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Auto-Deficit Households:
Determinants, Travel Behavior, and the Gender Division of Household Car Use

Final Report

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INTRODUCTION

The automobile plays a central role in the mobility of most households since in almost all metropolitan areas and neighborhoods within them automobiles offer greater access to destinations within a reasonable travel time than other modes of travel. Consequently, scholars find a robust and positive connection between car ownership and a range of quality-of-life outcomes such as employment, earnings, and residential location in better quality neighborhoods.

American households exhibit extremely high levels of vehicle ownership; ninety-three percent of U.S. households own at least one automobile, while over 65 percent own two or more cars. However, while only 7 percent of households do not own a car, another 15 percent have fewer vehicles than drivers. Some "car-deficit" households may *choose* to share vehicles, perhaps successfully combining auto travel with travel by other modes. Other car-deficit households may share vehicles because their incomes prevent them from owning as many cars as available drivers. In these households, auto deficits may limit the mobility of household members and, potentially, their access to opportunities.

Regardless, all auto-deficit households must negotiate use of the household vehicle, potentially privileging some household members over others. Of the many factors that influence intra-household car sharing, an individual's sex is almost certainly one. Numerous studies demonstrate the importance of gender in travel behavior suggesting that it also plays a role in household-level decisions surrounding automobile access. The allocation of auto resources within households may be determined by four factors, of which gender may play an important role: (a) the relative economic position of spouses, (b) the costs associated with their travel (e.g. travel time), (c) the division of household labor, and/or (d) gender preferences and roles.

Despite being twice as common as zero-vehicle households, car-deficit households have received relatively limited attention from scholars, particularly U.S. scholars. In this study, therefore, we aim to fill this gap. To do so, we examine the following three questions:

1. Are car deficits, like carlessness, largely a result of financial constraint or of other factors, such as built environment characteristics, transit supply, or household structure?
2. How do the mobility outcomes of car-deficit households compare to the restricted mobility of carless households and the largely uninhibited movement of households with at least one car per driver?
3. What role does gender play in promoting or inhibiting access to household vehicles?

To examine these questions, we draw on household-level data from the California Household Travel Survey (CHTS). The CHTS provides detailed demographic and socioeconomic data from over 40,000 households across the state coupled with comprehensive, single-day travel data for each individual in the household. In total, the CHTS includes data on the travel behavior of over 100,000 people, and captures roughly 350,000 person-trips. To examine the role of residential location, we match households in the survey to data on the characteristics of the neighborhoods in which they live using a census-tract identifier.

What do we find? The biggest differences in the characteristics of households by vehicle ownership status occur when households move from carlessness to auto ownership. However, there are still statistically-significant differences between auto-deficit households and households with one or more vehicles per driver. Auto-deficit households tend to be larger, suggesting the need to coordinate household travel either in the form of carpooling or negotiating complementary use of the household vehicle. They are also more likely to live in dense urban areas where some household members might be able to take advantage of high levels of transit service. Finally, auto-deficit households also are more likely to have lower incomes. In general, income is negatively related to the likelihood of being auto deficit except at very low incomes when the mobility benefits of an additional car may not outweigh the ownership costs.

Auto-deficit households also have different travel patterns; they travel fewer miles, take fewer trips, and are more likely to use public transit. However, higher-income auto-deficit households travel a lot – more than twice as much as low-income auto-deficit households, reflecting their greater choice in residential location; in theory, household members can move to neighborhoods that accommodate their transportation needs and preferences. Low-income auto-deficit households travel almost as much as low-income fully-equipped households. Data on miles per household vehicle suggest that these households achieve this level of mobility by negotiating complementary use of the household car.

Finally, with respect to use of the car in auto-deficit households, we find that practical necessity—in particular, the amount of time that an individual spends on household-serving or work-related activities—is the primary determinant of automobile access. Traditional gender norms and gender preferences hypotheses predict that men, not women, would claim use of the household car. However, we find that women have substantially greater access to the household vehicle than their male partners. Women's advantage in automobile access stems from their disproportionate responsibility for household labor. Balancing paid and unpaid work requires women to accomplish a range of tasks that are particularly varied and complex and better suited to travel by automobile than other modes.

The findings suggest the importance of policies to help increase automobile access among households who do not have cars and who live in neighborhoods or have responsibilities that make it difficult to reach opportunities without driving. However, the additional benefits of being a fully-equipped household are more limited than we had anticipated. These results indicate support for policies to offset the potential difficulties of sharing household vehicles, particularly for low-income households. Finally, women need cars to manage their complicated work and household responsibilities. A more equal division of household responsibilities likely would mean a renegotiation of car use. A simplified schedule would allow women the opportunity to increase their use of modes other than the car and to benefit from their improvement.

Our analysis is organized in two parts. In Part I, we analyze car-deficit households, focusing on their determinants and implications for household travel. In Part II, we examine the role of gender in the intra-household allocation of household vehicles.

PART I. CAR-DEFICIT HOUSEHOLDS: DETERMINANTS AND IMPLICATIONS FOR HOUSEHOLD TRAVEL

With almost 85 percent of all trips in the U.S. taken by car, the preeminence of the automobile in American travel is unmatched (Federal Highway Administration, 2009). U.S. residents drive roughly 13,500 miles per year, and the private vehicle is the principal mode of transportation for virtually every trip purpose (Davis, Williams, & Boundy, 2016). The central role of the automobile is not surprising since in most metropolitan areas and in almost all neighborhoods within them, automobiles offer greater access to destinations within a reasonable travel time than other modes of travel (Shen, 2001). Consequently, scholars find a robust and positive connection between car ownership and a range of quality-of-life outcomes such as employment, earnings, and residential location in better quality neighborhoods (Dawkins, Jeon, & Pendall, 2015; Gurley & Bruce, 2005; Raphael & Rice, 2002).

American households exhibit extremely high levels of vehicle ownership: 93 percent of U.S. households own at least one automobile, while over 65 percent own two or more cars (Ruggles, Genadek, Goeken, Grover, & Sobek, 2017). Only seven percent of adults live in zero-car households. However, these households may represent only a small proportion of the population that potentially struggles with inadequate vehicle access. Approximately 15 percent of U.S. households have fewer automobiles than drivers (Federal Highway Administration, 2009). Some of these "car-deficit" households may *choose* to live with fewer cars than drivers, a decision celebrated by many urban planners seeking to reduce the negative environmental externalities associated with driving. For other households, having fewer vehicles than drivers may represent a *constraint*—the inability to afford the costs of buying and driving multiple household vehicles. Low-income households (households with incomes below $35,000) are more than one and half times more likely to have an auto-deficit than higher-income households (Federal Highway Administration, 2009). For these households, being "car-deficit" may result in substantial limitations on mobility as well as access to opportunities.

Despite being twice as common as zero-vehicle households, car-deficit households have received limited attention from scholars. In particular, crucial questions about the roots of car deficits and their implications for household travel remain unanswered. This research aims to fill this gap in the literature. In this study, we examine the following two questions. First, are car deficits, like carlessness, largely a result of financial constraint or of other factors, such as built environment characteristics, transit supply, or household structure? Second, how do the mobility outcomes of car-deficit households compare to, what we already know is, the severely restricted mobility of carless households and the largely uninhibited movement of "fully-equipped" households, which we define as households with at least one car per driver?

We find that car-deficit households *are* different than households that are fully equipped. They have different characteristics, travel less, and are more likely to use public transit. Many auto-deficit households have incomes that presumably enable them to successfully manage with fewer cars than adults. Low-income auto-deficit households—by definition—are income constrained. Our analysis suggests that they manage their travel needs by carefully negotiating the use of household vehicles. In so doing, they travel far more than carless households but almost as much as low-income households with one or more vehicles per driver. They also use their household

vehicles as much as higher-income auto-deficit households. These results suggest that the mobility benefits of being fully equipped are more limited than we had anticipated. Results also indicate the importance of transportation and employment programs to ease the potential difficulties associated with sharing cars among household drivers.

1. Household Access to Automobiles

1.1 Household income and car ownership. Income is the strongest determinant of vehicle ownership among U.S. households (Chu, 2002; Schimek, 1996). Consequently, zero-car households tend to be carless not by choice, but due to financial constraints (Brown, 2017; Klein & Smart, 2017; Mitra & Saphores, 2017). Yet even households with limited financial resources place high premiums on car ownership; data from the 2011-2015 5-Year American Community Survey show that more than 80 percent of individuals in poverty live in households with automobiles (Ruggles et al., 2017). Several studies note that the Earned Income Tax Credit, which provides low-income working families with a yearly lump-sum tax rebate of up to several thousand dollars, is often directly converted into automobility, additional evidence of the importance of automobiles to low-income families (Adams, Einav, & Levin, 2009; Goodman-Bacon & McGranahan, 2008; Mendenhall et al., 2012). However, as incomes rise, the demand for automobiles is saturated, suggesting that much of the latent desire—the unmet demand—for auto ownership occurs at the bottom end of the income distribution (Blumenberg & Pierce, 2012; Chu, 2002).

Evidence of the opposite—the effect of falling incomes on car ownership rates—also speaks to the importance of household vehicle ownership by highlighting the asymmetry between elasticities of car ownership for those with rising incomes and those with falling incomes (Dargay, 2001). While the elasticity for increasing income is quite high, car ownership elasticity is appreciably lower as incomes fall. Put simply, households are eager to commit added resources to enhanced automobility; however they are loath to reduce their access to automobiles, even in the face of financial hardship.

1.2 Residential location and automobile access. There are more than 200 studies on the relationship between the built environment and travel (Ewing & Cervero, 2010). A subset of this body of literature examines the role of the built environment in vehicle ownership decisions (which are then related to other household travel outcomes). Households without automobiles tend to locate in dense, transit-rich neighborhoods oftentimes located in central cities where they can rely on modes other than the automobile to access needed destinations (Bhat & Guo, 2007; Glaeser, Kahn, & Rappaport, 2008). Even controlling for this residential self-selection process, some studies find relationships between the characteristics of the built environment—such as transit availability and street block density—and automobile ownership rates; however, these effects are typically smaller than the effects of demographic factors such as income (Bhat & Guo, 2007).

1.3 Auto access and personal mobility. Most households in the U.S. are willing to commit financial resources toward car ownership, even if these resources are severely limited, because households with unfettered access to automobiles also tend to have increased levels of mobility (Blumenberg and Pierce, 2012; Dieleman, Dijst, and Burghouwt, 2002; Giuliano and Dargay,

2006; Pucher and Renne, 2001). By and large, studies find that higher rates of car ownership translate into more personal miles traveled (PMT) (Giuliano & Dargay, 2006).

While more PMT is not positive *a priori*, the sprawling, decentralized development patterns of most metropolitan areas in the U.S. mean that key destinations are often spatially distant from one another and require a considerable amount of personal travel to access. Although public transit could theoretically fulfill an individual's transportation needs, the private automobile almost universally allows people to travel further, faster, and more efficiently than other modes. Studies show a relationship between automobile travel and access to both employment opportunities and non-work destinations such as health care facilities and grocery stores (Kawabata & Shen, 2007; Syed, Gerber, & Sharp, 2013; U.S. Department of Agriculture, 2009). Cars also are more convenient for trip chaining, in which travelers perform several activities at multiple locations *en route* to a primary destination (McGuckin, Zmud, & Nakamoto, 2005). Trip chaining is a highly efficient way to accomplish daily tasks; however, its complexity means that a private automobile is a virtual necessity (Hensher & Reyes, 2000; Ye, Pendyala, & Gottardi, 2007).

