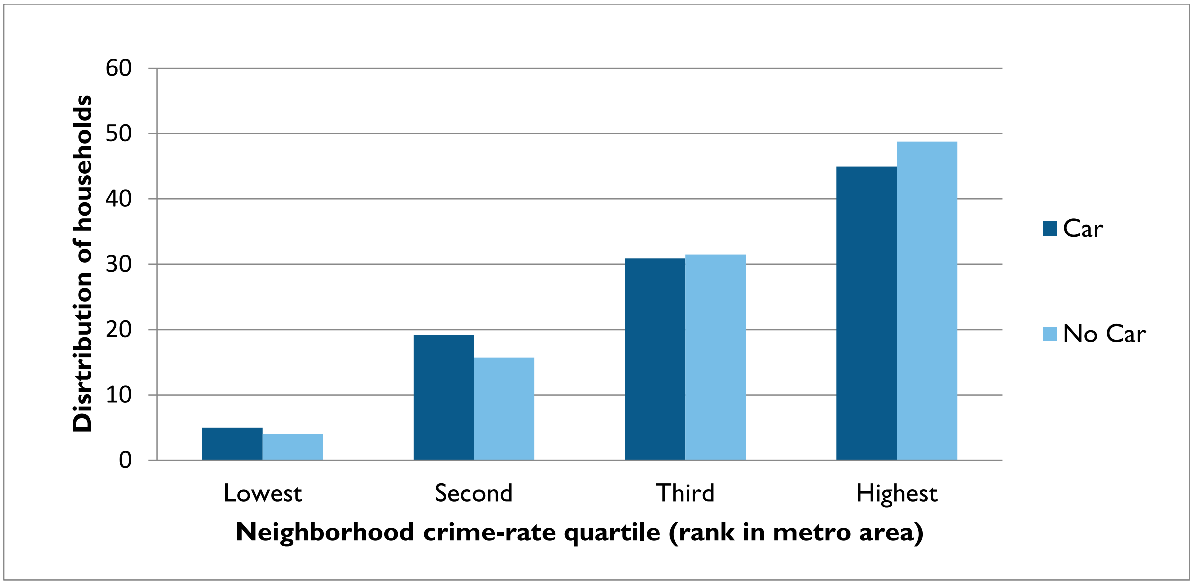
The remaining 20 percent of households—about 1,400 in total—lived in a range of clusters across the spectrum of neighborhood types. Unsurprisingly, households that had access to a car at baseline were more likely to live in the lowest-poverty cluster. In contrast, those without cars were more likely to live in the higher-poverty clusters.

Car Access, Crime, and Perceptions of Neighborhood Safety

As discussed above, we did not have complete information about crime rates for all our neighborhoods. However, we do have data on crime rates in six of the central cities of these 10 metropolitan areas and data from the MTO and WTW surveys on how participants perceived their neighborhoods' safety.

We examined the relationship between public safety and car access utilizing available crime data for six metropolitan areas in our study: Baltimore, Boston, Chicago, Los Angeles, Atlanta, and Houston. We tabulated the percent of households in each quartile (calculated individually for each site) of neighborhood violent crime rates, for those with car access and those without. The plurality of households—with or without cars—lived in the highest-crime neighborhood quartile; very few lived in the lowest-crime quartile (figure 6). Yet driving households were significantly less likely ($p<.05$) to live in the highest-crime quartile; whereas 49 percent of nondriving households lived in this quartile, 45 percent of driving households lived there. Driving households were also somewhat less likely to live in the second-highest quartile (but this was not statistically significant) and about 3 percentage points more likely than nondriving households to live in the second-lowest crime quartile.

Figure 6. Driving Households Less Likely than Nondrivers to Live in Highest-Crime Neighborhoods



Source: Authors' data.

In every site for which there was available crime data, the share of households with no car access that lived in the highest-crime quartile was higher than the share of households with car access that lived in the highest crime quartile. If we look at the top two crime quartiles together rather than only the one highest crime quartile, we see that the pattern persists. In each site, households with no car were more likely to fall in the top half of neighborhoods ranked by crime rate than households with car access. Finally, in three of the sites—Baltimore, Chicago, and Houston—there were large differences in the shares of car and noncar households in the lowest crime quartile, representing the safest neighborhoods in each site. In each of these sites, households with car access were about twice as likely to live in the lowest crime quartile compared to households without car access. In the other three sites, the shares between car and noncar households were about the same. Overall, these patterns suggest that the distribution of households with car access is shifted more towards relatively lower-crime neighborhoods compared with the distribution of households without car access.

We also examined perceptions of crime using the MTO and WTW survey responses, emphasizing the percent of heads of household who felt safe at night, out of those with car access and those without car access, by metropolitan area. We then performed chi-squared tests to determine whether, for each site, the percent of respondents who felt safe on the streets at night varied by car access status. The results of the tabulation are shown in table 5. For all sites except Los Angeles, chi-squared tests indicated a significant difference between the groups.

Table 5. Share of Households Reporting High Neighborhood Safety, by Car Access

	With Car		Without car	
	Percent	N	Percent	N
Baltimore	78	108	61	243
Boston	69	234	61	251
Chicago	77	183	66	360
LA[a]	56	140	52	136
NYC	72	73	54	374
All MTO	**69**	**738**	**59**	**1,364**
Atlanta	46	153	29	233
Augusta	66	231	52	212
Fresno	49	472	43	713
Houston	44	171	39	644
Spokane	65	330	59	380
All WTW	**53**	**1,357**	**42**	**2,182**
All sites	**58**	**2,095**	**48**	**3,546**

Source: MTO and WTW surveys.

[a] Los Angeles is the only site in which a chi-squared test found no statistically significant difference between groups.

For all WTW and MTO sites, a higher percentage of households with car access reported feeling safe than did households without car access, a difference that was statistically significant in all sites except Los Angeles. MTO households were more likely to feel safe than WTW households, but the perceived safety gap of about 10 percentage points was persistent across both groups. The gap was especially large, over 15 percentage points, for households in Baltimore, New York, Atlanta, and Spokane. For Houston, Fresno, and Los Angeles, the gap was only about 5 percentage points— small, but still consistent with the broader trend.

Summary of Neighborhood Characteristics and Residential Sorting Patterns

Our analysis of neighborhood clusters and residential sorting patterns advances the measurement of neighborhood quality, especially as it relates to the residential environments of low-income residents of metropolitan America, by identifying factors that matter in different ways for household outcomes. Our analysis of neighborhood sustainability dimensions has several implications.

First, despite the attention lavished on distressed neighborhoods, only a small minority of tracts in US metropolitan areas have crushing crime rates, failing schools, high levels of environmental degradation, and deep poverty. These distressed tracts also number among the most conveniently situated places in a nation whose metropolitan areas are undergoing a “Great Inversion” (Ehrenhalt 2013). Well-off households are rediscovering central cities, crime rates are falling, tax bases are stabilizing, new investments in all kinds of urban infrastructure are underway, and school districts are showing signs of improvement. Low-income residents, meanwhile, are finding it necessary to move farther away from the central city to neighborhoods where infrastructure is more dispersed and sparse and they must rely more heavily on cars to get around.

With their low land values and disempowered populations, the neighborhoods in the "H" clusters are ripe for reinvention as places for relatively well-off singles, couples without kids, and even young married people with kids. The retention of publicly owned land, affordable housing, and services for low-income people in these distressed neighborhoods is therefore much more important than was the case in the early 1990s; many of them have the potential to become mixed-income neighborhoods if public and private investment can be coordinated to accomplish that objective. The relatively small percentage of truly distressed neighborhoods and the prospect of adding another 100 million Americans by 2060 suggest that the nation could improve many of these neighborhoods if the incentives were aligned.

Second, while most neighborhoods are not distressed, practically none with housing prices affordable to most families offers mostly positive attributes and few disadvantages. Instead, households must balance neighborhood pros and cons as they decide where to live. In particular, neighborhoods whose poverty rates range between 10 and 30 percent—which in most metropolitan areas in this study account for at least the plurality, if not the majority, of tracts— have important differences in other characteristics. It therefore appears limited to characterize neighborhoods as offering either opportunity or environmental quality but not both, as found by Been and colleagues (2010). We found little or no relationship between poverty and income density, for example, meaning that while some high-poverty neighborhoods also have little economic vitality, others have enough income circulating per square mile to justify greater investment by the public and private sectors. The correlation between poverty and measures of exposure to hazardous conditions, while troubling, generally did not exceed 0.50. And on average, high-poverty neighborhoods had higher job density and better transit service (in the MTO metropolitan areas) than lower-poverty neighborhoods. These differences are important enough to yield a mosaic of choices among medium-poverty neighborhoods, as our cluster analysis showed.

Third, our two sets of metropolitan areas offer important contrasts with one another on one important dimension. The MTO metropolitan areas—Boston, Baltimore, Chicago, New York, and Los Angeles—offer many choices with respect to transit richness. Neighborhoods ranging from highly desirable to acceptable to miserable all have decent transit. The WTW metropolitan areas—Atlanta, Houston, Augusta, Spokane, and Fresno—contrast markedly with this picture. They have (collectively) so little good transit that we were forced to drop the transit measure when we constructed the neighborhood cluster analysis. While this finding partly reflects the incompleteness of the FHEA data on transit for some neighborhoods that do have bus routes, it also reflects the underlying reality of underfunded, sparse, and inconvenient transit in many large US metropolitan areas. For transit-dependent people—kids, people with mobility limitations, and those who prefer not to drive—this lack of transit is isolating and disempowering. Even for families who usually have access to a car, access to transit can provide an important safety net when the car is unavailable.

Regarding the patterns of household sorting across different dimensions of sustainability, our research shows that families with access to cars found housing in neighborhoods where environmental and social quality consistently and significantly exceeded the neighborhoods of households without cars. In both experiments, households with cars lived in neighborhoods with significantly lower poverty, higher social status, stronger housing markets, and lower cancer risk than those without cars. WTW households with car access also lived in neighborhoods with less exposure to TRI facilities and major highways than those without cars. And unexpectedly, MTO households with cars lived in neighborhoods with better transit access than those without cars.

Low-income households did make trade-offs, however. MTO households with cars lived in neighborhoods that were more spread out—with a lower density of aggregate income and housing and less diverse housing stock—and with worse measured school performance than transit-dependent households. While this result may be unexpected, it is consistent with findings that when they receive vouchers, families must think first about how to find an acceptable housing unit, and that they first look for safety when weighing neighborhoods against one another. Getting away from harmful relationships motivated some MTO households to move far from the housing projects where they lived, a decision made much more straightforward for families with cars (Briggs et al. 2010). But when they made these moves, they probably were finding neighborhoods with schools about which they lacked complete information. Interestingly, there was no school performance difference in the neighborhoods of WTW households according to their car access.

What Role Does Transportation Play in Voucher Users' Residential Choices?

In this section, we examine the influence of transportation access on three dimensions of location choice: (1) locational attainment, (2) neighborhood satisfaction, and (3) the dynamics of residential mobility. Each analysis, with the exception of the neighborhood satisfaction analysis, is conducted for a sample of MTO households and WTW households.

Locational Attainment

We begin with an investigation of the determinants of observed neighborhood opportunity outcomes. Specifically, we address the question, "Does vehicle access enable voucher recipients to move to neighborhoods exhibiting characteristics that are more sustainable, are more livable, and/or provide access to opportunity?" To investigate this question, we estimate several "locational attainment" models. In models of this sort, the dependent variable is a census tract characteristic associated with a household's chosen neighborhood, and independent variables include household-level determinants of location choice. A few examples of studies employing versions of this type of empirical approach include Alba and Logan (1992), Bayer et al. (2002), Dawkins (2005), Freeman (2008), and Woldoff (2008).

The dependent variables in our locational attainment models include a wide range of variables capturing the various dimensions of neighborhood opportunity outlined in the previous section, including the neighborhood functional environment, social environment, natural environment, economic vitality, and access to opportunity. Functional environment indicators, which capture the quality of available housing, transportation, and other physical neighborhood infrastructure, include median gross rent, vacancy rates, percent of housing that is owner-occupied, percent of rental housing occupied by voucher-recipients, and the FHEA transit access index. The neighborhood social environment refers to both the demographic makeup of residents and the strength and quality of the social networks present in a neighborhood. Indicators of this dimension include poverty rates, median household income, labor force participation rates, the percent of the population from a racial or ethnic minority group, the percent of households headed by females, and the percent of the adult population with a high school degree or GED.

The natural environment dimension captures the exposure to environmental hazards and presence of natural and built environment characteristics that may affect both residents' health and a neighborhood's desirability. Natural environment indicators include the percent of land that is in open space, population density, cancer risk per million persons, and the percent of a tract that is covered by 200 meter buffers surrounding major highways (a proxy for automobile emissions). A final natural environment indicator is average block length, which captures the average length of streets within a census tract. Tracts with longer average block lengths are assumed to exhibit more suburban street patterns.

The final two neighborhood dimensions examined are the neighborhood's level of economic vitality and access to opportunity. Indicators of economic vitality include job density and aggregate income density. Access to opportunity is quantified using a measure of the number of jobs accessible within 30 minutes of the census tract centroid and the FHEA school performance index.

The independent variables in each model include several household-level factors discussed in the literature that have been shown to be associated with neighborhood choice. To capture various policy effects, we include measures of the randomly-assigned “treatment” group for each sample, interacted with whether the household was still relying on voucher assistance at the time of the final survey. For the WTW final sample, the “voucher status” variable is defined in terms of those who used the voucher to lease-up in their current location. In the MTO final sample, including voucher lease-up information substantially reduced the sample size because of the large number of missing values on that variable in the final sample. Instead, our measure of voucher status captures not whether the household has leased-up in their current location using a voucher, but whether the household is receiving voucher assistance in their current location, regardless of whether they were awarded their voucher for use in the final survey location or previously in some other location. We also include indicators of the household’s metropolitan location, with Boston omitted as the reference category for the MTO sample and Augusta omitted as the reference category in the WTW sample. Households living in Los Angeles were excluded from the WTW sample, because the program was ultimately not implemented within this metropolitan area.

Other household characteristics include income, income squared, and number of children in the household. Income is defined slightly differently for the two samples. In the MTO sample, income is defined as the total household income earned during the previous year, whereas in the WTW sample, income is defined simply using a dummy variable indicating whether the household’s income is above or below the poverty threshold. We experimented with a measure of income based on annualized earnings for the WTW sample, but because of the number of missing values for particular quarters on this variable, it proved to not be very reliable. The only other available measure with sufficient coverage for the entire WTW sample was the household’s income relative to the poverty threshold.

Characteristics of the household head include age, age squared, race and ethnicity, marital status, gender, education, and employment status. We include three measures of auto access. The first is an indicator variable equal to 1 if anyone in the household owned a car, van, or truck that runs or has access to a valid driver’s license at the time of the interim survey (for MTO households) or at the time of the baseline survey (for WTW households). For the MTO sample, we also include two indicator variables that measure whether the household gained or lost access to cars or licensing since the interim survey. Change in auto access could not be calculated for the WTW sample, due to a change in the wording of the question between the baseline and follow-up survey which limited the variable’s coverage to only those who were employed at the time of the follow-up survey. We include access to a driver’s license in our definition of auto access, because even if a household does not own a car, access to a driver’s license may enable a household member to rent a car or borrow one from a friend or family member. All of these variables, with the exception of the auto access variables, were measured contemporaneously with the date of the final survey. Additionally, in each regression model we include the lagged measure (as of the baseline surveys) of the same neighborhood characteristic used to construct the dependent variable. All models are restricted to those who moved from their baseline neighborhood to a new census tract by the final survey.

Table 6 provides a summary of the regression coefficients for automobile access across all locational attainment regressions. These tables report the sign for all coefficients significant at the .05 level. We find that auto access has significant impacts across a variety of locational outcomes, whether access is measured in terms of having a car or license at an earlier period or gaining access during the survey period. Those with access to cars or licenses gain access to neighborhoods with a more highly-valued housing stock, higher school performance, lower poverty rates and unemployment rates, and among MTO households, a more educated adult population.

Table 6. Summary of Vehicle Access Regression Coefficients from Locational Attainment Models

Variable description	MTO Sample: Car access at interim	MTO Sample: Car access gained	MTO Sample: Car access lost	WTW Sample: Car access at baseline
Functional environment				
Median gross rent	+	+	-	+
Vacancy rate	-	NS	+	-
Owner occupied (%)	+	+	-	+
Vouchers (% of rental housing)	NS	NS	NS	NS
FHEA transit access index	NS	NS	+	-
Social environment				
Poverty rate	-	-	+	-
Median household income	+	+	-	+
Labor force participation rate	+	+	-	+
Unemployment rate	-	-	+	-
Minority population (%)	-	-	+	NS
Female-headed households (%)	-	-	+	-
25+ with high school diploma or GED (%)	+	+	-	NS
Natural environment				
Open space (%)	+	+	-	NS
Average block length	+	+	-	+
Population density	NS	-	+	-
Buffer of major highways (%)	NS	NS	NS	NS
Cancer risk per million	NS	NS	NS	-
Buffer of TRI facilities (%)	NS	NS	NS	NS
Economic vitality				
Job density	NS	NS	+	NS
Aggregate income density	NS	NS	NS	-
Access to opportunity				
FHEA school performance index	+	NS	NS	+
Number of jobs within 30 minutes	NS	NS	NS	NS

Source: Authors' data.

Notes: NS = not significant at .05 level; + = positive and significant at .05 level, - = negative and significant at .05 level.

We also find that when it comes to environmental conditions, economic vitality, and outcomes associated with access to opportunity, there are trade-offs associated with having access to a vehicle. While households with vehicles live in areas with more desirable environmental amenities, including more access to open space and less exposure to cancer risk (WTW households only), having a vehicle or license also encourages moves to neighborhoods that are less accessible to transit (among WTW households) and less conducive to walking. Thus, when it comes to measuring "opportunity," one must recognize that the spatial distribution of opportunities is heterogeneous. When faced with an uneven distribution of opportunity structures, households must often make trade-offs and choose those which are valued most highly. Although our approach does not allow us to distinguish between the effect of household preferences versus spatial supply constraints as they influence the residential outcomes observed, we find that auto access has fairly consistent effects across a range of housing market, social, economic, and environmental outcomes, and that accessing one particular dimension of neighborhood opportunity often comes at the expense of other dimensions of opportunity.

For the influence of voucher status and program treatment effects, we find that voucher status has more significant effects on locational attainment than being assigned to either the experimental or Section 8 group for MTO participants. Part of the explanation for these findings may be attributable to the length of time between the initial random assignment and the final survey, which was 10 to 15 years later in many cases. Even with this length of time, however, initial assignment to the experimental group has effects on locational attainment which persist across a variety of outcomes. This suggests that the initial exposure to low-poverty neighborhoods has impacts on long-term locational attainment, particularly when combined with voucher assistance.

Being randomly assigned to receive a voucher and using the voucher to lease up has less significant impacts on the range of locational attainment for those in the WTW program. This latter finding is consistent with Mills and colleagues (2006), who find evidence of only modest differences in the locational outcomes between the WTW voucher treatment group and the control group. Two findings are worth noting from the WTW results. First, leasing with a voucher, and in some cases being randomly assigned to the voucher treatment group, has an impact on a number of positive housing and labor market conditions. Second, random assignment to the voucher treatment group is associated with living in neighborhoods with higher levels of school performance.

A final finding worthy of note is the observation that having a voucher in the MTO program and leasing-up with a voucher in the WTW program is positively associated with moving to a neighborhood with a higher percentage of voucher holders. We interpret this as evidence of possible supply constraints limiting the locations where vouchers can be utilized. This finding is consistent with Pendall (2000), who finds that renters receiving housing assistance tend to live in distressed neighborhoods primarily due to the larger supply of rental housing in those neighborhoods.

Neighborhood Satisfaction

Access to adequate transportation is an important constraint influencing housing search and residential satisfaction, particularly among low-income households. In metropolitan areas lacking adequate public transportation service, households without access to an automobile may limit their housing search to nearby homes that are easily accessible by transit. Because public transit tends to be a slower travel mode than automobile-based travel, transit-dependent households may inspect fewer homes before making a residential location decision. Even if low-income households gain access to housing in areas with limited transit options, the neighborhoods chosen may fail to satisfy household needs if work and nonwork destinations are not easily accessible. Therefore, low-income households often must “satisfice” in their location choice decisions, selecting housing in transit-rich neighborhoods even if such neighborhoods do not necessarily provide other desirable amenities and economic opportunities.

This section examines the linkages between transportation access (defined in terms of access to a vehicle or public transportation) and neighborhood satisfaction using data from the MTO program’s final survey. Our models of neighborhood satisfaction are based on the ordered probit specification. The dependent variable is an ordinal measure of the household head’s response to the survey question, “Which of the following statements best describes how satisfied you are with your neighborhood? Would you say you are .... (1) very satisfied, (2) somewhat satisfied, (3) in the middle, (4) somewhat dissatisfied,

(5) very dissatisfied?” These responses were recoded so that answer five corresponds to the highest neighborhood rating and answer one corresponds to the lowest rating. Following Boehm and Ihlanfeldt (1991), we assume that this index is a proxy for the households’ unobserved level of utility attained from their neighborhood environment.

The covariates in the models include a variety of factors discussed in the literature that have been shown to be associated with neighborhood satisfaction. To capture various policy effects, we include indicator variables for each MTO treatment group, interacted with whether the household was receiving voucher assistance at the time the survey was conducted. We also include indicators of the household’s metropolitan location and whether the household lived in the suburbs at the time of the final survey. An indicator of mobility (number of moves) and its squared term is included to capture nonlinear impacts of mobility. Household characteristics include household income, household income squared, number of children in the household, and a measure of the household’s reported housing satisfaction, measured on a four-point scale. Characteristics of the household head include age, age squared, race and ethnicity, marital status, gender, education, and employment status.

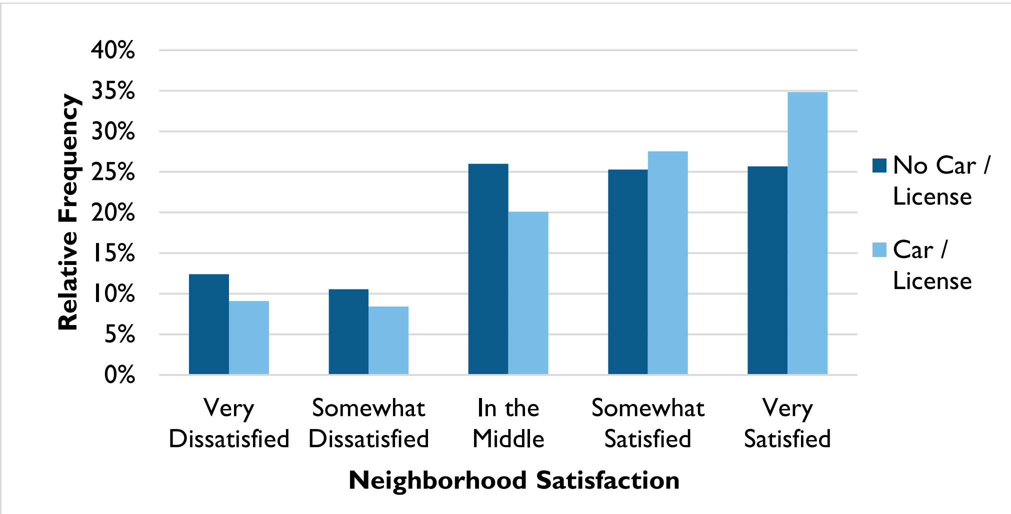
We include two measures of transportation access from the MTO survey. The first is an indicator variable equal to 1 if anyone in the household owns a car, van, or truck that runs or has a valid driver’s license. We include access to a driver’s license in our definition, because even if the household does not own a car, access to a driver’s license may enable a household member to rent a car or borrow one from a friend or family member. The second measure of transportation access is an ordinal variable that measures the household’s assessment of how long it takes to reach the nearest bus or train stop. Higher values indicate that public transportation is more accessible, with the levels of access measured in 15-minute increments.

Consistent with previous studies, we include two types of neighborhood characteristics in our models: (1) the household head’s self-reported evaluation of whether particular conditions are problematic in their neighborhood, and (2) observable neighborhood characteristics measured at the census tract level. Regarding the former, we include measures of the degree to which respondents viewed the following issues as problematic in their neighborhoods: trash, graffiti, public drinking, abandoned buildings, loitering, police activity, drug use, and safety on the streets. We also include two measures of social networks with friends and neighbors in the neighborhood. Regarding the observable neighborhood characteristics, we include various measures from the 2000 census, along with a variety of derived measures to capture various neighborhood amenities and built environment characteristics, including the percent of voucher holders in rental units, housing structure diversity, housing market strength factor, the FHEA job access index, FHEA environmental hazards index, FHEA school performance index, unemployment rate, poverty rate, female-headed household percentage, and racial and ethnic composition.