The access and convenience afforded by the automobile helps to explain the growing number of studies showing a causal relationship between car ownership and several quality of life outcomes such as employment, earnings, and residential location in better neighborhoods (Dawkins et al., 2015; Gurley & Bruce, 2005; Raphael & Rice, 2002). Those without car access thus face a significant disadvantage in terms of travel efficiency, and either must waste time and money on slow or unpredictable transit options, or completely forego trips deemed less essential.

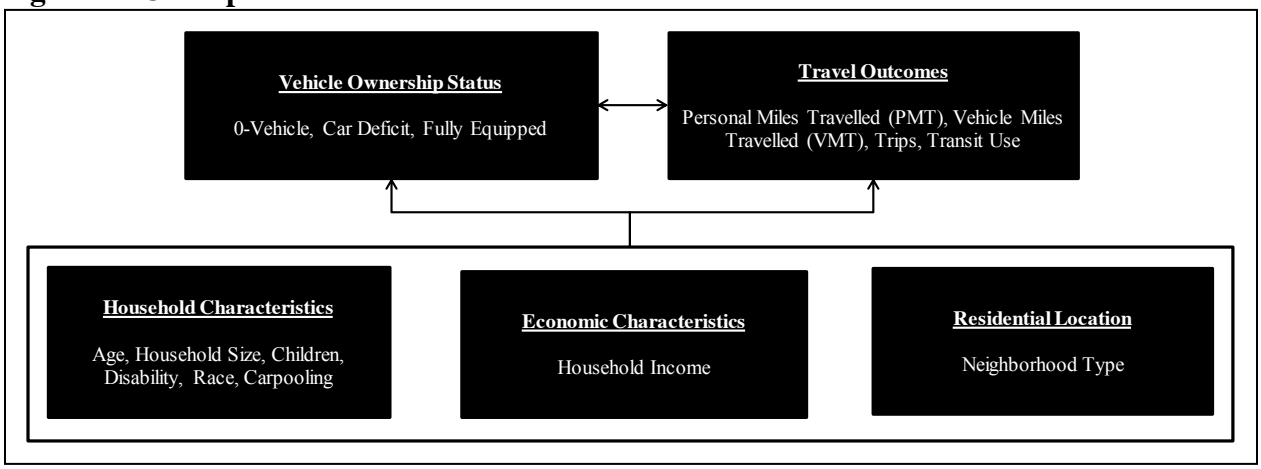
1.4 Car-deficit households. Despite the importance of the above findings, there are some notable gaps in the literature surrounding car ownership and car use. Because existing research often examines car ownership decisions at the household level (Lerman & Ben-Akiva, 1976; Scheiner & Holz-Rau, 2012a), the importance of internal household dynamics on car ownership and car use are frequently overlooked. One of the most salient of these internal factors is the role of intra-household competition for automobiles—in other words, the impact of car deficits on travel behavior. In households with more drivers than vehicles, internal competition for automobile use may mitigate the salutary effects of vehicle ownership, as household members are forced to allocate limited car access amongst individuals with diverse travel schedules and needs.

As we note above, such intra-household competition for vehicle use is by no means rare; however, research on car deficits is quite sparse. Among the few existing studies, the vast majority focus on European contexts, and examine the role of gender in intra-household car allocation decisions, perhaps because one-car, male-female households are likely the most common type of car-deficit household (Anggraini, Arentze, & Timmermans, 2008; Maat & Timmermans, 2009; Scheiner & Holz-Rau, 2012a, 2012b). However, virtually no attention has been paid to the factors that actually affect car deficits. Further, little is known about the travel outcomes of car-deficit households. Only Delbosc and Currie (2012), in their study of Melbourne, Australia, focus specifically on the mobility and travel behavior of households with an automobile shortage. They find substantial gaps not only in travel outcomes, but also in the psychological wellbeing those living in "involuntary" car-deficit households (i.e., households that could not afford to own additional vehicles). Because Delbosc and Currie's (2012) analysis—like virtually all car-deficit studies—was performed outside of the U.S., the way in which car deficits affect travel behavior in a U.S. context remains unexplored.

2. Conceptual Framework

Our research seeks to answer two questions. First, are car deficits, like carlessness, largely a result of financial constraints or of other factors, such as built environment characteristics, transit supply, or household structure? Second, how do the mobility outcomes of car-deficit households compare to the severely restricted mobility of carless households and the largely uninhibited movement of households that that have at least one car per driver? Figure 1 presents our conceptual model. Conceptually, the decision-making process governing car ownership is fundamentally different for car-deficit households than for carless or fully-equipped households. In particular, three key characteristics interact to make the car ownership decisions in car-deficit households uniquely complex: household income, residential location, and intra-household car allocation (e.g. carpooling). We briefly discuss each of these factors in turn.

Figure 1. Conceptual Model



For most households, the relationship between income and vehicle ownership is straightforward. Carless households, the majority of whom are low-income, are typically willing to tolerate the financial strain of car ownership in exchange for the dramatic mobility benefits an automobile affords. As a result, these households often quickly spend additional capital to purchase a vehicle (Blumenberg & Pierce, 2012). In contrast, fully-equipped households tend to eschew the substantial costs associated with an additional car, presumably because it provides virtually no additional household mobility. For car-deficit households, however, the calculus for purchasing an additional car is more nuanced. We predict that the mobility advantages of an additional car, while potentially significant, are far more modest than those gained from a transition out of carlessness. Therefore, car-deficit households considering an additional vehicle must choose between the benefits of a moderate bump in mobility and the considerable costs associated with an extra vehicle—a calculation that is much more complex than the one faced by carless or fully-equipped households.

The impact of residential location on vehicle ownership decisions is also uniquely complex in car-deficit households. If opportunities are highly accessible by non-automotive modes, zero-car households have little incentive to obtain a vehicle. In contrast, if a community offers little in the way of transit, walking, or biking access to destinations, these households either move to transit-rich neighborhoods (Glaeser et al., 2008) or transition out of carlessness whenever possible. The connection between neighborhood and car ownership is similarly straightforward for fully-

equipped households. The centrality of the automobile in the U.S. ensures that most neighborhoods are designed to handle a high level of vehicle ownership. This means that, in general, fully-equipped households have little reason to adjust their level of car access. Neighborhood characteristics, however, can exert a distinct influence on the vehicle ownership decisions of car-deficit households. Good transit, dense development, and mixed land uses might encourage a reduction in household automobiles (Bhat & Guo, 2007). Conversely, ample auto infrastructure might spur additional car ownership, but only if development is sprawling and dispersed enough to require a vehicle for every household driver.

Intra-household vehicle-allocation decisions—decisions about use of the household vehicle fleet—are complicated in car-deficit households. Drivers in carless and fully-equipped households typically do not compete for the use of household vehicles either because there is no car in the household or because household drivers have access to a vehicle whenever they need to use one. For car-deficit households, however, tension surrounding car sharing is presumably far more common, and the ability of households to effectively negotiate the use of their automobile resources will dictate their demand for further automobility. Household members may have complementary rather than competing travel needs, allowing them to efficiently share a single automobile among multiple drivers; they may travel together in a single vehicle (carpooling); and one or more of the drivers may be able to reach their destinations using modes other than the automobile. If these strategies are successful, car-deficit households should face few mobility constraints, and they will likely maintain a modest level of car ownership. Conversely, if car-deficit households are unable to effectively allocate their scarce vehicle resources, mobility may be restrained, and they may feel pressure to purchase an additional car.

Finally, it is important to note that household vehicle ownership can be transitory (Klein & Smart, 2017). Households buy and sell vehicles depending on a host of conditions such as fluctuations in household composition and income, the receipt of large lump-sum payments, and changes in residential location and vehicle reliability. Consequently, the "auto-deficit" category may be a function of the use of cross-sectional data—data at one point in time—rather than a reflection of a discrete household type and, therefore, difficult to predict.

3. Data and Research Design

To test our conceptual framework and to understand the determinants and travel behavior of car-deficit households, we use a variety of data sources. We use household-level data from the 2012 California Household Travel Survey (CHTS). In addition to providing detailed demographic and socioeconomic data from over 40,000 households across the state, the CHTS contains comprehensive, single-day travel data for each individual in the survey households. In total, the CHTS records the travel behavior of over 100,000 people, and captures roughly 350,000 person-trips.

With this wealth of household-, person-, and trip-level data, we can address how two facets of our conceptual framework—household income and intra-household car sharing—affect vehicle ownership and travel behavior. To examine the impact of the third component of our conceptual framework—residential location—we use a unique neighborhood typology developed by Voulgaris et al. (2016). The authors applied factor and cluster analysis to a range of tract-level built environment characteristics, including the presence of public transit, to identify seven distinct neighborhood types. Described in Table 1, the neighborhood typology consists of three

urban, three suburban, and one rural neighborhood type. Including this neighborhood typology in our analysis is advantageous in that it provides a holistic snapshot of residential location characteristics assembled from numerous built environment and transit system features. The neighborhood types are a more robust predictor of travel behavior than density alone (Ralph, Voulgaris, & Brown, 2017).

Table 1. Neighborhood Types

Character	Neighborhood Type	Description	Average Housing Density[1]	Average Job Accessibility[2]
Urban	Mixed-use	Downtowns and outlying commercial & industrial districts	5.2	181
	Old Urban	Very high-density, very transit-rich neighborhoods	27.5	533
	Urban Residential	Residential neighborhoods in mostly central city areas	5.9	147
Suburban	Established Suburbs	Older, mostly residential suburban neighborhoods	4.1	186
	Patchwork Suburban	Mix of residential and commercial land uses in suburban settings	1.7	94
	New Development	Mostly new, low-density suburban development often near the fringes of metropolitan areas	1.4	68
Rural	Rural	Most types of non-urban and non-suburban development	0.1	14

[1]National data on homes per acre
[2]National data on thousands of jobs within a 45-minute drive
Source: adapted from Blumenberg et al., (2015).

We divide our analysis in two parts. We first analyze the determinants of automobile ownership. Drawing on household licensure and vehicle ownership data, we divide households into three different levels of car ownership: zero vehicle, car deficit (less than a one-to-one ratio between household drivers and cars), and fully equipped (a one-to-one or higher ratio between household drivers and cars). In particular, we use a multinomial logistic model to assess the relative role of financial constraints, the built environment, and family structure in predicting vehicle ownership status. The model form is the following:

$$\ln \frac{\pi\,(x)}{1-\pi(x)} = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_p x_p$$

We then construct a set of statistical models to better understand the relationship between vehicle ownership status (as defined above) and four different outcome measures aggregated by household: (a) personal miles traveled (PMT) (b) vehicle miles traveled (VMT) (c) number of trips and (d) one or more transit trips. The models take different forms. The first two (PMT and VMT) are ordinary least squares regressions; the third model is a negative binomial regression appropriate for estimating count data, such as the number of trips; and the final model is a logistic regression to predict the likelihood of taking at least one transit trip on the survey day. In addition to vehicle ownership status, these models control for a set of household and built environment characteristics associated with travel outcomes, including household size, income, and residential location.