Figures 7 and 8 provide a descriptive look at the connection between neighborhood satisfaction and transportation access. As shown in Figure 7, those with access to a car or a license tend to report higher levels of neighborhood satisfaction. Specifically, 35 percent of those with access to a car or license report being very satisfied with their neighborhoods, compared with 26 percent among those without access to a car or license. Similarly, 12 percent of those without access to a car or license report being very dissatisfied with their neighborhoods, compared to 9 percent among those with access to a car or license. Responses vary more by level of proximity to public transit. The largest percentage of those who are very satisfied with their neighborhoods live more than 60 minutes from the nearest transit stop. Since these households are more likely to rely on automobiles to reach destinations, this finding complements the information displayed in Figure 7.

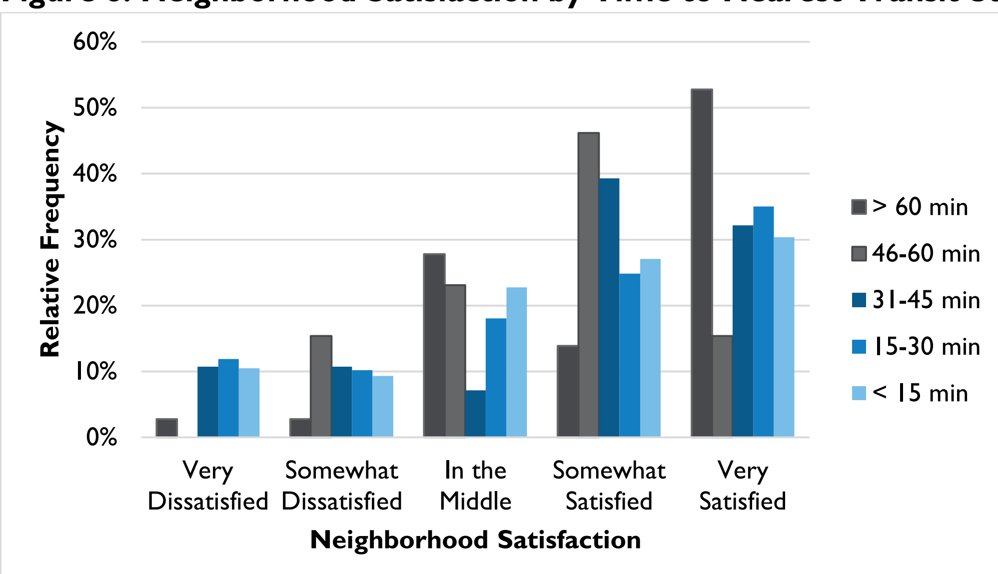
In the ordered probit models explaining household neighborhood satisfaction scores, we find that access to cars or licenses and transit each positively influence neighborhood satisfaction. The significance of the interactive effect of cars and transit suggests that the importance of automobile access varies by proximity to transit. Estimates from the full model suggest that automobile ownership matters most in neighborhoods with low transit accessibility. At relatively low levels of transit access (more than an hour to the nearest public transit stop), the marginal change in neighborhood satisfaction is much higher for car owners (1.67) than for households without a car (.20). However, in areas with high transit accessibility (less than 15 minutes to the nearest public transit stop), the marginal change in neighborhood satisfaction is slightly lower for car owners (.92) than for households without a car (1.02).

Figure 7. Neighborhood Satisfaction by Car or License Access



Source: Authors' data.

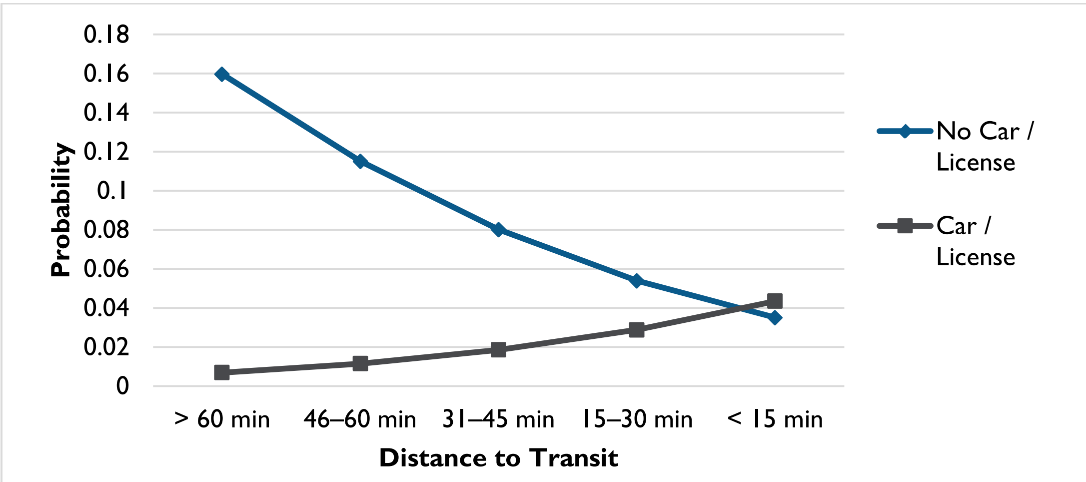
Figure 8. Neighborhood Satisfaction by Time to Nearest Transit Stop



Source: Authors' data.

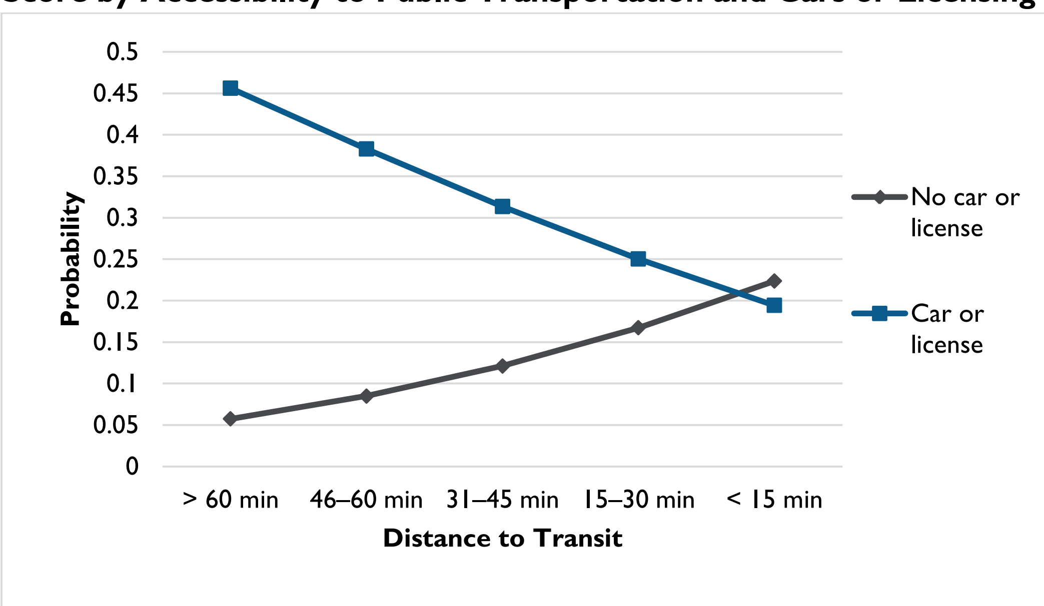
Figures 9 and 10 display the predicted probability that households will cite the lowest and highest neighborhood satisfaction ranking for different levels of access to transit and cars or licensing. The predicted probabilities hold values of nontransportation covariates at their respective means for the sample. Among those living within 15 minutes of a transit stop, those without access to cars or licenses report slightly higher levels of neighborhood satisfaction. Beyond this distance, the probability of being very satisfied with one's neighborhood decreases with distance from transit for those without access to cars or licenses and increases for those with access to cars. The reverse relationship holds in models predicting the probability of a household being "very dissatisfied" with their neighborhood.

Figure 9. Predicted Probability of "Very Dissatisfied" Neighborhood Satisfaction Score by Accessibility to Public Transportation and Cars or Licensing



Source: Authors' data.

Figure 10. Predicted Probability of "Very Satisfied" Neighborhood Satisfaction Score by Accessibility to Public Transportation and Cars or Licensing



Source: Authors' data.

Table 7 displays the predicted neighborhood satisfaction scores for different levels of car, license, and public transit access using coefficients from the full model and the models estimated for the experimental and control groups. Values of car access and public transit access are allowed to vary, while the other variables are held at their respective means. Table 7 suggests that in areas with the highest levels of transit access (less than 15 minutes to the nearest bus or transit stop), households without access to cars or licenses are slightly more satisfied with their neighborhoods. The disparity in neighborhood satisfaction between those with and without access to cars or licenses increases with distance from transit. In areas with the lowest levels of transit access, those with access to cars or licenses are about 1.5 times more satisfied with their neighborhoods than those without access to cars or licenses. Across all values of transportation access, car owners living in areas with the least-accessible public transit exhibit the highest levels of neighborhood satisfaction.

Table 7. Predicted Neighborhood Satisfaction by Transit and Car or License Access

Sample	Car or license access	Minutes to nearest transit stop				
		> 60	46–60	31–45	15–30	< 15
Full model	No car or license	2.83	3.05	3.26	3.47	3.67
	Car or license	4.23	4.08	3.92	3.75	3.57
Experimental group	No car or license	3.25	3.39	3.53	3.66	3.79
	Car or license	4.47	4.32	4.14	3.95	3.74
Control group	No car or license	2.39	2.67	2.96	3.24	3.51
	Car or license	4.10	3.91	3.71	3.50	3.29

Source: Authors' data.

Comparing the predicted probabilities for different treatment groups, we find similar differences between those with and without access to automobiles or licenses. The differential in neighborhood satisfaction between those with and without access to cars or licenses is largest for the control group. Among control group households with the lowest levels of transit access, those with access to cars or licenses are about 1.7 times more satisfied with their neighborhoods than those without access to cars or licenses. These group-level differences possibly reflect the differences in location choices between experimental and control group households. If those in the control group reside in locations with greater transit accessibility, we would expect to find a larger differential between the neighborhood satisfaction rankings of those with access to cars relative to those without access.

Duration of Exposure to High-Poverty Neighborhoods

While much has been written about the locational outcomes of MTO and WTW participants, we know less about the range of factors affecting low-income households' exposure to neighborhood poverty over time. Households that temporarily move into poor neighborhoods because of a temporary change in housing needs often face a different set of constraints than households that remain exposed to poverty over longer periods. Research from the MTO program suggests that while the program enabled many households to move to low-poverty neighborhoods that offered greater accessibility to different social and economic opportunities, many of those randomly-assigned to low-poverty neighborhoods subsequently moved back to high-poverty neighborhoods. Furthermore, few households that did not initially gain access to low-poverty neighborhoods subsequently moved to low-poverty neighborhoods at a later date (Turner et al. 2011). Some have pointed to these facts as possible explanations for the insignificant impacts of the MTO program on short-term employment outcomes.

This section examines the dynamics of exposure to neighborhood poverty for a sample of households from the WTW and MTO programs. We conduct descriptive analyses of the length and incidence of exposure to different neighborhood poverty conditions for the participants within each of these programs, emphasizing differences in outcomes by program treatment group and level of vehicle access, defining vehicle access as having access to either an automobile or a license. To be consistent with the MTO poverty threshold definition, we define high-poverty neighborhoods as those with poverty rates greater than or equal to 10 percent. Unlike MTO, which defines poverty rates using 1990 census data, we rely on 2000 census data, because the majority of the residential spells for those in both the MTO and WTW programs occurred during the 2000s.

Tables 8 and 9 examine several measures of residential mobility for the entire sample in each program, and separately for each treatment group and for different levels of vehicle access. For each of these metrics, it is important to note the differences in average duration between the two samples (shown in the first row of tables 8 and 9). The length of time between the baseline and final MTO survey is on average about 13.8 years, whereas the length of time between the baseline and end-of-the-period "follow-up" WTW survey is on average about 4.5 years. The following two rows display the average length of exposure to high- and low-poverty neighborhoods over the analysis period, using the 10 percent poverty threshold defined above. The fourth and fifth rows express the duration of exposure to high- and low-poverty neighborhoods as a percentage of each household's total duration.