4. Determinants of Vehicle Ownership Status

We first examine whether car-deficit households are distinctive relative to the two other household types—zero car and fully equipped. Table 2 includes descriptive statistics on household structure, socioeconomics, demographics, and residential location for each of the three household types and the significance of these characteristics relative to fully-equipped households.

Table 2: Household Characteristics by Automobile Ownership

	Zero car	Car deficit	Fully equipped	All
Household Characteristics				
% with children under 10	10.9***	18.6*	17.7	17.3
% with children	13.5***	23.7***	21.8	21.4
Household members	1.8***	3.5***	2.6	2.7
Household adults	1.6***	3.2***	2.3	2.4
Household workers	0.5***	1.4***	1.2	1.2
Household drivers	0.5***	2.7***	1.8	1.8
Age (household head)	57.3***	53.6***	54.8	54.8
% with a disabled member	41.2***	25.2***	15.1	18.7
Number of cars	0.0***	1.5***	2.1	1.9
% income under $35k	75.3***	30.1***	24.9	29.7
% income over 100k	2.9***	19.1***	26.6	23.6
% White (household head)	44.6***	58.3***	67.9	64.6
% Black (household head)	12.5***	4.6***	3.5	4.4
% Asian (household head)	3.3***	7.3***	5.4	5.5
% Hispanic (household head)	34.9***	25.9***	18.8	21.1
Neighborhood Characteristics				
% Rural	2.8***	6.2***	7.9	7.2
% New Development	8.2***	21.2***	24.3	22.6

% Patchwork	9.3***	12.0***	13.5	12.9
% Established Suburb	12.0***	22.8	22.6	21.8
% Urban Residential	26.9***	23.3***	19.6	20.7
% Mixed Use	11.8***	4.7	4.9	5.4
% Old Urban	29.1***	9.8***	7.2	9.3
n	2,458	6,019	33,954	42,431

Note: Significance values are relative to the "fully equipped" category.
*p < 0.1 **p < 0.05 ***p<0.01

The table shows several clear differences in the composition of the three household types with the largest differences between zero-car households and the two other household types. Compared to car-owning households, carless households are smaller, much poorer, and far more likely to be headed by an African-American or Hispanic individual. They also are less likely to include an adult who works outside of the home—32 percent compared to over half (52%) in fully-equipped households. Finally, zero-car households also live in very different types of neighborhoods than households that are fully equipped. Two-thirds of carless households live in urban-type neighborhoods; by contrast, fully-equipped households are heavily suburban.

A comparison of car-deficit households and fully-equipped households reveals few dramatic differences. Car-deficit households are larger, more likely to be poor, less likely to be wealthy (have household incomes over $100k), and tend to live in neighborhoods with slightly more urban characteristics than fully-equipped households. By and large, however, car-deficit households are far more similar to fully-equipped households than to zero-car households—for virtually every variable listed above, the gap between carless and car-deficit households is substantially larger than the gap between car-deficit households and those that are fully equipped.

Table 3 presents the results of the car ownership model. Coefficients represent the log odds of a household either being carless or having a car-deficit, relative to the likelihood of being fully equipped. All dependent variables are measured at the household level. In general, the control variables perform as expected. Race is a strong predictor of car ownership, and households with nonwhite heads are far more likely to be carless or have a car deficit versus being fully equipped. Household structure also plays an important role in vehicle ownership, and the both number of children and age of a household head are negatively related to the likelihood of having zero cars or a car deficit (although the negative relationship with age weakens as one grows older). In contrast, the presence of household members with a disability is associated with a dramatic increase in the likelihood that the household will be carless or have a car deficit.

Table 3. Likelihood of Being a Zero-car or Car-deficit Household Relative to a Fully-equipped Household

	Zero car		Car deficit	
Sociodemographic Characteristics				
Number of workers	-0.877***	(0.004)	0.056***	(0.017)
One-driver household	-1.177***	(0.003)	-17.089***	(0)

Number of children	-0.404***	(0.003)	-0.184***	(0.022)
Disability in household	0.648***	(0.002)	0.558***	(0.01)
Age (household head)	-0.029***	(0.002)	-0.051***	(0.002)
Age squared (household head)	0.0002***	(0.00003)	0.0005***	(0.00003)
Race (household head) (Reference: Non-Hispanic White)				
Black	0.957***	(0.0004)	0.451***	(0.0001)
Asian	-0.025***	(0.0002)	0.307***	(0.002)
Hispanic	0.339***	(0.004)	0.149***	(0.015)
Other	0.189***	(0.0002)	-0.033***	(0.001)
Income (Reference: Under 10k)				
10-25k	-0.723***	(0.001)	0.119***	(0.006)
25-35k	-1.844***	(0.00003)	-0.136***	(0.003)
35-50k	-2.481***	(0.0001)	-0.386***	(0.003)
50-75k	-3.048***	(0.0002)	-0.817***	(0.0004)
75-100k	-3.466***	(0.0002)	-0.962***	(0.004)
100-150k	-3.220***	(0.0002)	-1.168***	(0.006)
150-200k	-3.367***	(0.0001)	-1.183***	(0.002)
200-250k	-3.219***	(0.00002)	-1.463***	(0.0005)
250k+	-4.108***	(0.00001)	-1.516***	(0.001)
Don't know	-1.375***	(0.0002)	-0.329***	(0.001)
Refused	-2.627***	(0.0002)	-0.883***	(0.001)
Neighborhood type (Reference: Rural)				
Mixed-use	2.211***	(0.0005)	0.597***	(0.0003)
Old urban	2.716***	(0.0001)	1.001***	(0.001)
Urban residential	1.416***	(0.003)	0.537***	(0.019)
Established suburb	0.847***	(0.002)	0.381***	(0.022)
Patchwork	0.844***	(0.0005)	0.237***	(0.002)
New development	0.278***	(0.001)	0.145***	(0.026)
Constant	0.479***	(0.0005)	0.365***	(0.001)
Akaike Inf. Crit.	39,312.84		39,312.84	
Note:*p<.01 **p<.05, ***p<.01				

The number of workers in a household functions differently in terms of predicting carlessness and car deficits. Additional workers dramatically reduce the likelihood of being carless versus being fully equipped, with an additional worker associated with a 58 percent ($1 - e^{-0.877}$) decrease in the odds of carlessness. Conversely, an extra employed household member is correlated with a 6 percent ($e^{0.056}$) higher likelihood of having a car deficit.

The fact that an additional household worker decreases the odds of being carless but increases the likelihood of having a car deficit (relative to being fully equipped) potentially stems from a confluence of factors. The first is the importance of automobiles in accessing employment and non-work destinations (Kawabata & Shen, 2007; Syed et al., 2013; U.S. Department of Agriculture, 2009). The second is the role of intra-household vehicle sharing; households with more workers may be able to maximize the use of vehicles through car sharing or carpooling. In such a context, the increased mobility afforded by a one-to-one vehicle-to-driver ratio does not justify the added expense additional vehicles, and, as the model predicts, households may be more likely to limit auto ownership than to pursue fully-equipped status.

With respect to income, relative to households in the lowest income category (incomes less than $10,000 per year), household income is negatively related to being carless. This relationship is similar for auto-deficit households, with one exception. Households in the $10,000 to $25,000 income range are about 13 percent ($e^{0.119}$) *more* likely than the lowest income group to have a car deficit. For this income group, the finding almost certainly stems from the inherent tension outlined in the conceptual framework—a tension in which low-income households must balance the mobility gains of vehicle ownership against the costs associated with the purchase and upkeep of an automobile. For zero-car households, with their severely limited mobility, the decision seems to clearly favor vehicle ownership, even among the very poor. For very low-income households with a car-deficit, the mobility gains of owning an additional vehicle may not justify the heightened purchase and maintenance costs.

Finally, residential location also influences vehicle ownership status. Compared to households living in Rural neighborhoods, residence in any of the other neighborhood types is associated with a higher probability of either carlessness or a car deficit, with the largest effect for residents in Old Urban neighborhoods. The relationship between residence in an urban neighborhood and low levels of car ownership suggests that, at least to some degree, living in dense urban areas can compensate for limited automobility. To be sure, there is undoubtedly endogeneity at play in these results. People who, for whatever reason, own few automobiles almost certainly settle in highly urban neighborhoods where they can more easily travel by modes other than the automobile. Moreover, the high likelihood of being carless or having a car deficit in Old Urban neighborhoods is not necessarily due solely to the positive travel-related characteristics of the neighborhood. Instead, low levels of car ownership likely stem, at least in part, from the expense, congestion, and inconvenience of owning a vehicle in dense urban environments. However, the coefficients, particularly for carless households, also speak to the importance of built environment and transit system characteristics, and highlight their role as a partial substitute for high levels of automobility.

5. Vehicle Ownership Status and Travel Outcomes

In the second part of our analysis, we examine travel outcomes by vehicle ownership status. Table 4 provides descriptive statistics for our three household types. Similar to Table 2, Table 4 shows dramatic differences in travel behavior between zero-car households and households with at least one automobile. While differences between car-deficit and fully-equipped households remain, they are significantly smaller in comparison to the gap in travel outcomes between carless and car-owning households. For example, zero-car households have far fewer total trips,

more trips by non-auto modes, and fewer miles traveled compared to either car-deficit or fully-equipped households. Car-deficit households travel more than the other two household types as measured by number of trips, vehicle miles traveled, personal miles traveled, and travel minutes. This finding is due to their size. As the data show, car-deficit households are larger than the two other household types. Although not included in the table, standardizing travel outcome measures per person shows, as we would expect, that adults in car-deficit households travel far more than zero-vehicle households but still significantly less than fully-equipped households.

Table 4: Household Travel Outcomes by Vehicle Ownership Status

	Zero Car	Car Deficit	Fully Equipped	All Households
People	1.8***	3.5***	2.6	2.7
Adults	1.6***	3.2***	2.3	2.4
Drivers	0.5***	2.7***	1.8	1.8
Vehicles per driver	0.0***	0.6***	1.1	1.0
Car trips	1.0***	8.2***	7.0	6.7
Carpool trips	0.9***	5.1***	3.7	3.7
Walk/bike trips	1.7***	1.2***	0.8	0.9
Transit trips	1.1***	0.3***	0.1	0.2
Total trips	4.0***	9.8***	8.0	8.0
Vehicle miles traveled (VMT)	7.0***	57.4***	53.8	50.6
Personal miles traveled (PMT)	17.6***	63.4***	57.0	54.8
Car travel (minutes)	24.3***	149.3***	130.8	125.0
Total travel (minutes)	104.1***	186.4***	151.1	152.6
n	2,458	6,019	33,954	42,431

Note: Significance values are relative to the "fully equipped" category.
*p < 0.1 **p < 0.05 ***p<0.01

The above table does not address the role of choice in vehicle ownership decisions, particularly in car-deficit households. In short, we seek to understand *why* those households with a car-deficit have a much lower vehicle-to-driver ratio than most American households. It is possible, for example, for car-deficit households to choose to forgo high levels of vehicle ownership because they find it unnecessary; in other words, they are able to accomplish their desired travel without having one car per driver. Conversely, car-deficit households may own relatively few automobiles not by choice, but due to financial necessity. In other words, they may have a latent desire for more automobility but are unable to afford the myriad costs associated with owning an additional car, and thus must make due with less than one vehicle per household driver.

Unfortunately, while the CHTS includes data on households' reasons for carlessness (Brown, 2017; Mitra & Saphores, 2017), it does not contain information on the reasons why households have a car deficit. Therefore, to assess the travel behavior differences of "choice" and "non-choice" car-deficit households, we use a proxy, in this case household income. Given the costs

associated with car ownership (American Automobile Association, 2017), we assume that low-income households (those making less than $35,000 per year) face non-choice car deficits. Similarly, since high-income households (those making over $100,000 per year) can, in most cases, afford to equip each household driver with a vehicle, we assume that these households are likely car deficit by choice. More than a quarter of auto-deficit households have incomes less than $35,000.

Table 5 shows travel outcomes for car-deficit households by three income groups.

Table 5. Travel Outcomes of Car-Deficit Households by Income Group

	Car-Deficit Households			Fully equipped (1+ Vehicle per Driver)
	Low-income car deficit	Medium-income car deficit	High-income car deficit	
	< $35,000	$35,000-$100,000	>$100,00	
People	3.5***	3.5***	3.5***	2.6
Adults	3.1***	3.2***	3.2***	2.3
Drivers	2.5***	2.8***	2.9***	1.8
Vehicles per driver	0.5***	0.6***	0.6***	1.1
Car trips	7.2	8.6***	9.6***	7.0
Carpool trips	4.8***	5.2***	5.8***	3.7
Walk/bike trips	1.0***	1.1***	1.9***	0.8
Transit trips	0.2***	0.3***	0.4***	0.1
Total trips	8.6***	10.1***	12.1***	8.0
Vehicle Miles Traveled (VMT)	48.5***	61.0***	68.7***	53.8
Personal Miles Traveled (PMT)	52.7**	66.7***	78.7***	57.0
Car travel (min)	133.8	155.6***	172.3***	130.8
Total travel (min)	167.7***	189.6***	223.9***	151.1
n	1,522	2,555	1,368	33,954

Note: Significance values are relative to the "fully equipped" category.
*p < 0.1 **p < 0.05 ***p<0.01

As the table shows, there are significant differences in travel outcomes between households that presumably have car deficits by choice and those that face car deficits due to financial constraints. In terms of the most meaningful travel outcomes—total trips, VMT, and PMT—low-income households travel far less than high-income households. Wealthy car-deficit households make 40 percent more trips, travel 44 percent more miles by car, and 51 percent more miles overall than poor car-deficit household. Furthermore, those living in high-income car-deficit households, despite making a relatively high number of car trips, also make more walking and bicycle trips, and the same number of transit trips as individuals in low-income households. Thus

while Tables 1 and 2 suggest a relatively small difference in terms of household characteristics and travel outcomes between car-deficit and fully-equipped households, there is demonstrable diversity in travel behavior within car-deficit households themselves.

Next, in Table 6, we examine the relationship between vehicle ownership status and the four travel outcomes—household PMT (Model 1), VMT (Model 2), number of trips (Model 3), and the likelihood of transit use (Model 4). The household variables in the models largely conform to expectations. There is a strong positive relationship between the number of household members and travel across all four measures; however, households that include young children tend to travel less than other households. Age is also consistently associated with travel across all measures; however, the squared term indicates that travel declines with advanced age, a finding consistent with other data (Santos, McGuckin, Nakamoto, Gray, & Liss, 2011). As expected, compared to middle-income households, low-income households travel less and higher-income household travel more. Higher-income households, however, are more likely to use transit than middle-income households. Finally, the models show less travel and more transit use in all of the neighborhood types compared to rural areas; however, these effects are largest in the most urban neighborhood types.

With respect to race and ethnicity, non-white households are more likely to use transit than white households with the effect largest for black households, again a finding consistent with the broader literature. Non-white households also take fewer trips than white households. However, controlling for income, black households have higher PMT (but not VMT), perhaps reflecting the need to make long-distance trips on public transit. Kneebone and Holmes (2015) find that between 2000 and 2012 the number of nearby jobs declined for everyone; however, the decline was greatest for poor and non-white residents, groups most likely to use public transit.

Table 6. Vehicle Ownership Status and Travel Outcomes

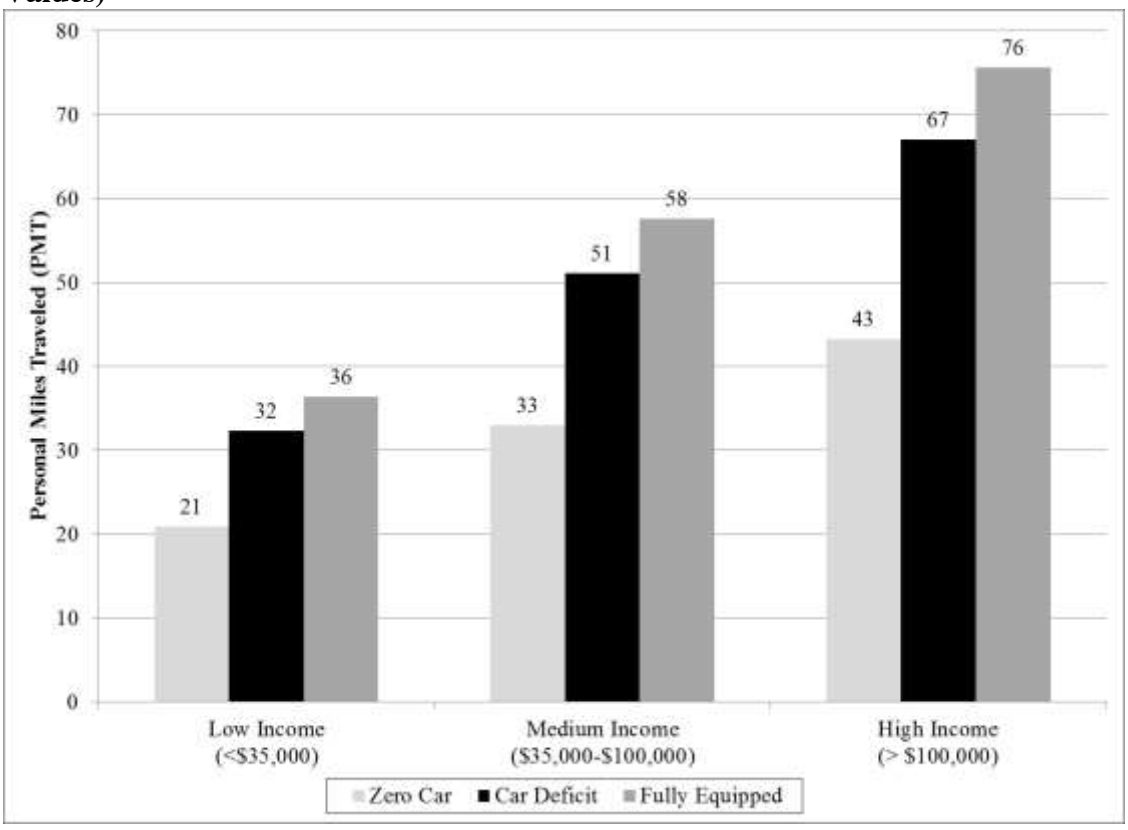
	Model 1	**Model 2**	**Model 3**	**Model 4**
	PMT	**VMT**	**Trips**	**Transit**
Vehicle Household Type (Reference: Fully Equipped)				
Zero car	-0.556***	-1.485***	-0.189***	2.534***
	0.034	0.035	0.019	0.068
Car deficit	-0.120***	-0.224***	-0.032***	0.996***
	0.022	0.022	0.011	0.056
Income (Reference $35-100k)				
Low (< $35,000)	-0.458***	-0.460***	-0.178***	0.061
	0.02	0.02	0.011	0.061
High (> $100,000)	0.272***	0.242***	0.118***	0.403***
	0.018	0.018	0.009	0.056
Other Household Characteristics				
Household members	0.241***	0.225***	0.249***	0.204***
	0.007	0.007	0.004	0.02
1+ child under 10	-0.390***	-0.411***	-0.070***	-0.382***

	0.026	0.027	0.013	0.072
Disability in household	-0.271***	-0.254***	-0.176***	-0.129**
	0.02	0.021	0.011	0.059
% of trips by carpool	0.015***	0.017***	0.009***	-0.004***
	0.0002	0.0002	0.0001	0.001
Race (Reference: Non-Hispanic White)				
Black	0.079*	0.048	-0.140***	0.435***
	0.041	0.042	0.022	0.095
Asian	-0.052	-0.075**	-0.101***	0.406***
	0.035	0.036	0.018	0.087
Hispanic	0.019	-0.001	-0.079***	0.317***
	0.021	0.022	0.011	0.058
Other	-0.122***	-0.115***	-0.140***	0.008
	0.039	0.039	0.02	0.122
Age (household head)	0.030***	0.029***	0.023***	0.021**
	0.003	0.003	0.002	0.009
Age squared (household head)	-0.0004***	-0.0004***	-0.0003***	-0.0004***
	0.00003	0.00003	0.00002	0.0001
Neighborhood type (Reference: Rural)				
Mixed-use	-0.185***	-0.324***	0.184***	1.743***
	0.039	0.04	0.02	0.145
Old Urban	-0.175***	-0.426***	0.192***	2.350***
	0.036	0.037	0.019	0.134
Urban residential	-0.146***	-0.218***	0.143***	1.534***
	0.027	0.027	0.014	0.13
Established suburb	-0.042	-0.112***	0.161***	1.644***
	0.027	0.027	0.014	0.13
Patchwork	-0.137***	-0.167***	0.133***	1.055***
	0.028	0.028	0.015	0.138
New development	-0.022	-0.022	0.051***	0.609***
	0.025	0.026	0.013	0.137
Constant	1.874***	1.710***	0.521***	-5.024***
	0.092	0.093	0.047	0.269
R^2	0.304	0.354		
Adjusted R^2	0.303	0.353		
Residual Std. Error	1.424	1.446		

F Statistic	824.087*** (df = 20)	1,034.127*** (df = 20)		
Log Likelihood			-107,844.20	-7,728.50
theta			2.675*** (0.031)	
Akaike Inf. Crit.			215,730.30	15,498.99
Note: Observations = 37,830; *p < 0.1 **p < 0.05 ***p<0.01				

Vehicle household type is our variable of interest. The models show that even controlling for other characteristics, including income and residential location, cardeficit households travel less than full-equipped households; they are also more likely to use public transit. As the descriptive statistics also show, the effect is much larger for zero-car households but remains statistically significant for car-deficit households.