Table 8. Descriptive Analysis of Neighborhood Mobility, MTO Participants

		Treatment Group			Vehicle Access	
	Total households	Exp.	Section 8	Control	Vehicle access	No vehicle access
Average total duration (days)	5,050.8	5,119.6	4,950.8	5,057.9	5,011.3	5,073.6
Average duration in high-poverty neighborhood (days)	4,566.3	4,369.6	4,587.7	4,795.3	4,371.4	4,677.5
Average duration in low-poverty neighborhood (days)	485.4	751.4	363.8	262.6	639.2	397.8
Total duration in high-poverty neighborhood (%)	90.5	85.4	92.7	94.8	87.4	92.3
Total duration in low-poverty neighborhood (%)	9.5	14.6	7.3	5.2	12.6	7.7
High-poverty neighborhood at least once (%)	100.0	99.9	100.0	100.0	100.0	99.9
High-poverty neighborhood at beginning and end of survey (%)	85.6	82.9	85.7	89.1	81.8	87.8
High-poverty neighborhood consecutively during the survey (%)	74.5	65.1	77.2	83.9	70.0	77.0
Who exit a high-poverty neighborhood (%)	23.5	33.1	20.6	14.0	28.4	20.8
Who re-enter a high-poverty neighborhood after exit (%)	12.7	20.8	9.6	5.4	13.8	12.1
Sample Size	**4,594**	**1,812**	**1,348**	**1,434**	**1,679**	**2,904**

Source: Authors' analysis.

Rows 6 through 10 in the tables display different poverty transition measures for the households in the sample. Row six displays the percent of households, by group, who lived in a high-poverty neighborhood at least once during the analysis period. Next, we display the percent of households that began and ended their spells in a high-poverty neighborhood, ignoring whether they possibly moved to a low-poverty neighborhood at some time during the analysis period. Row eight considers the percentage of households in each group who lived in high poverty neighborhoods continuously throughout the analysis period. For all measures in rows six through eight, we include all households in each analysis, regardless of whether the household moved or not. For example, the continuous exposure to poverty for some households may have been due to never having moved from a high-poverty neighborhood, whereas for others, it may have been due to moves between two or more high-poverty neighborhoods.

Table 9. Descriptive Analysis of Neighborhood Mobility, WTW Participants

		Treatment Group		Vehicle Access	
	Total households	Voucher	control	Vehicle access	No vehicle access
Average total duration (quarters)	18.0	18.0	18.0	18.0	18.0
Average duration in high-poverty neighborhood (quarters)	16.4	16.5	16.4	16.1	17.1
Average duration in low-poverty neighborhood (quarters)	1.6	1.5	1.6	1.9	0.9
Total duration in high-poverty neighborhood (%)	91.4%	91.6%	91.1%	89.4%	95.1%
Total duration in low-poverty neighborhood (%)	8.6%	8.4%	8.9%	10.6%	4.9%
In high-poverty neighborhood at least once (%)	96.3%	96.5%	96.2%	95.4%	98.2%
In high-poverty neighborhood at beginning and end of survey (%)	86.8%	86.8%	86.7%	83.7%	92.3%
In high-poverty neighborhood consecutively during the survey (%)	85.6%	85.5%	85.7%	82.3%	91.5%
Who exit a high-poverty neighborhood (%)	8.2%	8.2%	8.1%	9.9%	5.1%
Who re-enter a high-poverty neighborhood after exit (%)	1.4%	1.6%	1.3%	1.6%	1.1%
Sample Size	**8,657**	**4,645**	**4,012**	**5,517**	**2,937**

Source: Authors' analysis.

The final two measures shown in tables 8 and 9 display information regarding transitions into and out of high-poverty neighborhoods. Row nine displays the percent of households that exited a high-poverty neighborhood at least once during the analysis period, and row 10 displays the percent of households that initially lived in a high-poverty neighborhood at least once, exited to a low-poverty neighborhood at least once, and subsequently returned to a high-poverty neighborhood after an initial exposure to a low-poverty one. We now turn to a discussion of these various measures and their implications.

We find that the exposure to high-poverty neighborhoods, whether measured in terms of the total exposure or percent of total duration, is lowest for those in the MTO experimental group. This is expected, given that this group was required by the program to reside in a low-poverty neighborhood for at least one year. We find that on average, MTO households resided in low-poverty neighborhoods for slightly more than two years, compared to those in the Section 8 and control group, whose average spells in low-poverty neighborhoods were each less than one year. On average, those in the WTW program stayed in low-poverty neighborhoods for a much shorter period of time, regardless of whether they were assigned to the treatment or control group. As a percent of the total duration time, WTW participants, regardless of treatment group, spent a larger proportion of the analysis period in low-poverty neighborhoods than those in either the MTO Section 8 or control group, but the MTO experimental group spent the largest proportion of their time in low-poverty neighborhoods. These findings are expected, given the geographic focus on the MTO program. While these findings offer promise to those advocating the use of geographically targeted residential mobility programs for the purposes of reducing exposure to poverty, it is important to note that the average exposure to low-poverty neighborhoods was only slightly longer than the required minimum of one year. Furthermore, even those in the MTO treatment group spent a large proportion of their time (85.4%) in neighborhoods with poverty rates greater than 10 percent.

The effect of vehicle access on exposure to poverty is evident from the first five rows of tables 8 and 9. For both samples, those with access to vehicles spent a larger proportion of their time in low-poverty neighborhoods and a smaller proportion of their time in high-poverty neighborhoods. In the WTW program, the effects of having access to a vehicle were greater than the effects of being assigned to the voucher treatment group, with vehicle owners spending 10.6% of their spells in low-poverty neighborhoods compared with 8.4% for those in the WTW treatment group. The differences between poverty exposure for those with and without access to cars in the MTO sample are similarly large, although vehicle owners spend a slightly lower proportion of their time in low-poverty neighborhoods than do those assigned to the MTO treatment group. These findings suggest that combining auto assistance with geographically-targeted housing assistance could go a long way toward reducing the length of exposure to poverty.

We now turn to the various transition measures displayed in rows 6 through 10 of tables 8 and 9. First note the large proportion of households that lived in a high-poverty neighborhood at least once, particularly for MTO participants. This is expected given the initial locations of the subsidized units for those recruited for participation in the MTO program. A similarly large proportion of households in each program began and ended their spells in high-poverty neighborhoods or remained in high-poverty neighborhoods throughout the entire analysis period. For these two transition types, we note similarly large differences among MTO treatment groups and by vehicle access, with little difference observed between those in the WTW treatment and control group.

The last two transitions displayed in tables 8 and 9 provide a different perspective on the influence of mobility on exposure to poverty. Unlike the other dynamic patterns displayed in these tables, the last two focus exclusively on neighborhood mobility, through exits from and eventual returns to neighborhood poverty. Focusing on exits, we see similar patterns to those displayed in previous analyses, with the MTO treatment group assignment and vehicle status having a significant influence on a household's likelihood of exiting poverty. Again, we see little difference between the WTW treatment and control group in rates of exit. These findings are expected, since MTO treatment group assignment and vehicle access should influence exposure to poverty primarily through its influence on the propensity to move.

When we examine the last column in tables 8 and 9, we find that fostering residential mobility, through geographically-targeted policies or enhanced vehicle access, also increases the likelihood of eventually returning to a high-poverty neighborhood. More than 20 percent of those in the MTO experimental group eventually returned to a high-poverty neighborhood after their initial exposure to low-poverty neighborhoods, compared with only 9.6 percent for those in the Section 8 group and 5.4 percent in the control group. Interestingly, while those with access to vehicles were more likely than those without access to return to poverty after an initial exposure to low-poverty neighborhoods, those with vehicle access were much less likely to return than those in the MTO experimental group. Taken together, these findings suggest that vehicle access has effects on exposure to poverty that are comparable to those of geographically-restricted mobility programs.

Summary of the Influence of Transportation on Residential Choices

While much has been written about the effects of neighborhoods on the social and economic outcomes of households participating in the experimental MTO and WTW programs, less is known about the types of neighborhoods chosen and the factors influencing these choices. Even less is known about the effect of car accessibility on the types of neighborhoods chosen. This section fills this gap in the literature, examining the impact of various household characteristics along with voucher assistance and auto access on the locational outcomes of low-income households.

In several locational attainment models, we find that car and license access, whether measured in terms of initially having access to a vehicle or subsequently gaining access to one, has statistically significant effects across a range of locational outcomes. This suggests that vehicles influence housing search and the types of neighborhoods considered when making a location decision. Generally speaking, having access to a vehicle has effects that are much stronger and more consistent than any other household characteristic, including income. Regarding whether the neighborhoods chosen by vehicle-owners are more desirable, it depends on how neighborhood opportunity is defined. Those with access to cars are able to locate housing in areas with lower concentrations of poverty and higher concentrations of households that are employed or participating in the workforce. These areas also tend to have higher median rents, more owner-occupied housing, lower vacancy rates, and higher-performing schools. There are trade-offs when it comes to environmental features. While vehicle owners are shown to live in areas with more access to open space and less exposure to cancer risk and toxic facilities, this comes at the expense of lower levels of transit access and urban environments that are potentially less conducive to walking. We also find that those who lose access to cars compensate by choosing neighborhoods that have higher levels of job accessibility.

We also find that access to vehicles influences neighborhood satisfaction interactively with transit access. Estimates from an ordered probit model suggest that access to automobiles or a driver's license matters most in neighborhoods with low transit accessibility. In areas with the highest levels of transit access, those with and without access to cars or licenses are each moderately satisfied with their neighborhoods, although predicted neighborhood satisfaction levels are slightly higher for those without access to cars or licenses. In areas with the lowest levels of transit access, car owners are about 1.5 times more satisfied with their neighborhoods. Considering different levels of car and transit access together, those living in areas with the least-accessible public transit and who lack access to cars or licenses exhibit the highest levels of neighborhood satisfaction.

Comparing the predicted levels of neighborhood satisfaction across MTO treatment groups, we find evidence of similar differences between those with and without access to automobiles or licenses, although the differential in neighborhood satisfaction between those with and without access to cars or licenses is largest for the control group. Among control group households with the lowest levels of transit access, those with access to cars or licenses are about 1.7 times more satisfied with their neighborhoods than those without access to cars or licenses. These group-level differences suggest that the effect of housing mobility programs on neighborhood satisfaction is likely to be influenced by the availability of transportation options in destination neighborhoods. We also find that these effects vary by metropolitan area, likely because of differences in transportation networks across metropolitan areas.

Our descriptive analysis of the dynamics of exposure to poverty provides evidence of significant differences between those with and those without access to vehicles. The total length of exposure to low poverty was slightly lower than for those in the MTO experimental group, but vehicle-owners were also less likely than MTO experimental group members to return to high-poverty neighborhoods. Those with vehicle access exhibited high rates of exit from poverty, suggesting that mobility is the primary channel through which vehicle access influences poverty exposure. Vehicles arguably facilitate housing search and increase the accessibility of destinations following moves to low-poverty neighborhoods.

Taken together, these findings suggest that having access to vehicles facilitates mobility to low-poverty neighborhoods over time and eventual satisfaction with the neighborhood chosen. Geographically-targeted housing assistance also has measurable effects that persist over time, but the magnitude and significance of the effect varies once the geographic requirement is lifted.

How Do Transportation Access and Residential Location Choice Influence Economic Opportunity?

In this section, we examine the influence of transportation access on employment and earnings. For MTO participants, we examine the exposure of households to access opportunity neighborhoods, which we define as census tracts in the top quartile of their metropolitan area in terms of employment and public transit availability. Then we proceed to examine the influence of transportation access on employment transitions for those in the MTO and WTW program. We conclude with an analysis of the joint relationship between automobile ownership, residential location in transit-rich neighborhoods, and earnings for MTO participants.

Access Opportunity Neighborhoods: Public Transit and Employment Availability

In this section, we examine whether the MTO program provided participants with greater access to opportunities—by improving either their access to employment or their ability to use public transit to travel to opportunities. We focus on access opportunity neighborhoods, which we define as census tracts in the top quartile of their metropolitan area in terms of employment availability and public transit availability. Particularly, we examine these two areas of opportunity in the neighborhoods to which individuals moved at first lease-up, how much time they spent in high-access neighborhoods during the course of the experiment, and access at their final reported neighborhood location. The purpose of this analysis is to (1) assess whether households in the MTO experimental group have greater access to jobs and public transit than households in the Section 8 and control groups, (2) examine how these relationships are mediated by access to automobiles, and (3) determine how closely these measures of access are correlated with other dimensions of opportunity. A secondary goal of this section is to assess the reliability of different census tract-level public transit and jobs access measures, which have only recently become available with full national coverage. Because low-income individuals face complicated trade-offs among relevant dimensions of opportunity in any neighborhood, from a research perspective, there are many ways to measure neighborhood quality and accessibility (Handy and Niemeier 1997).