Figure 2. Income, Vehicle Ownership Status, and Personal Miles Traveled (Predicted Values)

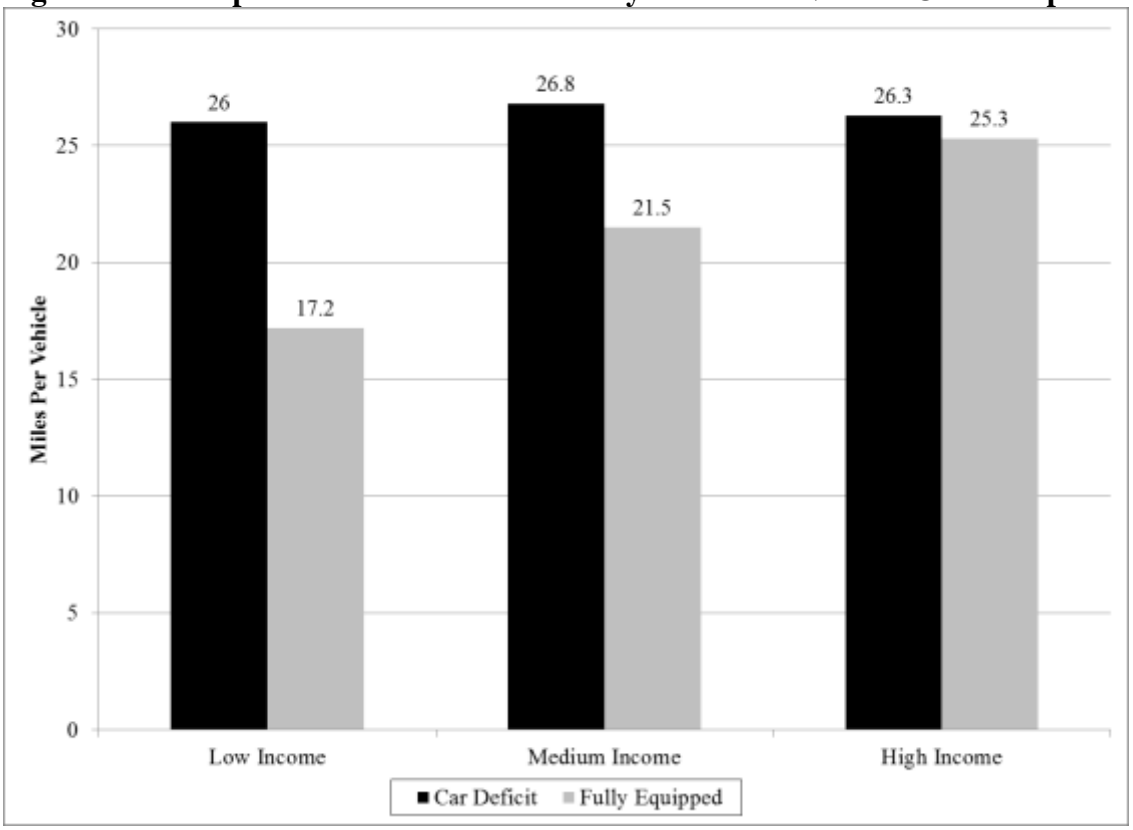


In Figure 2 we again examine the role of choice and constraint in the travel outcomes. The graph shows the relationship between income, vehicle ownership status, and one of our outcome measures—PMT—using predicted values from the model.[1] As expected, there is a positive

[1]All of the continuous variables are held constant at the mean. Neighborhood type was held constant at "New Development" and race at non-Hispanic white.

relationship between income and PMT for each vehicle ownership type; in other words, travel is positively associated with income no matter how many cars relative to drivers are in the household. The graph also shows differences in PMT by income and vehicle ownership status. Across all three income groups auto-deficit households travel less than fully-equipped households, with zero-car households traveling the least. However, households gain far more mobility transitioning from having zero-cars to having a vehicle (regardless of the number of drivers) compared to moving from auto deficit to fully equipped. On average, low-income fully-equipped households travel just four more miles a day than low-income auto-deficit households, compared to 15 miles more than low-income carless households.

Figure 3 . Miles per Household Automobile by Household Vehicle Ownership and Income



Data on miles per household vehicle suggest that low-income households carefully manage their household fleet to accomplish their necessary travel. As Figure 3 shows, miles-per-vehicle is higher in auto-deficit households than in fully-equipped households for all income groups. In other words, when household members must share an automobile, the automobile gets more use. However, despite traveling fewer miles than higher-income households, low-income auto-deficit households use their vehicles about as much as auto-deficit households in the other two income groups.

6. Conclusion

In summary, what do we now know about auto-deficit households? Although much of the scholarly attention has centered on zero-vehicle households, there are many more auto-deficit

households than zero-vehicle households. The biggest differences in the characteristics of households by vehicle ownership status occur when households move from carlessness to auto ownership. Yet there are still statistically-significant differences between auto-deficit and fully-equipped households across many dimensions. Auto-deficit households tend to be larger, suggesting the need to coordinate household travel either in the form of carpooling or negotiating complementary use of the household vehicle. They are also more likely to live in dense urban areas where some household members might be able to take advantage of high levels of transit service.

Auto-deficit households also are more likely to have lower incomes than fully-equipped households. The vehicle ownership status model provides insight on the relationship between income and vehicle ownership. Household income is negatively related to the likelihood of being an auto-deficit household. However, this relationship is far weaker than the relationship between income and zero-vehicle household status. In other words, echoing the broader literature, zero-vehicle households quickly devote additional income to the purchase of a car. Auto-deficit households do the same but at a lower rate. Additionally, among very low-income households, income is not associated with a decline in the likelihood of being an auto-deficit household. These results underscore the importance of auto ownership—having at least one vehicle in the household—and also suggest that at some income threshold, the mobility benefits of an additional car may not outweigh the ownership costs.

Auto-deficit households also have different travel patterns than fully-equipped households; they travel fewer miles, take fewer trips, and are more likely to use public transit. However, higher-income auto-deficit households travel a lot – more than twice as much as low-income auto-deficit households, reflecting their greater choice in residential location; in theory, household members can move to neighborhoods that accommodate their transportation needs and preferences. Low-income auto-deficit households travel almost as much as low-income fully-equipped households. Data on miles per household vehicle suggest that these households achieve this level of mobility by negotiating complementary use of the household car.

The findings, once again, underscore the importance of car ownership—having at least one household car—to mobility, particularly of low-income households. However, sharing vehicles among household drivers can be challenging. It requires that household members plan to either carpool or arrange their schedules so that they do not need to use the household vehicle at the same time. These arrangements may negatively affect household residential location, employment outcomes, and the ability of households to partake in other activities, topics for future research. Also, the extensive use of vehicles in auto-deficit households likely results in more frequent vehicle maintenance and replacement, costs that are difficult to evaluate without longitudinal data. Finally, unless they live in transit-rich neighborhoods, single-vehicle households can be stranded when the household car malfunctions.

The findings suggest the importance of policies to help increase automobile access among households who do not have cars and who live in neighborhoods or have jobs that make it difficult to reach opportunities without driving. However, the additional benefits of being a fully-equipped household are more limited than we had anticipated. These results indicate support for policies to offset the potential difficulties of sharing household vehicles, particularly

for low-income households. Policies might include subsidies to support pay-per-mile access to non-household automobiles such as car sharing and ride hailing services. It also might mean the adoption of policies to incentivize flexible work schedules. Our findings coupled with support for these types of programs may have the collateral benefit of motivating some households to reduce or limit their household vehicle fleets without compromising their mobility and access to opportunities.

PART II. WHO'S IN THE DRIVER'S SEAT? GENDER AND THE DIVISION OF CAR USE IN AUTO-DEFICIT HOUSEHOLDS

Given the central role that the automobile plays in personal travel, it is not surprising that scholars from across the globe have explored the myriad factors that shape car ownership (see, for example, Bhat & Guo, 2007; Oakil, Manting, & Nijland, 2016; Soltani, 2017; Yagi & Managi, 2016). The breadth and depth of this body of research speaks not only to the primacy of the automobile in contemporary society, but also to the importance of clearly understanding how access to cars can affect travel and policy decisions.

While a wealth of research examines car ownership and use, several aspects of the relationship between vehicle access and travel behavior remain unexplored. In particular, the way in which automobiles are allocated within households has only recently begun to garner substantial interest from scholars. So-called "car-deficit" households—households in which a single automobile is shared by two or more licensed drivers—are relatively commonplace, meaning intra-household competition for automobile access is a relatively widespread phenomenon. Nevertheless, little is known about the calculus that determines who gets to use the household vehicle, when he or she gets to use it, and for what purposes the car is prioritized. At present, only a handful of studies, all from outside of the U.S., have directly investigated how individuals negotiate vehicle sharing within the household (Anggraini, Arentze, & Timmermans, 2008; Scheiner & Holz-Rau, 2012a, 2012b; Simma & Axhausen, 2001; Vance & Hedel, 2007).

Of the many factors that might influence intra-household car sharing, an individual's gender is almost certainly one of the most salient. Numerous studies demonstrate the importance of gender in travel behavior, noting that for both work and non-work trips, men and women have substantially different travel patterns (Crane, 2007; MacDonald, 1999; Taylor, Ralph, & Smart, 2015). Given this well-established relationship between gender and travel behavior, it is likely that household-level decisions surrounding automobile access and vehicle use also have a significant gendered component. Yet despite the strong connection between gender and car use, there is virtually no research on how gender shapes vehicle access in households with fewer cars than drivers (with the work of Scheiner and Holz-Rau an exception).

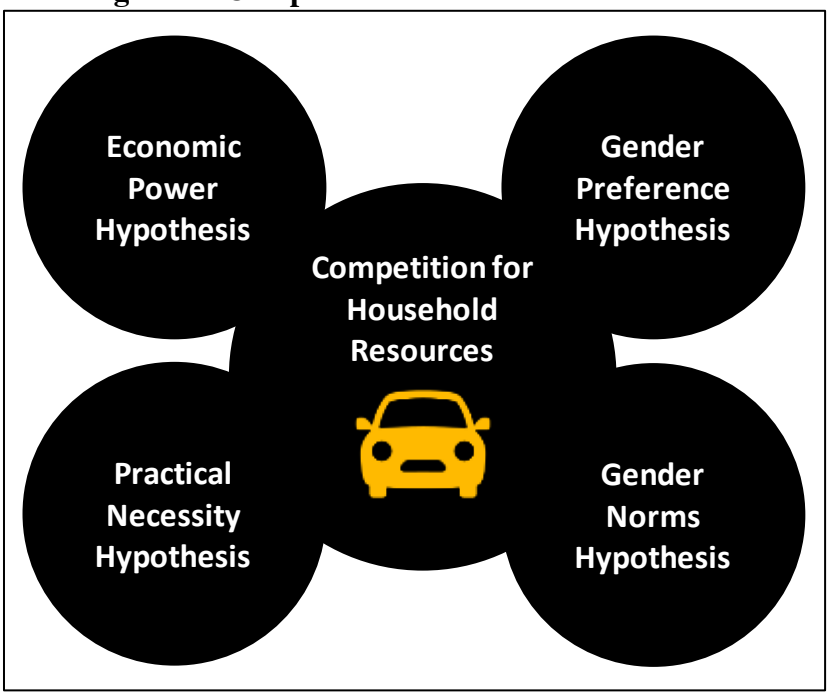
In order to address this gap in the literature, we examine a context in which competition for car use is expected to be quite high: dual-earner, dual-driver, heterosexual households that own a single automobile. Within this context, we assess the role that gender plays in promoting or inhibiting access to household vehicles. Our analysis begins with a review of the literature as it pertains to gender, vehicle ownership, and automobile use. Next, we present our data and methodology, followed by our results. Finally, we discuss the implications of our findings for policy.