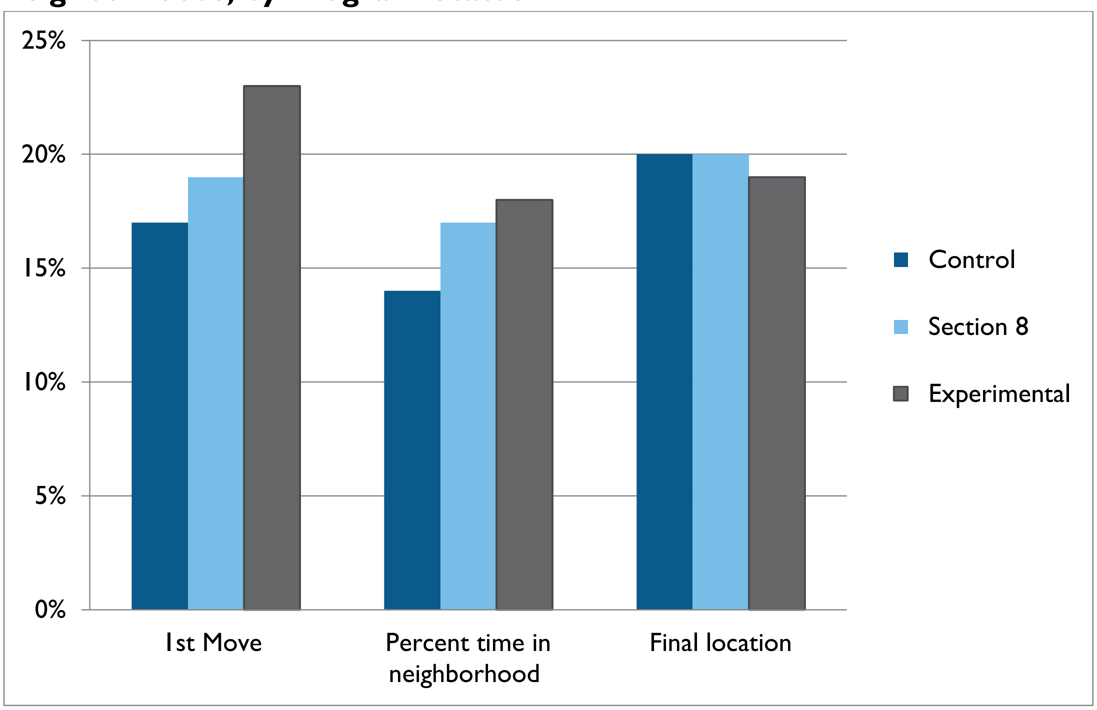
Our analysis reveals findings in a number of important areas for participants in the MTO program, which may be applicable to urban, low-income adults more broadly. Our findings can be broadly summarized in three categories: the spatial location of jobs, the residential location of program participants relative to both employment opportunities and transit, and the measures by which we calculate both of these important measures of opportunity.

Spatial Location of Program Participants Relative to Jobs

Households in the control group live in neighborhoods in closer proximity to jobs than households in either the Section 8 or the experimental (MTO) groups. Public housing tends to be located in central-city areas in close proximity to downtown (Crump 2002; Wilson 2012). Although jobs have decentralized, central-city neighborhoods typically remain the largest areas of concentrated employment within metropolitan areas (Shen 2001).

While control-group households live in close proximity to jobs, many of these positions are practically very difficult to obtain because there tends to be intense competition for job openings in dense central-city neighborhoods. Therefore, an improved measure of "job access" controls for the relative competition for jobs. Using this measure, we find that a higher percentage of households in the experimental group initially find employment in high job-access neighborhoods compared to households in the control and Section 8 groups. Further, households in the experimental and Section 8 groups spent more time in high job-access neighborhoods than households in the control group. However, as figure 11 shows, by the end of the program, the differences narrow when approximately one fifth of households in all three groups live in high job-access neighborhoods. Finally, by the end of the program, fewer households in the experimental group live in high job-rich neighborhoods compared with their neighborhoods at lease-up. This finding suggests that the effects of the MTO program on moving adults to areas of better job opportunity were short-term, at best.

Figure 11. Percent of MTO Program Participants in High Job-Access Neighborhoods, by Program Status



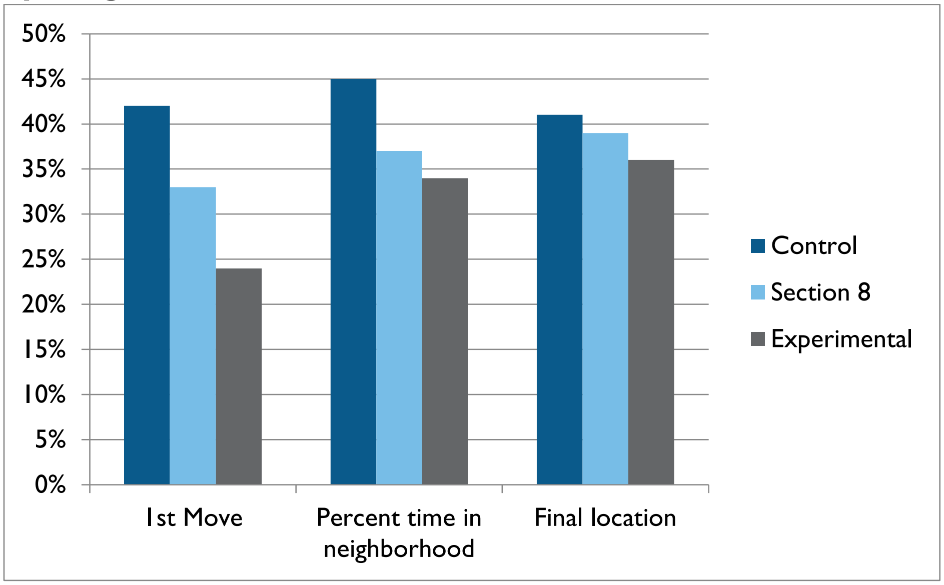
Sources: HUD and Google.

Spatial Location of Participants Relative to Public Transit

We use three measures to examine the transit characteristics of the neighborhoods in which program participants live—walk times to transit, service frequency, and jobs accessible by public transit. To summarize our findings we focus on the last measure, because—at least in theory—job access by public transit incorporates both the time it takes to walk to a transit stop or station as well as how quickly transit users can board a bus or train.

As depicted in figure 12, our analysis shows that residents in the control group are much more likely to live and remain in transit-rich neighborhoods. This finding holds true for all three measures—at lease-up, percent of time in transit-rich neighborhood, and at the close of the program. As mentioned previously, both jobs and transit networks are highly concentrated in central-city neighborhoods, where, as discussed, public housing tends to be located. Over time, households in the experimental group are more likely to live in neighborhoods that are transit rich. Since our transit data do not change over time and, therefore, do not incorporate changes in levels of transit service over time, this finding likely reflects the relocation decisions of families in the experimental group.

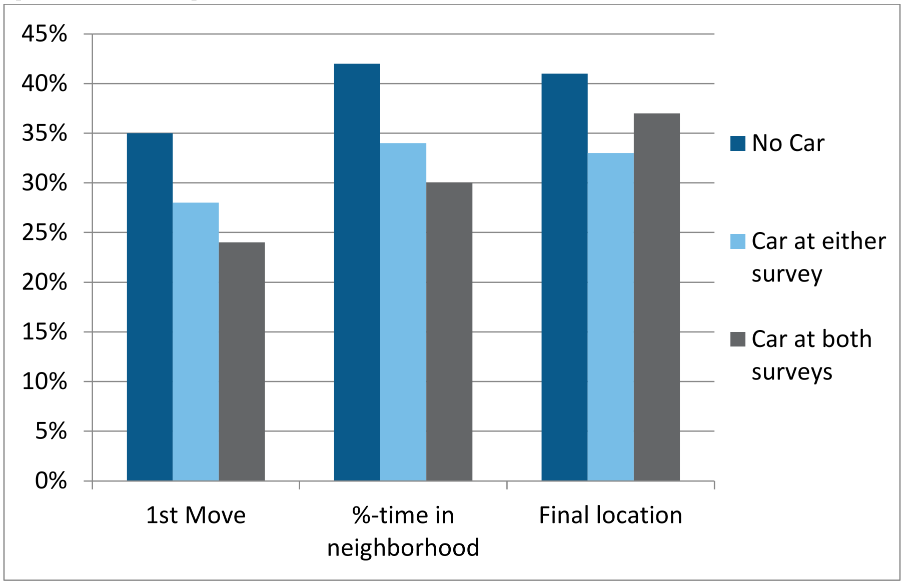
Figure 12. Percent of MTO Program Participants in Transit-Rich Neighborhoods, by Program Status



Sources: HUD and Brookings Institution.

There is a strong relationship between automobile ownership and residential location that runs in both directions (Pinjari et al. 2007; Schwanen and Mokhtarian 2005). As figure 13 shows, households without automobiles are more likely to reside and stay in transit-rich neighborhoods since they tend to be reliant on the transit network for their mobility, a finding consistent with the broader literature (Glaeser et al. 2008). However, by the end of the program, households in all three groups are more likely to live in transit-rich neighborhoods than they were at lease-up.

Figure 13. Percent of MTO Program Participants in Transit- Rich Neighborhoods, by Availability of Automobile



Sources: HUD and Brookings Institution.

Measurement Issues

There are many measurement issues that ought to be the subject of additional data collection and research. First, our findings are only as good as the data on which they are based. The evidence suggests that transportation—particularly access to automobiles—can play an important role in residential location decisions and economic outcomes. Yet the data available to analyze participants' access to transportation (both automobiles and public transit) are quite limited. MTO participants were asked a simple yes or no question regarding their access to automobiles. At baseline they were asked whether "they had a car that runs" and in the final survey they were asked whether they "own a car or truck, or other motor vehicle that runs and can be driven on the road." The exact question differed slightly over time. However, more importantly, automobile ownership is not a simple yes or no dynamic. A much better measure would have been the relationship between the number of working automobiles in the household and household drivers. Many low-income adults live in auto-deficit households, households in which there is less than a one-to-one ratio between vehicles and drivers. Adults in these households may not have reliable access to vehicles.

The job access and transit measures also are limited. Historical data on both jobs and transit service are scarce. Due to limitations with the census travel data, we used data from Google to calculate job richness and job access. However, these data are from 2013, and therefore do not match the years in which we have MTO survey data. Further, our calculations depend on Google drive times for the MTO areas and census data on employment; they could be enhanced by incorporating better estimates of employment competition (which would require data from areas well outside our metropolitan areas of interest) as well as travel by transit. We calculate a competition-based measure of jobs accessibility by car by employing the Google drive time data and the 2000 Census Transportation Planning Package's estimates of job locations by census tract. We calculate the number of jobs that an individual living in a given census tract could access within 30 minutes' drive time, but divide the number of jobs in each tract by the number of workers who could reach those same jobs in 30 minutes' drive time. We borrow this methodology from Shen (1998) and others. While we improve on standard methods of calculating this metric by including competition from outside the metropolitan area, in some cases (particularly in the Baltimore's metropolitan area, which overlaps considerably with Washington, DC, and Philadelphia), we expect some error on the urban fringe.

Our analysis of transit supply rests on relatively current data from the Brookings Institution which, again, does not match the years in which we have MTO survey data. Also, while very useful, cross-sectional data do not allow us to examine changes in the transit network over time. However, many metropolitan areas expanded their transit systems over the course of the MTO program (American Public Transit Association 2013). From the beginning of the MTO program in 1994 to the end of the program (sometime between 2008 and 2010), transit agencies increased the number of vehicle miles operated by over 50 percent.

Access to public transit is an important factor in the residential location decisions of families without automobiles (Glaeser et al. 2008). However, there is relatively little research on the qualities of public transit that residents believe are important. Handy and Niemeier (1997, 1176) state that "a practical definition of accessibility must come from the residents themselves, rather than from researchers, and reflect those elements that most matter to residents." Yet we do not know how low-income travelers evaluate the various characteristics of the transit network and how much these public transit characteristics differ even within a single neighborhood. For example, some low-income residents may live in neighborhoods close to transit stops, but where service frequencies are low or travel times to employment are lengthy.

Finally, residents' perceptions of the transit system may also be quite different from the actual characteristics of the transit system. The MTO survey includes a question on self-reported walk time to a bus stop. This variable is only loosely correlated to the Brookings data on walk time to transit (.10). This weak relationship suggests that individuals do not necessarily experience neighborhoods in the same way that aggregate, tract-level statistics would lead us to believe in isolation. Moreover, the relationship may also be skewed by respondents who have little experience using public transit, and therefore have little basis for assessing the walk time to the stop.

Opportunity Neighborhoods

Finally, there is an important caveat to any analysis of opportunity based on our findings. Neighborhoods are complex and even seemingly clear notions of opportunity along one dimension (e.g., job opportunities) may be offset by other neighborhood characteristics that limit the opportunities available to program participants and other low-income families. Future programs need to consider a range of opportunity indicators. Moreover, additional attention should be given to facilitating households' interest in remaining in neighborhoods with a rich variety of opportunities, the cumulative effects of which may only accrue after a lengthy duration rather than a short spell.

Transportation and Employment Outcomes

In this section, we examine the influence of transportation assets on the employment outcomes of MTO and WTW participants. We supplement the survey data with information on the characteristics of the neighborhoods in which program participants live, including their access to public transit. Combined, these data provide a rich array of individual, household, and neighborhood characteristics allowing us to control for the many factors that influence employment. Specifically, we use multinomial logistic regression models to examine the relationship between automobiles and public transit availability on employment transitions between baseline and interim surveys, controlling for other potential determinants of employment, including experimental group status.

The employment models are similar in many respects. However, there are a few differences, one of which is the way in which "automobile access" is specified. The MTO data allow us to examine transitions in automobile access between baseline and interim surveys. Therefore, our models include the following variables: no car at both time periods, gained a car between baseline and follow-up survey, lost a car between baseline and follow up, and the presence of a car at both time periods. In contrast, as we mention previously, in the WTW follow-up survey, the automobile question was asked only of respondents who indicated that they were employed. Because we did not have follow-up automobile data for all participants, we were unable to capture transitions in automobile access. Instead, the WTW employment model includes access to an automobile at the time of the baseline survey.

MTO Results

Table 10 presents the results of a regression model predicting discrete change in employment for all adults in the sample. We report the relative risk ratios and robust standard errors. The relative risk ratio is the probability of choosing one outcome category over the probability of choosing the base category for a unit change in the predictor variable. Our model specifications explain a moderate amount of the variation in employment outcomes, in comparison to similar auto-employment models and our own analysis of the WTW voucher dataset. Low levels of prediction for individual outcomes, particularly among vulnerable population groups, are common for other similar studies reported in the literature. In our primary model specification, exactly half of the predictions are correct. We predict consistent unemployment and job gain best, and loss of a job very poorly.

Table 10. Employment Model (Base = Not Employed → Not Employed)

Independent variables	Not employed→ employed	Employed→ not employed	Not employed→ employed
Individual characteristics			
Age	+	NS	+
Age^2	-	NS	-
Male	NS	NS	NS
Black	NS	NS	+
Hispanic	-	NS	NS
Other race	NS	NS	NS
High school graduate	+	NS	+
Household characteristics			
Household size	NS	NS	NS
Aid to families with dependent children	NS	-	-
Supplemental Security Income	-	-	-
Moved between baseline and interim	NS	NS	NS
Program Status [excluding control group]			
Section 8	NS	NS	NS
Experimental	NS	NS	NS
Transit access			
Improved public transit between baseline and interim	NS	NS	+
Live < 15 minute walk to transit (self-	NS	NS	+

reported)			
Automobile access [excluding no car]			
Gained car between baseline and interim	+	NS	+
Lost car between baseline and interim	NS	NS	+
Had car at baseline and interim	+	NS	+
Neighborhood Characteristics			
Job access (relative to metropolitan statistical area)	NS	NS	NS
Poverty rate	NS	NS	NS
Population density	NS	NS	+
Metropolitan Area [excluding Los Angeles]			
Baltimore	+	NS	+
Boston	NS	NS	NS
Chicago	+	NS	+
NYC	+	NS	NS

Source: Authors' analysis.
Notes: NS = not significant at .05 level; + = positive and significant at .05 level, **-** = negative and significant at .05 level. *N*=3,199. R^2=.17. Significance: < .10.

For the independent variables of interest, gaining a car between baseline and interim and maintaining access to a car at both time points are positively and strongly correlated with finding employment and being employed at baseline and interim. The effect of the presence of a car raises the probability of finding a job by a factor of two and the probability of being employed at both time points by a factor of four. While improved transit access is not a significant factor in finding employment, it appears to be the most important factor associated with being employed at both time points. Having moved to a neighborhood with better transit between baseline and interim and living within 15 minutes of a bus stop both raise the probability of having consistent employment by a factor of 14. As other studies have shown, experimental group status has no discernible effect on participants' ability to find or keep work.

Neighborhood characteristics also appear to be weakly correlated with employment outcomes, after we control for individual and household attributes. With one exception, the presence of a high number of jobs near the census tract, the poverty rate of the census tract, and the residential density of the tract are not associated with employment. Higher density is correlated with having employment at both time periods. Metropolitan-level effects are stronger than neighborhood associations, but mixed. Compared with participants in Los Angeles (the excluded group) participants in Baltimore and Chicago were more likely to both obtain a job and retain a job over the survey period, although the significance of the relationship in Chicago was weaker. The variable New York (participants living in New York) also exhibited a relationship to gaining employment (which was statistically significant at the .10 level).

We also estimated similar employment models only for those adults living in households without cars. The sample size in these models is reduced by less than one-fifth, because there were few households with cars at baseline, and as a result, the model's fit is slightly lower, correctly predicting 44 percent of the cases. Similar to the full model, transit— as measured by both self-reported bus access and households moving to neighborhoods with better service between baseline and interim— has a large positive effect on retaining employment. Both of these measures raise the likelihood of being employed at both time points by a factor of 10. Improved public transit also has a negative but nonsignificant effect on gaining employment. Individual and household-level characteristics largely operate as in the full model, but with some demonstrating attenuated correlation to employment. Experimental group status is not correlated with work outcomes in any significant manner. At both the neighborhood and metropolitan scale, access to jobs and the surrounding poverty level have no effect on employment, while density continues to play a positive role in individuals' retention of work at both time points. Living in Baltimore continues to have a positive relationship with gaining and keeping employment, but there are no other discernible metropolitan impacts on participants' work status.

WTW Results

Table 11 presents the results of a model predicting the discrete change in employment for all adults in the WTW sample. As in table 9 above, we report the relative risk ratios and standard errors, along with a measure of model fit.

In comparison with those who are not fully employed at the baseline and follow-up surveys, access to an automobile has a significant, positive effect on the likelihood of adults going from unemployment to employment and the likelihood of adults remaining employed at the two time points. For adults employed at both time points, relative risk ratios indicate that automobile access is the most important determinant. Improved transit between baseline and follow-up surveys is not significantly related to employment outcomes. Public transit may not effectively connect low-income workers to jobs. However, it may also be true that public transit—particularly in the WTW metropolitan areas—does not provide enough service to adequately connect voucher recipients to employment opportunities. Finally, it is possible that households with characteristics that make it more difficult for them to find employment are more likely to move to and live in transit-rich neighborhoods.

In response to the levels of transit service hypothesis, we explored whether there was a relationship—or interaction—between our public transit measure and metropolitan area. In other words, might there be a positive effect of public transit on employment outcomes in metropolitan areas that provide more extensive transit service? Indeed, we find some variation by metropolitan area. Relative to program participants in Atlanta, moving to transit-richer neighborhoods has a negative effect on employment. Although tentative, this finding suggests that public transit may be more effective in connecting low-wage workers to employment opportunities in some metropolitan areas than others. These results should be interpreted with caution as the sample sizes for participants who moved to transit-richer neighborhoods in some of the metropolitan areas, particularly Spokane, are quite small. Moreover, relative to Augusta, Fresno, and Spokane, Houston also has a more developed transit network, yet the interaction term is negative.

In terms of neighborhood characteristics, job access is significantly and positively related to unemployment. Unexpected, this finding may suggest the presence of high job turnover among low-income adults, or may simply show the positive role that job access plays in an adult having had a job at any point in time, as opposed to never having had a job. Jobs access is not significantly related to employment at baseline and follow-up, whereas poverty rates are negatively related and population density is positively related to steady employment. Finally, there is significant variation in employment outcomes across metropolitan areas. In comparison with adults living in Atlanta, adults in Fresno, Houston and Spokane were less likely to find employment. Moreover, adults in Augusta, Houston and Spokane were less likely to be employed at both time points, though with varying degrees of significance.

Table 11. Model 1—Aggregate Employment Model (Base = Not Employed→ Not Employed)

Independent variables	Not employed→ employed	Employed→ not employed	Employed → employed
Individual characteristics			
Age	NS	NS	+
Age^2	NS	NS	-
Male	+	NS	+
Black	NS	NS	NS
Hispanic	NS	NS	NS
Other race	NS	NS	NS
High school graduate	+	NS	+
Household characteristics			
Household size	NS	NS	NS
Public housing	NS	NS	NS
Welfare	NS	-	-
Supplemental Security Income	-	-	-
Moved between baseline and follow-up	NS	NS	NS
Improved public transit at final	NS	NS	NS
Experimental group	NS	NS	NS
Automobile access	+	+	+
Job access relative to metropolitan statistical area	NS	+	NS
Neighborhood Characteristics (by tract)			
Poverty rate	NS	-	-
Population density	NS	NS	+
Metropolitan Areas [excluded=Atlanta]			
Augusta	NS	NS	-
Houston	-	-	-
Fresno	-	NS	NS
Spokane	NS	NS	-

Source: Authors' analysis.
Notes: NS = not significant at .05 level; + = positive and significant at .05 level, - = negative and significant at .05 level. *N*=3,199. R^2=.17. Significance: < .10.

We also estimated a separate model that replicates the aggregate model but includes only those program participants in households without access to automobiles. The independent variables operate very similar to the full specification, but in this model there is a positive relationship between being employed at both time points and jobs access. In other words, among adults without automobiles in the household, the likelihood of employment at any point in time is higher among those with access to more local jobs. Transit access, however, still does not appear to play a significant role in improving employment outcomes. Although the models control for a number of individual and household characteristics, it is likely that the transit variable reflects other characteristics of carless individuals that make it more difficult for them to find and retain employment.

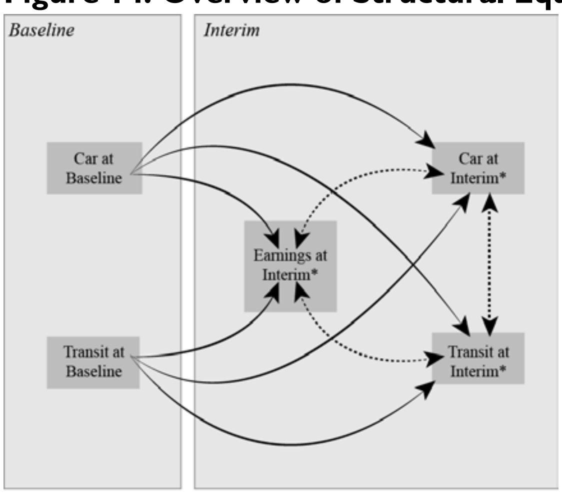
Finally, we considered the determinants of employment for participants in two of the metropolitan areas in our sample, Fresno and Houston, by running separate, metropolitan-level models. Descriptive evidence from the sample suggests that there are major demographic differences across these two areas. Namely, adults in Fresno are much more likely to be Hispanic, have access to automobiles, and be employed at baseline than adults in Houston. Among the adults living in the Fresno sample, there is a positive relationship between automobiles and both gaining employment and staying employed. In Houston, however, there is no apparent relationship between automobiles and transitions to employment. There is, however, a positive relationship between automobile access and maintaining employment at both time points. For public transit, this variable is not significant in either metropolitan area.

Automobile Ownership, Transit Accessibility, and Earnings

In this section, we take advantage of longitudinal data from the MTO program to examine the role of transportation in improving outcomes for MTO households. In particular, we examine the relationship between automobile ownership, residential location in transit-rich neighborhoods, and earnings. We are also interested in the effect of program status (being in the experimental group) itself on all three out of these outcomes. Because we expect that the relationships between these outcomes are themselves interrelated, we employ structural equation modeling, which allows the researcher to posit more complex, interrelated pathways of causation than other modeling approaches.