1. Gender and the Car—Previous Research

Perhaps the primary reason for the lack of research regarding gender's role in intra-household car allocation is that traditionally, competition for the household vehicle—like most other shared resources—was essentially a non-issue. Classic unitary models of household behavior assume that individual members of a family act to maximize individual utility by maximizing household consumption (Becker, 1981). This means in a "traditional" context—in other words, when the male is the primary breadwinner and the female's wages are constrained—all family members are best served by deferring to the interests of the male household head. As such, conventional wisdom long held that if a man required use of the car, he was assumed to have priority. Pickup (1984), for example, points out that for decades, gender was not viewed as *an* important determinant of car access, but rather it was *the only* meaningful factor. She contends that in two-driver, heterosexual households "the general pattern [was] for husbands to have first choice of car-use, usually for commuting and for wives to rely on public transport or receiving lifts to meet travel needs" (p. 63). Other researchers have pointed out the durability of this conceptualization (Matthies, Kuhn, & Klockner, 2002), providing additional insight into why relatively little analysis on this issue has been done to date.

More recently, however, critics have recognized that intra-household resource sharing is more complex than traditional models purport, and that many of the assumptions made by these models are untenable. For example, unitary models ignore the fact that in many cases, the interests of individual household members are at odds with those of the household head, meaning the maximization of household utility can be a more contentious process than is often implied (Nussbaum, 1995). Furthermore, some have argued that unitary models are too focused on intra-household dynamics, and fail to account for the broader social, economic, and political contexts that impact household-level decision making (Bergmann, 1995). In light of these shortcomings, scholars have put forth more nuanced explanations for how households might make shared choices. With regard to automobile allocation, most research has coalesced around four main factors that potentially determine how intra-household car use is prioritized: economic power; practical necessity; gender norms; and gender preferences. These are represented in Figure 4 below.

Figure 4. Competition for Household Resources



1.1 Economic power hypothesis

The first of these notions—the economic power hypothesis—suggests that the spouse most responsible for the household's financial well being—generally, the spouse earning the highest wage—has the upper hand in automobile allocation decisions. Of course, due to the persistent gender gap in wages, combined with women's restricted access to labor markets (Nunn & Mumford, 2017), vehicle allocation based on economic power means that in most cases, men presumably enjoy higher levels of car access than women.

While this conceptualization is straightforward and might hold intuitive appeal, direct evidence of its explanatory power is limited. Several studies—including those focusing specifically on car-deficit households—speak to higher levels of car availability for men than women (Anggraini et al., 2008; Scheiner & Holz-Rau, 2012b; Simma & Axhausen, 2001, 2004; Vance & Hedel, 2007), seemingly confirming that an individual's income may be central in determining intra-household car use. In most of these studies, however, the role of earnings is not explicitly tested, and thus conclusions regarding the economic power hypothesis rest upon the assumption that the male is the principal household breadwinner. In fact, one of the few studies that directly assesses the relationship between individual income and automobile use (Scheiner & Holz-Rau, 2012a) finds no evidence to suggest that intra-household car allocation decisions are based on individual earnings.

1.2 Practical necessity hypothesis

Like the economic power hypothesis, the idea that practical necessity shapes intra-household car allocation decisions is both simple and intuitively appealing. In such a framework, vehicle priority goes to the household member whose travel needs are least likely to be met by alternative modes. For example, when a primary wage earner has a long, complex commute ill-suited to public transportation, the practical necessity hypothesis predicts that he or she will have

higher rates of car use. A study by Maat and Timmermans (2009) supports this notion, with longer commute distances and lower workplace densities both associated with a higher likelihood of car use in dual-earner, single-vehicle households. Several other studies, while not specifically examining car-deficit households, also report a connection between workplace locations with relatively poor transit access and high levels of car use (Chatman, 2009; Chen, Gong, & Paaswell, 2008; Frank & Pivo, 1994; Shiftan & Barlach, 2002).

These studies may hint at an advantage in car access for the household breadwinner, particularly *male* breadwinners since men tend to commute longer distances than women (Crane, 2007). However, in many cases, the practical necessity perspective actually suggests the opposite. Research shows that household-serving trips, as opposed to commute trips, are often quite complex and time-consuming (McGuckin & Murakami, 1999), placing a considerable travel burden on the individual who is responsible for the bulk of household-related labor. In order to alleviate this burden, a household might assign automobile priority to the member making the majority of household maintenance trips (Fan, 2017). Maat and Timmermans (2009) again offer support for this theory, finding that in car-deficit households with children, men are more likely to commute by alternative means, while women—who tend to shoulder a disproportionate share of household-service trips regardless of employment status—have automobile priority. Similarly, Scheiner and Holz-Rau (2012a) conclude that in car-deficit families with small children, auto use increases among women and decreases among men.

1.3 Gender norms hypothesis

Scholars have shown that, despite massive social changes over the past half century, adherence to "traditional" gender roles persists in many realms. For example, even in families where females are the primary wage earner, women still tend to perform the majority of household labor (Krantz-Kent, 2009) Theorists and researchers ascribe the unequal division of household-serving labor to customs learned during early childhood (Artis & Pavalko, 2003; Bianchi, Milkie, Sayer, & Robinson, 2000). Gendered norms also exist with respect to attitudes about the automobile itself, a technology historically identified with men as a means to limit women's mobility and, therefore, their autonomy (Scharff, 1991a, 1991b).

The durability of gender norms has significant implications for the study of intra-household car allocation decisions, as men have traditionally had automobile priority (Pickup, 1984). As such, the gender norms hypothesis posits that in households where the vehicle is a scarce resource, men are expected to do the majority of automobile travel. A descriptive analysis by Scheiner and Holz-Rau (2012a) confirms this notion, finding that in car-deficit homes, men drive much more frequently than women.

Other studies, while not specifically examining automobile allocation, also speak to the strength of gender norms in travel patterns. Taylor, Ralph, and Smart (2015), for example, note that regardless of education or employment status, women almost universally make more child-serving and grocery trips than men. Schwanen (2007), focusing only on childcare trips, comes to similar conclusions. While these studies do not provide definitive proof that gender norms dictate automobile allocation decisions within the household, they do speak to the persistence of gender norms in travel behavior, and thereby suggest that men, with their traditional advantage in car access, might be more apt to have automobile priority when a vehicle is a scarce household resource.

1.4 Gender preferences hypothesis

In contrast to the typical view of travel as a strictly derived demand, a range of studies show that attitudes, emotions, and personality types can contribute to a person's relative enjoyment of (or dislike for) certain modes of travel (Mokhtarian & Salomon, 2001; Ory & Mokhtarian, 2005). The gender preferences hypothesis builds on this concept, positing that, in addition to individual attitudes, sex-specific inclinations might affect mode choice, and consequently car allocation within the household. Steg (2005) provides evidence of this, suggesting that men have a particularly strong "symbolic" attachment to cars. As such, this automobile predilection could potentially encourage inordinately high rates of car use among males, even in households where availability is limited. Other work indicates that women have weaker attachment to cars, and are more willing to take alternative modes of transportation, even when vehicle access is unrestricted (Polk, 2004). Matthies, Kuhn, and Klockner (2002) argue that this may be due to a stronger commitment to ecological and sustainability causes among women, while Scheiner and Holz-Rau (2012a) suggest that the importance of cars as a status symbol among men might contribute to a male penchant for automobile use. Regardless of the underlying factors, a good deal of empirical work implies that gender preferences for travel do exist, and might play a role in intra-household car allocation decisions.

Each of the hypotheses discussed above implies that gender is an integral factor when households allocate the use of a shared vehicle. Few studies, however, have empirically tested the validity of these hypotheses. Moreover, there is little understanding of how gender shapes automobile access and travel outcomes in households with a car deficit. In the analysis that follows, we address both of these issues. Using a combination of descriptive statistics and multivariate models, we isolate the determinants of vehicle use in car-deficit households, and highlight the role of gender in vehicle allocation decisions in households where automobiles are a scare resource.

2. Data and Methodology

The majority of our data for this analysis come from the 2012 California Household Travel Survey (CHTS). The CHTS contains one-day travel diaries for over 40,000 households and 100,000 individuals from across the state. Since we are primarily concerned with the relationship between gender and intra-household car access, we limit our sample to households where we expect a relatively high degree of competition for vehicle use: households with two licensed adults but only one operational vehicle. To further ensure that we are able to accurately assess to role of gender in car allocation decisions, each of the two-adult households in our sample is comprised of one male and one female, both of whom are employed, have a driver's license, and define themselves as either the "spouse" or "partner" of the other household adult.[2]

2.1 Descriptive Statistics

Table 7 contains descriptive statistics for individuals in these car-deficit households, as well as data for those living in comparable "fully-equipped" households—defined as households

[2] The CHTS does not distinguish between "spouse" and "partner," and thus these terms will be used interchangeably throughout this analysis.

consisting of male-female partners who are both employed and licensed to drive, but who own at least two automobiles. In terms of demographics, members of car-deficit and fully-equipped households are quite similar. While fully-equipped households are older than their car-deficit counterparts and this age difference is statistically significant, practically speaking, this difference is small. Similarly, the two household types are almost equally likely to have at least one child under the age of 10, with approximately one-quarter of both car-deficit and fully-equipped households having young children.

Table 7. Descriptive Statistics for Individuals in Car-deficit and Fully-equipped Households

	Car deficit	Fully equipped
Trips	4.1***	3.8
Trips by car	3***	3.5
Trips as a driver	2.25***	3.01
Solo driver (SOV) trips	1.2***	1.9
Share of trips by car	71%***	92%
Share of trips as a driver	51%***	79%
Monopoly minutes	130.3***	320.6
Personal Miles Traveled (PMT)	24.4***	35.1
Vehicle Miles Traveled (VMT)	20.1***	32.9
Mean age	43.5***	46.3
Child under 10 in household	24%***	26%
n	1,504	15,554

With regard to travel behavior, there are some noteworthy differences. Generally speaking, members of car-deficit households make more trips than their counterparts in fully-equipped households, however, far fewer of these trips are by automobile. Those living in fully-equipped households also travel more miles, with substantially higher vehicle miles traveled (VMT) and personal miles traveled (PMT) than individuals that share a household car. Finally, there is a clear gap in "monopoly minutes" between household types. We define monopoly minutes as the amount of time that an individual spends driving a household vehicle without his or her partner, plus the amount of time spent at the destination of such a trip—in short, the number of minutes that a person monopolizes a household vehicle, making it unavailable for use by the other spouse. Not surprisingly, individuals living in fully-equipped households—households where these is presumably little conflict over automobile allocation—spend far more time monopolizing a vehicle than those with a car deficit.

Table 8 focuses on car-deficit households, examining differences in travel outcomes in these households by sex. Of note, while women take more vehicle trips and make a higher percentage of their trips by automobile, women's VMT is slightly lower than men's, and women are less likely to make trips as a driver (these differences, however, are not statistically significant). Somewhat surprisingly, however, women in car-deficit households monopolize the car

significantly more than men, spending on average almost 40 more minutes per day with exclusive access to the household automobile.