We depict our structural equation modeling approach in figure 14. Our conceptual model rests on the assumption that access to transportation resources—cars and high-quality public transportation—can increase an individual's probability of employment and enhance earnings by expanding the geographic scope of the individual's job search and improving punctuality and reliability. However, in the US context, the two transportation options we examine—cars and transit—are typically substitute goods for the journey to work. Therefore, we expect that individuals—particularly low-income individuals looking to economize—would make trade-offs in selecting between the two. We therefore expect car ownership and transit richness to both be positively associated with earnings, but negatively associated with one another. We further expect car ownership to be more strongly associated with earnings than transit access, as previous studies have found (Cervero et al. 2002; Gurley and Bruce 2005; Sandoval et al. 2011).

Figure 14. Overview of Structural Equation Modeling Approach



Source: Authors' analysis.
Note: Dashed lines indicate modeled covariance of error term.
*Also controlled for randomization group, race/ethnicity, age, sex, and employment at baseline. The earnings submodel includes additional controls: years of education and having not moved residences by interim.

As depicted on the left side of the diagram, we use characteristics of the individual at the time of the baseline MTO interview (roughly 1994 to 1998), as well as a series of time-invariant variables such as race or ethnicity, gender, and randomization group to predict our three outcomes of interest at the time of the

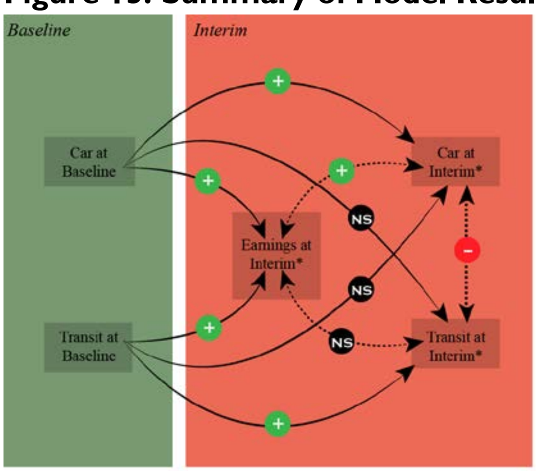
MTO interim interview. These outcomes are: automobile ownership, the transit richness of the respondent's home census tract, and the respondent's self-reported earnings. Most of these data are derived directly from the MTO baseline and interim surveys. For example in the baseline and interim surveys, households were asked whether they had a car that ran. We use administrative records attached to the interim dataset to determine whether the household had not moved by the interim survey.

We supplement the information on individuals and their households with data on public transit service in the neighborhoods in which program participants live. A census tract identifier allowed us to match the survey data to census tract-level data on public transit from the Brookings Institution. Between May 2009 and February 2011, researchers at the Brookings Institution collected data on the routes, schedules, and stops for 371 agencies located in the 100 largest metropolitan areas. They combined these data with employment data to develop a number of different measures of transit access including the number of jobs available in a 30-minute transit trip from a given census tract. We use these data measuring transit richness as a Z-score using the regional mean of jobs accessible by transit in thirty minutes; thus, a one-unit increase in our "transit richness" metric indicates a (region-specific) standard deviation increase in jobs accessible by transit in thirty minutes.

We also relate the three outcomes measures to one another in the overall modeling approach. We estimate a covariance parameter for the error covariance of each of the submodels. This approach assumes that the unobserved variables that help to explain car ownership, choice of residence in a transit-rich neighborhood, and earnings co-vary in meaningful ways. For instance, those who have a preference for owning a car also choose to live in a neighborhood with ample parking and lower levels of transit access.

Figure 15 summarizes the results of our model, focusing on the variables of interest. Having owned a car at the time of the baseline interview is a strong predictor of owning a car at the interim interview, perhaps reflecting both the likelihood of retaining a valuable asset such as an automobile as well as individuals' preferences for automobile ownership. Similarly, having a job at baseline is a strong predictor of automobile ownership several years later, reflecting the need for employment to cover the financial costs of car ownership.

Figure 15. Summary of Model Results



Source: Authors' analysis.
Note: Dashed lines indicate modeled covariance of error term.
*Also controlled for randomization group, race/ethnicity, age, sex, and employment at baseline. The earnings submodel includes additional controls: years of education and having not moved residences by interim.

Only two variables are statistically significant predictors of living in a transit-rich neighborhood. Being a member of the control group for random assignment has a strong positive association with transit richness at the time of the interim survey. The control group in the MTO experiment did not receive Section 8 vouchers, and thus most participants remained in traditional public housing, which is often located in transit-rich, inner-city areas, or left housing assistance altogether for one reason or another. The only other significant predictor of transit richness at interim is transit richness at baseline. This relationship may reflect individuals' transit preferences and the "lumpiness" of transitioning to transit's main competitor, the automobile (through vehicle purchases and licensing). It also may be because of the high financial and social costs of moving to a new neighborhood. With respect to this last point, voucher households can experience difficulty moving out of their current neighborhoods because of limited resources, landlord practices, and institutional obstacles associated with the voucher program (DeLuca et al. 2012).

Access to transportation at baseline appears to make a difference in earnings several years later. Both automobile access and transit richness in the home census tract at the time of the baseline interview are statistically significant predictors of higher earnings. However, the earnings effect for owning a car is considerably greater than the effect of transit richness. Our results suggest that one would have to live in a neighborhood nearly eight standard deviations above the mean regional transit richness to achieve the same estimated effect on earnings as owning a car. Our model further suggests that the effect of living in a transit-rich neighborhood is similar for those individuals with and without cars.

Finally, we find that the error terms of our earnings and transit richness models are both correlated with that of the car ownership submodel. This suggests that omitted variables that are associated with higher earnings but difficult to measure (such as perseverance, intelligence, a highly developed social network, or other factors) are also associated with automobile ownership. Similarly, the model results suggest that there are clear trade-offs between the choice to own a car and the choice to live in a transit-rich neighborhood. Controlling for a host of other factors, those who are more likely to choose one of these transportation options (for instance, buying a car) are considerably less likely to choose the other (for instance, living in a very transit-accessible neighborhood). This relationship likely reflects both attributes of the person (preference for one mode over the other) as well as a host of unobserved factors associated with living in a particular neighborhood. For instance, if a person lives in a transit-poor neighborhood in order to be close to friends and family, that person may be more likely to purchase a car as well.

Summary: Influence of Transportation and Location Choice on Economic Opportunity

In this section, we analyzed the relationships among various transit measures, and using robust measures of transit access and vehicle access, we examined the relationship between transportation access and transitions into and out of employment. We also considered the relationships among transportation access, residential location choice, and earnings. Here we summarize the primary findings from these analyses.

In our analysis of access opportunity neighborhoods, we find that transit and job opportunity metrics are largely incongruent, even when data for these metrics are collected contemporaneously by the same organization. Discernible trends in the data include better job richness but worse job access among the control group and those without cars, although this disparity appears to attenuate by the time of the final survey. We are surprised to find that access to public transit is not notably better among those without cars or among the control group, and in fact service frequency sometimes appears discernibly worse.

We also used several multinomial logistic regression models to investigate the relationship between public transit and automobile access on transitions into and out of employment. In models estimated for MTO households, we find that keeping or gaining access to automobiles is positively associated with the likelihood of employment. Improved access to public transit is positively associated with maintaining employment but not with transitions to employment. Consistent with previous MTO program evaluations, we find that experimental group-status is not statistically significant.

In models examining the influence of baseline access to automobiles and public transit on follow-up employment for WTW households, we find that baseline access to automobiles has a strong positive relationship to follow-up employment, but transit access does not. While there are substantial differences in employment rates across metropolitan areas, the determinants of employment outcomes are largely consistent across the metropolitan-specific models. These findings suggest that enhancing car access will notably improve the likelihood of employment among very low income adults, but investments in transit in areas with concentrated poverty will only have, at best, marginal effects.

Finally, we examine the effect of transportation resources on earnings outcomes for MTO participants using a structural equation modeling approach to examine the interrelationships among automobile ownership, residential location in transit-rich neighborhoods, and earnings. We find evidence that both cars and transit access have a positive effect on earnings, though the effect for auto ownership is considerably greater. We also find evidence that low-income households make trade-offs between owning a car and living in a transit-rich neighborhood. We find little evidence that participation in the MTO experimental group influenced transportation decisions or earnings.

Taken together, these findings show that automobile access importantly influences employment outcomes and earnings for low-income households. The effects of public transportation are mixed, likely because of the substantial variability in transit coverage among the metropolitan areas included in the study. Moreover, we find that access to automobiles is more important that assignment to the MTO or WTW experimental group. In the next section, we discuss the implications of these findings and those discussed above for expanding low-income households' access to economic opportunities.

Conclusion and Policy Implications

In this study, we examined the interrelationships among transportation assets, residential location choice decisions, and economic outcomes for housing choice voucher recipients broadly and for those participating in the MTO and WTW experimental programs. Our analyses point to several implications for future research and data collection efforts, voucher-enhanced mobility programs, and strategies for coordinating housing and transportation policies in ways that enhance economic opportunity for low-income households.

Several findings presented above suggest that HUD would be well advised to learn more about whether all their assisted tenants have access to working cars. Collection of such information would be possible, though potentially controversial, annually as part of the income verification process. Tenants might have concerns that housing agencies would disqualify them for assistance if they revealed that they own a car. But car ownership provides both access to better neighborhoods and a way to get to work and better schools. If HUD knew which of its households had cars, it could develop new programs and partnerships to help able families become economically self-sufficient. Information about car access could also be helpful for identifying neighborhoods where assisted families with cars are living so that new economic development efforts could concentrate there, including affordable options for car maintenance, and educational opportunities for courses in auto mechanics, for example. It is clear that even in high-density, transit-rich cities, voucher users—like many other low-income people—make huge sacrifices to get and maintain car access. Housing and community development policies and programs can be shaped so that the needs of assisted households with and without cars are accounted for individually.

Our findings also have implications for policies designed to enhance "access to opportunity" for low-income households. Our results imply that housing search services should be tailored to the transportation needs of households receiving assistance. Transporting those without access to a car to prospective residential locations along with providing information about the public transportation options available in different neighborhoods may help to improve the number and quality of units inspected prior to a housing search. This policy recommendation is echoed by Shroder (2002), who finds that car ownership and the intensity of housing counseling services both increase the likelihood of lease-up among MTO program participants. He goes on to argue that while providing long-term transportation services may be expensive, combining such assistance with other educational programs may go a long way towards increasing the rate at which mobility program participants successfully lease-up in desirable neighborhoods.

Currently, the provision of transportation-based services is an integral component of the WTW program but has been less of a focus for the MTO program. HUD provides guidance to public housing agencies participating in the WTW program regarding ways in which to tailor services to the transportation needs of households receiving assistance. The HUD website also provides information about how to coordinate housing assistance with the various local transportation programs sponsored by nonprofits, transit agencies, and the business community.[17] But HUD's role in this effort is primarily advisory, with local public housing agencies playing the lead role in designing such programs.

An implication of our findings is that combining rental vouchers with subsidies for automobile purchases may be one possible approach to expanding the location choices available to low-income households. Alternatively, short-term car rental services such as ZipCar and Car2Go have the potential to address the travel needs of some low-income adults at a lower cost. (See, for example, McCarthy [2012] and Ortega [n.d.]). These services may be particularly useful to households with at least one licensed driver but who do not have sufficient assets to own and maintain a car. Coordination of housing voucher assistance with nonprofit car donation services and rideshare services is a third possibility[18]. Of course, the trade-offs of such policies are that additional car-based travel will exacerbate the negative externalities associated with auto use, including congestion and air quality degradation. Furthermore, car ownership itself entails costs that accrue directly to owners, which may place undue burdens on low-income families. These trade-offs should be considered with any auto-based mobility strategy.

The importance of automobile access may also reflect the inadequacy of public transportation service in meeting the needs of many low-income households. Our research examining the link between transportation assets and employment transitions for MTO households suggests that while automobile access has the largest impact on transitions to employment, policies to enable households to move to transit-rich neighborhoods can also help participants' retain employment.

Despite these findings, there are few federal programs aimed at helping low-income families gain access to automobiles and some programs actually act as barriers to gaining such access. Post–welfare reform, policymakers turned to transportation as a strategy for rapidly moving welfare recipients and other low-income adults into the labor market. In 1998, Congress passed the Job Access and Reverse

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[17] "Supportive Services Resources – Welfare to Work Vouchers," US Department of Housing and Urban Development, accessed February 14, 2014, http://www.hud.gov/offices/pih/programs/hcv/wtw/resources/bs10/transportation.cfm#1.