Table 8. Descriptive Statistics for Individuals in Car-deficit Households by Sex

Variables	Female	Male
Trips	4.1	4.1
Trips by car	3.1	2.9
Trips as a driver	2.1	2.4
Share of trips by car	73.7%***	67.9%
Share of trips as a driver	47.3%***	55.3%
Solo driver (SOV) trips	1.1	1.2
Monopoly minutes	148.9***	110.1
Personal Miles Traveled (PMT)	23.4	25.4
Vehicle Miles Traveled (VMT)	19.5	20.7
Mean age	42.2***	45.0
Child under 10 in household	24%	24%
Has a higher level of education than spouse/partner	25%	22%
Does more household-related work than spouse/partner	35%***	30%
Does more employment-related work than spouse/partner	25%***	33%
n	752	752
Note: $^{*}p < 0.1$ $^{**}p < 0.05$ $^{***}p<0.01$		

Table 8 also contains a set of "relative" measures that allow us to make intra-household (i.e., between partner) comparisons in three key areas: education level; amount of time dedicated to household-serving activities outside of the home; and amount of time spent on work-related activities outside of the home. These variables are included as a way of testing the various hypotheses that seek to explain intra-household car allocation. For example, because both an individual's level of education and the amount of time he or she spends on employed work are highly correlated with income, these measures can serve as a proxy for expected earnings.[3] Consequently, if a partner or spouse has more education and spends more time at work, he or she presumably contributes more to the household budget, and—according to the economic power hypothesis—should have primary access to the household vehicle. Similarly, if a partner spends more time at work or more time on household serving activities, he or she potentially has a stronger need for vehicle use. This individual should—according to the practical necessity hypothesis—have priority access to the household car, and ostensibly be its primary user.

For these relative measures, the descriptive statistics largely conform to expectations. On average, women have a slightly higher level of education than their partner, reflecting a long-term trend of growing educational attainment among women in the U.S. The data regarding

[3] In the CHTS, income is only provided at the household level and there is no data on wages. Therefore, individual-level income only can be evaluated via proxy.

relative time spent on household-related and employment-related work are also as expected, and mirror traditional gender norms: the female partner typically spends a higher share of time on household-serving tasks, while the male partner tends to spend more time on employment-related activities.[4]

2.2 Model Specification

The descriptive statistics presented above provide an instructive snapshot both of how the travel patterns of car-deficit households differ from those of fully-equipped households, and of how gender dynamics shape travel outcomes within car-deficit households themselves. They do not, however, allow us to fully address our primary area of interest, specifically the role that gender plays in shaping vehicle access in car-deficit households. In order to obtain a more complete picture of car allocation and travel outcomes in car-deficit households, we specify two Ordinary Least Squares (OLS) models that examine the determinants of car access in car-deficit households.

Our OLS models use the amount of time an individual spends monopolizing the household automobile as the dependent variable, which serves as a proxy for his or her strength in vehicle allocation decisions. We test two models—a base model, and a model containing several interaction terms—and control for a range of independent factors, including those related to household structure (the presence of children under 10 in the household), individual features (age, number of trips on the survey day), and neighborhood characteristics (residential density). Most importantly, the models also contain relative measures that compare an individual to his or her partner. These measures—which include a spouse's relative level of education, the amount of time he or she spends on household-related activities, and the amount of time he or she spends on employment-related activities—allow us to evaluate the validity of the various car-allocation hypotheses that are described above in our review of the literature. Since we are specifically interested in households where partners make decisions about vehicle allocation, we examine only households in which at least one member made a monopoly trip (suggesting that there is some level of intra-household competition for the automobile), and exclude those where neither partner monopolized the vehicle.

3. Results

Table 9 shows the results of the car allocation models. The base model provides a straightforward look at the association between household vehicle allocation and several key factors. Variables controlling for household structure (children under 10 in the household) and neighborhood type (residential density) are not statistically significant predictors of an individual's monopolization of the household automobile. A person's age is also not associated

[4] In order to calculate an individual's relative amount of household-serving and employment-related activities, we first calculated the amount of time spent on such trips, including time spent at a corresponding destination. This time was then divided by the couple's total time spent on household-serving or employment-related, yielding a percentage. Individuals who accounted for less than one-third of the couple's total household-serving or employment-related time were defined as doing less of these activities; those who accounted for more than two-thirds of these activities were define as doing more; and the remaining individuals were defined as contributing equally to these tasks.

with monopoly minutes, while the number of trips a person makes is positively correlated with the duration of his or her car monopolization. In other words, people who take more trips tend to monopolize cars for more minutes of the day.

Our variables of interest almost universally show a statistically significant relationship with vehicle monopolization. Sex is a strong predictor of monopoly minutes, with women spending over 80 more minutes making exclusive car trips than men, *ceteris paribus*. A spouse's relative contribution to household-serving activity is also closely related to his or her vehicle monopolization. Compared to individuals who share household-serving tasks with their partner equally, those that spend more time on household-related activities have significantly more access to the vehicle (about 104 additional monopoly minutes), while those that spend less time on household work monopolize the car for a much shorter period of time (about 97 fewer minutes, all else equal). The relationship between paid employment and car access follows a similar pattern: doing more work outside of the home translates into increased vehicle access (about 67 additional monopoly minutes), whereas doing less employed work is associated with far less monopolization of the household automobile (about 195 fewer minutes). The only relative measure that is not associated with vehicle monopolization at a statistically significant level is education: partners have roughly the same number of monopoly minutes regardless of their relative educational achievement.

Table 9. Car Allocation Model Results

Independent Variables	*Dependent variable:*	
	Monopoly minutes	
	Base	Interaction
Female	81.762***	65.614
	(14.698)	(48.630)
Child under 10	-5.496	18.559
	(18.322)	(24.399)
Child under 10 * female		-45.487
		(32.596)
Age	-0.289	-0.248
	(0.671)	(0.666)
Residential density	-0.489	-0.546
	(0.824)	(0.825)
Number of trips	6.630**	7.032**
	(2.807)	(2.797)
Relative education higher	-0.476	16.304
	(18.114)	(26.096)
Relative education lower	7.031	52.968**
	(17.979)	(24.644)
Relative education unknown	-14.033	71.734
	(59.410)	(85.937)
Relative education higher * female		-38.790
		(36.052)
Relative education lower * female		-101.298***

		(35.677)
Relative education unknown * female		-156.294
		(118.176)
Relative household work higher	104.124***	81.289**
	(23.530)	(33.545)
Relative household work lower	-97.680***	-119.610***
	(25.296)	(33.767)
No household work	74.027***	18.600
	(27.605)	(37.621)
Relative household work higher * female		48.765
		(46.759)
Relative household work lower * female		59.571
		(46.584)
No household work * female		110.011**
		(51.350)
Relative employed work higher	67.328***	20.403
	(21.534)	(29.349)
Relative employed work lower	-194.502***	-191.337***
	(21.572)	(31.324)
No employed work	-145.177***	-123.634***
	(19.642)	(27.396)
Relative employed work higher * female		105.903**
		(42.824)
Relative employed work lower * female		-3.295
		(42.915)
No employed work * female		-42.976
		(38.719)
Constant	200.820***	203.792***
	(46.804)	(52.094)
Observations	968	968
R^2	0.253	0.277
Adjusted R^2	0.242	0.259
Residual Std. Error	225.606 (df = 953)	223.139 (df = 943)
F Statistic	23.111*** (df = 14; 953)	15.081*** (df = 24; 943)
Note: *p < 0.1 **p < 0.05 ***p<0.01		

While the base model highlights the importance of household-serving and employment-related activity in vehicle use, it does not indicate how these factors interact with gender to affect automobile access. Specifically, the base model does not show whether doing more household-serving or employment-related work translates into extra vehicle access for one sex in particular. In other words, does contributing more to household labor provide one sex with more "bang for its buck" in terms of monopoly minutes?

The model with interaction terms allows us to address this issue. Because of the difficulty of interpreting the coefficients of multiple interaction terms—in particular, interaction terms that

include two categorical variables—we discuss the results of this model using the graphs in Figure 5. These graphs predict an individual's monopoly minutes across multiple values of one variable of interest, while holding all other variables constant. Figure 5a, for example, demonstrates the effect of a spouse's relative education on his or her monopolization of the household vehicle. The left side of the figure displays an individual's predicted number of monopoly minutes when the female spouse has a higher level of education than her spouse; the middle section shows predicted monopoly minutes for spouses with the same level of education; and the right side presents predicted monopoly minutes in a household where the male partner has more education than his spouse.

As Figure 5a shows, there is no substantial relationship between a spouse's education and his or her monopolization of the household vehicle. Men monopolize the vehicle at a slightly higher rate when a couple's level of education is unequal, regardless of which spouse has more education. By contrast, when partners have an equal amount of education, women's monopoly minutes outpace men's. In all cases, however, the magnitude of these differences is rather small and there is no statistically significant gender gap in vehicle use.

Figure 5. Predicted Monopoly Minutes by Activity

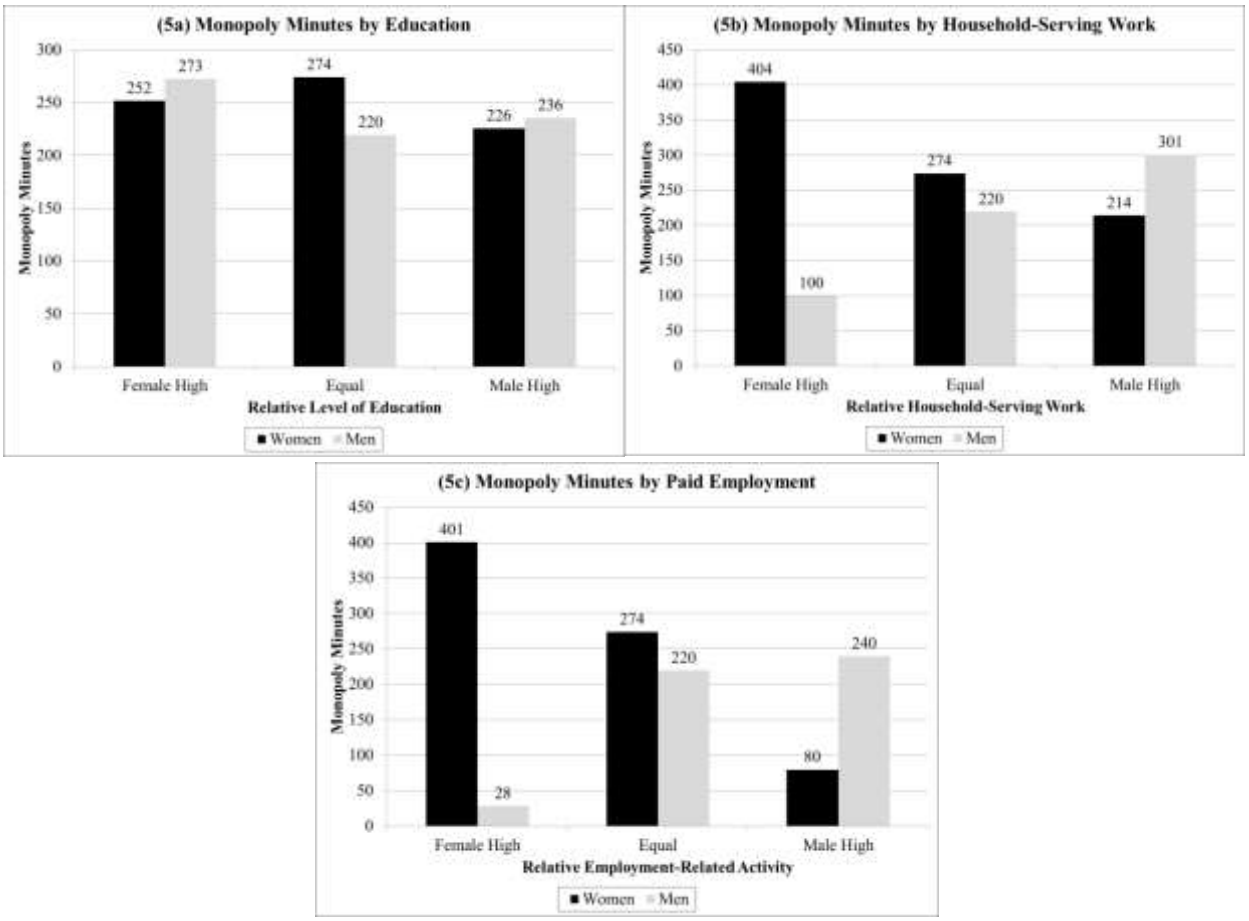


Figure 5b and Figure 5c, however, reveal substantial gaps in car access by sex. The amount of time spent on household-serving activities is strongly predictive of monopoly vehicle use, and

differs significantly depending on an individual's sex. When the female spouse does more household-related work, she has monopoly access to the automobile for over 6.5 hours per day, compared to just over 1.5 hours for the male spouse. In households where the roles are reversed—in other words, where men do more of the household-serving work—the gender gap is flipped: men monopolize the vehicle substantially more than women. In this case, however, the male-female gap in monopoly time is not nearly as large: men monopolize the car for roughly 5 hours per day, while women have exclusive access to the vehicle for just over 3.5 hours.

A spouse's relative contribution to employment-related activities follows a similar pattern, with the impact of sex on car allocation even more pronounced. In households where women spend more time at work, females are responsible for the vast majority of exclusive vehicle use. In fact, their monopoly minutes outpace men's by a factor of about 14, with women predicted to monopolize the vehicle for over 6.5 hours compared to only 28 minutes for men. When the roles are reversed, so is access to the household vehicle: men who work more than their spouse are also more likely to monopolize the car. However, just as with household-serving activity, this gender gap is much less pronounced, with men monopolizing the car for 4 hours, and women having sole access to the vehicle for only about 1 hour and 20 minutes.

4. Discussion

In addressing our research question, we investigate the factors that influence automobile access in car-deficit households. Specifically, we evaluate the degree to which sex influences car allocation decisions. Scholars have proffered a number of hypotheses that seek to explain how vehicle use is distributed in households where the automobile is a scare resource. Some scholars argue that an individual's earning potential is the primary determinant of car access (the "economic power" hypothesis). Others suggest that a household member's relative need for automobility will shape his or her ability to use a vehicle (the "practical necessity" hypothesis), while still others have put forth the notion that traditional gender roles dictate household car allocation (the "gender norms" hypothesis). Finally, some scholars maintain that men and women have varying levels of desire for car travel, which shapes their differential demand for automobile access and use (the "gender preferences" hypothesis).

Our findings suggest that practical necessity is the primary determinant of intra-household vehicle allocation. A spouse, regardless of sex, is far more likely to have exclusive access to the household vehicle if he or she "needs" the automobile—in other words, if he or she is doing most of the household-serving or employment-related work. Women who do more than two-thirds of the household-serving work monopolize the car more than 5 hours longer than their partner, while women who are the primary household worker also dominate vehicle use, monopolizing the car roughly 6 hours longer than their spouse. The relationship is the same for men when they do more household-related or employed work, although the level of monopoly use is somewhat less dramatic. Men who do the majority of household-related activities monopolize the automobile 1.5 hours more than women, and men who work substantially more than their female partners have exclusive car access for about 2.5 hours longer than their spouse. These findings echo the results of other analyses that point to practical necessity as a key determinant of intra-household car allocation (Maat & Timmermans, 2009; Scheiner & Holz-Rau, 2012a).

In contrast to the clear importance of practical necessity in car allocation decisions, the role of economic power and car access is somewhat more ambiguous. There is evidence that a spouse's earning potential shapes his or her ability to use the household automobile: partners who work more—and thus potentially earn more—monopolize the household vehicle a disproportionate amount, regardless of their sex. However, findings regarding the role of education cast some doubt on the importance of one's economic power in facilitating vehicle access. Given the close correlation between education and earnings, one would expect that when there is a gap in education level between a couple, the spouse with more education would be the primary breadwinner. As such, according to the economic power hypothesis, the better-educated, higher-earning partner should then have priority in car allocation decisions. Our findings, however, imply that a partner's relative level of education has a negligible relationship with his or her monopolization of the household car. Similar to the work of Scheiner and Holz-Rau (2012a), our results cast doubt on the importance of economic power in influencing access to the household vehicle.

With regard to gender norms or gender preferences, there is little to suggest that either of these factors influence vehicle allocation decisions in car-deficit households. To be sure, sex is an important determinant of vehicle access—both the descriptive statistics and the base model affirm that men and women differ in their access to the household car. However, our findings show that gender's role in vehicle allocation decisions, rather than supporting the traditional gender norms and gender preferences hypotheses, actually contradicts these theories. For example, notwithstanding men's traditional dominance in intra-household vehicle access (Pickup, 1984), and their affinity for vehicle travel (Steg, 2005), women actually have more exclusive access to the vehicle than men in dual-earner, car-deficit households. On average, women have monopoly access to the household vehicle approximately 1 hour and 20 minutes more than men, *ceteris paribus*.

Additionally, contributing more to the household-serving activities or employed work outside of the home translates into far more exclusive vehicle use for women than for men. When women do more household-serving or employed work, they have monopoly access to the vehicle for over 6.5 hours, compared to 5 hours for men who do more household-serving work, and about 4 hours for men who do more employed work. Thus while access to the vehicle in dual-earner, car-deficit households is very much gendered, men do not disproportionately enjoy access to the household vehicle, and patterns of car use do not conform to those predicted by traditional gender norms and gender preference theory.

Overall, our results demonstrate that sex, in combination with the practical need for vehicle access, play a central part in the car allocation decisions of dual-earner, car-deficit households. Given the widespread disadvantage that women have traditionally faced in obtaining vehicle access (Pickup, 1984), the *a priori* expectation is for men to enjoy an advantage in automobile use when competition for vehicle access is high. However, we find the opposite: all else equal, women in car-deficit households monopolize the vehicle significantly more than men. While these results ostensibly suggest that women are no longer at a disadvantage in the allocation of household resources, the reality is likely far more complex. For example, women's access to household vehicles, rather than reducing gender inequities, could potentially exacerbate them by making it easier for women to engage in both paid and unpaid work (Cowan, 1976). As such the

high level monopoly minutes among females, instead of indicating a trend toward gender equality, may reflect both an overall increase in women's household responsibilities, as well as a strengthening of the sexual division of household labor. These hypotheses are consistent with the large gender gap in effect size for spouses who do more household-serving activities or employed work.

Another potential explanation for the gender gap in monopoly minutes lies in the travel behavior of "carless" partners—in other words, individuals who are left behind when their spouse makes a monopoly trip. Table 10 provides information regarding these spouses, shedding light on what we term "orphan trips," or trips made by an ostensibly carless partner while the other partner is monopolizing the household automobile. For the most part, the characteristics of orphan trips conform to expectations. The total number of orphan trips (712) is far lower than the number of monopoly trips (1910), suggesting that, at least to some degree, the mobility of the carless spouse may be restrained by a lack of vehicle access. When carless partners do make orphan trips, the use of alternative modes of transportation is predictably high: almost 18 percent of trips are made on transit, and over 40 percent are made by bicycle or on foot.

Table 10. Orphan and Monopoly Trips

	orphan trips, female	orphan trips, male	orphan trips, all	monopoly trips, all
Share of Trips by				
SOV	17.3***	32.8	27.4	75.2
Carpool	15.7**	9.3	11.5	24.8
Transit	21.4*	15.5	17.6	0.0
Walk	33.9**	25.0	28.1	0.0
Bike	10.5*	15.3	13.6	0.0
Distance	6.1**	8.2	7.5	6.9
Time	25.0	24.8	24.8	17.8
n	248	464	712	1,910

Note: Significance values for the "orphan trips, female" category are relative to the "orphan trips, male" category.
$^{*}p < 0.1$ $^{**}p < 0.05$ $^{***}p<0.01$

What is surprising about orphan trips—and what may help to at least partially explain why men have a monopoly-minutes deficit—is the high percentage of men that make orphan trips by car, particularly as the driver of a single-occupancy vehicle (SOV). Men in car-deficit households make just under one-third of their orphan trips by SOV, a startlingly high percentage considering that these same men make just over 31 percent of *all* their trips by SOV. In contrast, women travel by SOV on just over 17 percent of their orphan trips—still a substantial proportion, but far less than their male counterparts. In fact, this difference is so substantial that when monopolization of non-household vehicles is included in our base model, the magnitude of the monopoly-minutes gender gap drops by 62 percent, from just over 80 minutes to approximately 30 minutes.

Unfortunately, our data do not allow us to determine from where these orphan trip vehicles come. For example, they may be borrowed, rented, or obtained in some other way. Nevertheless, it is clear that men in dual-earner, car-deficit households have surprisingly good access to non-household automobiles. Therefore, we must interpret our model findings with some caution: while women do have an advantage in access to the household car, it is possible that this advantage is predicated, at least in part, on men's ability to monopolize automobiles from external sources.

5. Conclusion

This analysis addresses the issue of intra-household vehicle access, specifically the role that gender plays in car allocation decisions among dual-earner, car-deficit households. We find that practical necessity—in particular, the amount of time that an individual spends on household-serving or work-related activities—is the primary determinant of automobile access. Our results also suggest that gender plays a key role in shaping one's ability to use the household vehicle, however, not in the expected manner. Contrary to the assumptions of gender norms and gender preferences hypotheses, women actually have substantially more exclusive access to the household vehicle than their male partners. Finally, with regard to the role of economic power in vehicle allocation decisions, our findings are mixed and inconclusive.

Given the importance of practical necessity in shaping access to the household vehicle, it is likely that the female advantage in automobile access stems from women's need to accomplish a range of tasks that are particularly varied and complex. While this analysis focuses on the role of household-serving and employment-related travel in car allocation decisions in car-deficit households, future research might examine other factors that might necessitate access to an automobile. The relative frequency of spouses' trip chains, their respective time budget constraints, and their need for flexible transportation options are all considerations that might shape decisions about how to share the household vehicle, and all potential reasons why women in car-deficit households use automobiles more than men.

It is likely that cars—and by extension policies to increase women's access to automobiles—address women's "practical needs," making it easier for women to carry out both work and non-work household responsibilities.[5] In so doing, access to the household vehicle serves as a proxy for the gender division of labor and, as we note above, a mechanism for reinforcing traditional gender roles. The findings, therefore, underscore the broader need for policies to equalize gender roles both within and between the home and the workplace.

The travel behavior of the carless spouse—in other words, the partner who makes so-called "orphan trips"—is also an issue that merits further attention from scholars and policy makers. In theory, orphan trips—if they are less complex than other trips—ought to be good candidates for travel by non-auto modes. However, the data show that orphan trips are frequently made in non-household automobiles, often with the carless spouse as a solo driver. Little is known about how individuals secure access to these cars, the ease with which they are able to obtain the use of non-household vehicles, and the role that this access plays in a household's decision to maintain a car deficit. If procuring a vehicle places considerable strain on members of car-deficit

[5] See Moser (1989) for a discussion of the difference between practical and strategic gender interests.

households, or if their mobility is restricted by an inability to obtain vehicle access, policy makers should focus on solutions that make vehicles available for car-deficit households on a temporary basis, and try to ensure that alternative modes adequately serve their travel needs.

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