[18] See National Economic Development Law Center (2007) and "Working Cars for Working Families," accessed February 14, 2014, http://www.workingcarsforworkingfamilies.org/.

Commute program, one component of the Transportation Equity Act of the 21st Century (Stommes et al. 2002). Additionally, other federal agencies—US Departments of Health and Human Services, Housing and Urban Development, and Labor—made resources available to provide transportation for welfare recipients and other low-wage workers. However, these efforts focused on public transit and, in particular, strengthening transit connections from center cities to suburbs. In the absence of building extensive transit networks which are fiscally impracticable in all but the densest US metropolitan areas, our study suggests that cars present a more viable means of connecting low-income workers to jobs. To be effective, federal strategies should be coordinated with local and state approaches. While most states have lifted or eased vehicle asset limitation rules that previously had limited welfare recipients' ability to own (reliable) automobiles, some states still maintain asset limits (Kassabian et al. 2012).

As new transportation legislation is being debated, and social equity concerns are playing a more prominent role in the design of federal transportation policy, perhaps it is time to better coordinate federal housing and transportation programs in ways that enhance the upward mobility of low-income households. The Sustainable Communities Partnership between HUD, the Department of Environmental Protection, and the Department of Transportation is one example of such coordination. Our findings lend support for additional programs such as these that consider social mobility more broadly, emphasizing the role of transportation access as it affects both residential mobility and economic mobility.

Finally, our findings call for a more nuanced reframing of the geography of opportunity debates. In our descriptive sorting analysis, locational attainment models, and descriptive characterization of access opportunity neighborhoods, we find that low income HUD-assisted households make trade-offs among different neighborhood characteristics. Areas with high-performing schools, access to open space, and a lower risk of environmental contamination may have inadequate transportation systems, have less accessibility to jobs, and have an increased risk of exposure to automobile emissions. Furthermore, households at different life-cycle stages and with different levels of access to transportation value each of these amenities differently. Given the spatial heterogeneity of preferences and opportunity structures, our findings call for an expansion of housing assistance services that are tailored to the particular needs of individual households. Thus, the goal of "moving to opportunity" may be more usefully phrased as "moving to opportunities."

As promising as these findings about car ownership may be, more research is needed on the relationship between cars and other outcomes. A full accounting of the effects of car ownership on neighborhood choices would require a methodological approach accounting as fully for self-selection into car ownership as MTO tried to do for self-selection into low-poverty neighborhoods. Undoubtedly, families with access to cars differ in unmeasured ways from those without access to cars. Neither experiment "treated" voucher-assisted households with auto access, denying access in an experiment to a control group. Many of the factors that would lead a household to secure access to a car could also motivate moves to good neighborhoods and to get and keep jobs. For the present, therefore, our results on car access must be treated as preliminary and promising.

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Appendix A. Indicators, Labels, Descriptions, and Sources

Table A.1. Indicators, Descriptions, and Sources

Indicator	Description	Source
Natural environment		
Land within buffer of TRI site (%)	Total buffer area of TRI facilities within 1 mile in a given census tract divided by area of the census tract	EPA Toxic Release Inventory 2000
Log of cancer risk score	The sum of all carcinogens in assessment and individual pollutant contributions to total risk, multiplied by 1 million	2002 National-Scale Air Toxics Assessment
Land within 200m of major highway (%)	Total buffer area of major highways within 200 meters in a given census tract divided by area of the census tract	Authors' analysis using 2000 US census TIGER files,
Land developed as urban uses (%)	Total developed areas with low, medium, and high intensity including open space in a given census tract divided by area of the census tract	National Land Cover Database 2001
Functional environment		
Housing market strength factor	The first factor score resulting from authors' varimax rotation of vacancy rate, percent owner-occupied units, and median gross rent	2000 US census, SF3
Vacancy rate	Vacant units, except those held for seasonal or occasional use or for farmworkers, divided by total housing units in the census tract	2000 US census, SF3
Owner-occupied housing units (%)	Number of owner-occupied units divided by total number of housing units in 2000	2000 US census, SF3
Median gross rent ($)	Median gross rent in 2000	2000 US census, SF3
Housing diversity factor	The first factor score resulting from authors' varimax rotation of diversity index of structure type, housing density, and median housing age	2000 US census, SF3
Diversity index of structure type	See table description below	2000 US census, SF3
Housing density (units/acre)	Average number of housing units per acre on blocks in a given census tract, excluding blocks with no housing units	2000 US census, SF3
Housing 50+ years old	Percent of year-2000 housing units built before 1950	2000 US census, SF3
Housing <11 years old	Percent of year-2000 housing units built in 1990 or later	2000 US census, SF3

FHEA transit access index	Score on a 1–100 index of the accessibility by bus or rail of retail, entertainment, recreation, food, and accommodations. For more information, see table description below.	HUD FHEA 2012 data
Social environment		
Poverty rate	Percent of persons in census tract with incomes below the poverty line	2000 US census, SF3
Social status factor	The first factor score resulting from authors' varimax rotation of percent non-Hispanic white, percent of households consisting of a single female with at least one child under 18, and percent of persons over 25 with at least four-year college degree in 2000	2000 US census, SF3
Non-Hispanic white (%)	Percent of population non-Hispanic white 2000	2000 US census, SF3
Female-headed households (%)	Percent of households that consist of an unmarried woman with at least one child under 18	2000 US census, SF3
Adults with college degree (%)	Percent of persons at least 25 years old with a four-year college degree or greater	2000 US census, SF3
Economic vitality		
Aggregate income per square mile	Aggregate household income (in 1999) divided by tract land area	2000 US census, SF3
Job density per square mile	Jobs as reported in the Census Transportation Planning Package part 2, divided by tract land area	2000 US Census Transportation Planning Package
Access to opportunity		
FHEA school performance index	Score on a 1–100 index of the average test scores of schools in or closest to the census tract. For more information, table description.	HUD FHEA 2012 data

Notes: TRI is Toxics Release Inventory; FHEA is Fair Housing Equity Assessment.

In table A.1, the diversity index is computed as

$$H_1 = -\sum_{i=1}^{s}\{(p_i)\ln(p_i)\,/\ln(s)\}$$

where H_1 is diversity, P_i is proportions of each of the eight housing structure types, and s is the number of structure types; in this case, s = 8. High values indicate high diversity of structure types.

As explained in the documentation to the August 2012 vintage Fair Housing Equity Assessment Database, which was distributed by HUD to its Sustainable Communities program grantees:

> HUD has constructed a transit access index where available data exists to support local analysis. HUD uses data on over 200 transit agencies that provide data through GTFS Exchange (http://www.gtfs-data-exchange.com/) to assess relative accessibility within metro areas (or balance of state). The appendix

contains a list of metropolitan areas where GTFS data was available and used. The GTFS- based accessibility index is designed to model relative accessibility to amenities via bus or trains within a metro. Because standardized data on the location of amenities is not uniformly available at a granular level, HUD uses the number of jobs in retail (NAICS 44-45), arts entertainment & recreation (NAICS 71), and food & accommodations (NAICS 72) as proxies for the magnitude of amenities at the block- group level from the Local Employment Dynamics dataset published by the census bureau. (For states without Work Area Characteristics les in the LED data, population was used as a proxy.) First, HUD identified the number of jobs in these sectors within 1=2 mile of each bus stop and 3=4 mile of each rail transit stop and summed them. Then for each trip in the transit system, HUD calculated a stop-specific measure of the additional amenities accessed in each ensuing stop on that route, which it then divided (deflated) by the additional travel time to each ensuing stop. Mathematically, this can be expressed in several terms.

Let (s_{ij}) represent the accessibility of stop i on trip j, a is the amenity radius of a stop (the total jobs mentioned above), and T is the marginal travel time with each stop. Each stop of each trip takes on a value equal to the sum of the amenity radius of each ensuing stop divided be the time to that next stop for all stops on a trip.

$$s_{ij} = \sum_{i}^{N} \frac{a_{i+1}}{T_{t+1}}$$

These stop-journey specific (s_{ij}) values are then summed over all journeys j (where a journeys in opposite direction are counted as two trips) made in 24-hours to create a single aggregate accessibility value for each stop in the system (where k is the total stops in the system).

$$A_i = \sum_{j}^{k} s_{ij}$$

To translate these stop accessibility values (A_i) to block-groups, HUD then calculates the distance between each stop and the population-weighted centroid of each block-group. The three highest accessibility stops within 3/4 of a mile are summed to generate a block-group value for accessibility. Finally, these values are placed into deciles (10-percentile) buckets within-metro or balance of state, and are scaled up by a factor of 10 to align with the other indices. Block-groups that are not within 3/4 of a mile of either a bus or transit stop are normalized to a value of 1, the lowest accessibility score. For communities with fixed rail, but no available GTFS data, HUD calculates a simple access measure as the distance of the block-group centroid to the nearest fixed-rail.

As explained in the documentation to the August 2012 vintage Fair Housing Equity Assessment Database, which was distributed by HUD to its Sustainable Communities program grantees:

The neighborhood school proficiency index uses school-level data on the performance of students on state exams to describe which neighborhoods have high-performing elementary schools and which have lower performing elementary schools. The proficiency index is a function of the percent of elementary school students proficient in read (r) and math (m) on state test scores for the *ith* school associated with the neighborhood (i = 1; 2; ... n)where N is the maximum number of schools in any block-group in the state-distribution, and school enrollment *s*:

$$School_i = \sum_{i}^{N} \left(\frac{s_i}{\sum^n s_i} \right) * \left[\frac{1}{2} * r_i + \frac{1}{2} * m_i \right]$$

Elementary schools are linked with block-groups based on a geographic mapping of attendance area zones from School Attendance Boundary Information System (SABINS), where available, or within-district proximity matches of up to the four-closest schools within a mile. In cases with multiple school matches, an enrollment-weighted score is calculated following the equation above.

Factor Analysis Results

We used factor analysis to develop three indices: housing market strength, housing diversity, and neighborhood socioeconomic status. We used common factor analysis, which creates a composite index from a selective series of measures predetermined to be related in a certain way; that is, we had already decided what the first "factor" represents. Therefore, we know that certain variables measure the concept of housing market strength, housing diversity and neighborhood socioeconomic status, and we use this method because we want to extract an index capturing where these variables intersect. We conducted the factor analysis separately for the MTO and WTW subsets (i.e., each factor analysis used five metropolitan areas). Factor patterns for each of these variables appear in table A.2.

The housing market strength factor extracts a single index from the vacancy rate, homeownership rate, and the standardized gross rent (i.e., contract rent plus utilities converted to a z-score within each metropolitan area to account for inter-metropolitan area differences). The first factor extracted by this common factor analysis explained 51 percent of the variance across the MTO cases and 50 percent across the WTW cases. Higher scores on the housing market strength indicate lower vacancy rates, higher homeownership rates, and higher median gross rent.

The housing diversity factor is a single index created by the first factor extracted from the structure diversity index described above; the housing density in the tract net of blocks without housing units; the percent of housing over 50 years old (i.e., built before 1950); and the percent of housing less than 10 years old (i.e., built since 1990). High scores indicate more diverse, denser, and older housing stock. The MTO housing diversity factor explained 55 percent of the variance across cases, and the WTW factor explained 58 percent of the variance.

The social status factor extracts a single index from the percent of the population that is white non-Hispanic, standardized within the metropolitan area using a z-score; the percent of persons with at least a high school diploma or GED; and the percent of families and subfamilies composed of an unmarried mother with at least one child under age 18. High scores indicate high levels on all these indicators, meaning that "low" social status is indicated by high scores on this factor. The MTO social status factor accounted for 80 percent of the variation across cases, and the WTW factor accounted for 76 percent of the variation.

Table A.2 Factor Patterns, Housing Market Strength, Housing Diversity, and Social Status Factors

	MTO	WTW
Housing market strength		
Vacancy rate	-0.285	-0.493
Owner-occupied housing units (%)	0.608	0.543
Z-score of median gross rent, by metropolitan statistical area	0.601	0.549
Housing diversity		
Diversity index of structure type	0.406	0.601
Average number of housing units per acre on blocks	0.386	0.522
Housing 50+ years old (%)	0.652	0.406
Housing less than 10 years old (%)	-0.471	-0.524
Social status		
Z-score of percent white alone, by metropolitan statistical area	0.871	0.847
Persons age 25+ high school diploma or GED (or greater) (%)	0.744	0.636
Female-headed families	0.572	0.612

Source: Authors' calculations using data from 2002 US census.