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Carpooling and drivers without household vehicles:

**Gender disparity in automobility among Hispanics and non-Hispanics in
the U.S.**

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Abstract

Personal automobility is critical for accessing economic and social opportunities in the auto-oriented built environment of the United States. Despite declines over the past 40 years, household carpooling remains the most popular alternative mode to solo-driving regardless of demographic group. While carpooling provides a degree of automobility, carpool-dependent passengers often suffer from practical and other disadvantages. This paper explores gender gaps and ethnicity in personal automobility levels, particularly among Hispanics. The analysis explicitly considers drivers' access to household vehicles and non-drivers' access to household carpooling. The research finds that Hispanic females, especially immigrants, are low in automobility, both in the probability of being a driver and in access to household vehicles. The large gender gap is specific to Hispanics, and differs from gaps found for non-Hispanic Whites or Blacks. The gender gap decreases, but persists, as immigrant Hispanics stay longer in the U.S., gain or maintain employment, or become college-educated. Surprisingly, the gender gap in personal automobility level exists even among U.S. native Hispanics. Gender gaps in personal automobility among different ethnicity groups, particularly Hispanics, merit more study, especially as commercial car-sharing and ridesharing services become more common.

Keywords: Mobility, Automobility, Hispanics, Gender, Immigrants, Ethnicity, Carpool

1 Introduction

2 Automobility is critical for accessing economic and social opportunities in the auto-
 3 oriented built environment of the U.S., and household carpooling is by far the most popular
 4 mode after solo-driving (Blumenberg and Smart 2010; Ferguson 1997). Household
 5 carpooling is popular because carpooling provides a certain degree of automobility in terms
 6 of spatial reach and temporal flexibility, and because household carpooling is technically and
 7 emotionally easier than non-household carpooling. An increasing volume of research
 8 explores various perspectives of household and non-household carpooling (Buliung et al.
 9 2012; Buliung et al. 2010; DeLoach and Tiemann 2012; Ferguson 1997; Ferguson et al. 1994;
 10 Habib et al. 2011; Neoh et al. 2017; Shin 2017; Teal 1987). Yet, little research has examined
 11 carpooling as a mode that constitutes personal automobility, particularly for non-drivers or
 12 drivers without primary access to a household vehicle.

13 Carpooling has social benefits such as reducing congestion and pollution; however,
 14 dependence on carpooling has negative socioeconomic consequences. For example, research
 15 finds that Hispanics, particularly immigrants, carpool inside and outside the household more
 16 often than other racial/ethnic groups do (Blumenberg and Smart 2010; Smart 2015). Non-
 17 Hispanics often believe “there is no transportation problem” because “[Hispanic immigrants]
 18 are helping each other” (Bohon et al. 2008). Yet, many Hispanic immigrants report that
 19 carpooling provides a limited solution due to the scheduling requirement and unreliability,
 20 and this limitation often prevents access to education, employment, shopping, and socializing
 21 (Bohon et al. 2008; Hendricks 2014; Maldonado et al. 2016). Previous research finds that
 22 immigrants of all racial/ethnic groups, both documented and undocumented, gradually
 23 increase their automobility as they stay longer in the U.S. (Blumenberg and Smart 2010;
 24 Chatman and Klein 2013; Hu 2017). However, some focus group interviews find that
 25 immobility issues persist for undocumented Hispanic immigrants even if they stay in the U.S.

longer than 10 years (Lovejoy and Handy 2008). Furthermore, anecdotes from those interviews, along with other research, indicate gender affects automobility. Hispanic female immigrants are much less likely to be drivers than male counterparts, female immigrants of other racial/ethnic groups or Hispanic female natives, even after residing in the U.S. for a decade (Matsuo 2016). Instead, they continue to depend on household and community carpools (Shin 2017; Smart 2015). As a result of auto-immobility, female Hispanic immigrants are more likely to report that they face challenges in job searches, job retention and wages (Bohon et al. 2008; Lovejoy and Handy 2008; Maldonado et al. 2016).

This paper further explores the gender disparity in automobility, particularly among Hispanics, with explicit consideration to drivers' access to household vehicles and non-drivers' access to household carpooling. Solo-driving and household carpooling remain the two dominant modes of transportation in the U.S., even among immigrants (Blumenberg and Smart 2010). This holds true despite four decades of an overall decline in household carpooling, the emergence of governmental and commercial ridesharing services, and flourishing ethnic community carpooling (Chatman and Klein 2013; Ferguson 1997). Previous research on automobility often narrowly focuses on whether a person is a driver; however, availability of a household vehicle and/or household carpooling also can affect personal automobility. First, drivers need a household vehicle to fully utilize their ability to drive. Immigrant households typically have fewer vehicles than the number of drivers, a difference which suggests that multiple drivers with different priorities are sharing vehicles (Bohon et al. 2008; Giuliano 2000). In addition, for both non-drivers and drivers without primary access to vehicles, household carpooling is an important transportation option. Thus, a nuanced analysis of automobility should consider the different degrees of vehicle availability for drivers and the availability of household carpooling for non-drivers.

The analysis finds that Hispanic females, particularly Hispanic female immigrants, are not only less likely to be drivers but also are de-prioritized in their access to household vehicles. A source of this observed gender gap is differences in post-immigration mobility adjustment. Automobility of Hispanic female immigrants is low after they have just immigrated to the U.S., and it stagnates even after more than ten years in the U.S. In contrast, Hispanic male immigrants become drivers and secure access to household private vehicles soon after their immigration to the U.S. In addition, a smaller but considerable gender gap in automobility surprisingly exists among U.S. native Hispanics. Although literature documents that females prefer carpooling more than males do, regardless of race/ethnicity, these large gender gaps among both native and immigrant populations are specific to Hispanics (Buliung et al. 2012; DeLoach and Tiemann 2012; Neoh et al. 2017; Teal 1987). More specifically, the analysis of this paper finds that the females are often higher in automobility than males among native and immigrant non-Hispanic White workers. In addition, gender gaps for native and immigrant non-Hispanic White *non*-workers as well as native non-Hispanic Black (hereafter Black) workers and non-workers are much smaller than the gender gaps for native and immigrant Hispanics whether they work or not.

The gender gap in automobility found for Hispanics is particularly large for those who immigrated to the U.S. as adults and lack college degrees. The gender gap narrows when Hispanic females, whether immigrant or native, are highly educated. This finding suggests that their higher wage potential (i.e., higher opportunity costs of immobility) and/or subsequent actual higher wages make them more likely to afford the initial cost of becoming a driver as well as secure and retain priority access to a household vehicle.

1 **Gendered automobility, particularly among Hispanic immigrants**

2 Literature on automobility explains the “combination of greater and different trip-
3 making supported by the car” (Rosenbloom 2001), and more broadly, how contemporary
4 urban structure, life, and culture have been shaped by the popularity of private vehicle driving
5 (Beckmann 2001; Sheller and Urry 2000; Stuesse and Coleman 2014; Urry 2004). Although
6 some urban neighborhoods are transit-friendly, most of the U.S. is auto-oriented. As Urry
7 (2004) discusses, automobility provides freedom for automobile users, yet, simultaneously,
8 much of the built environment forces people to live in a spatially stretched and fragmented
9 manner. In such an environment, people without personal cars and people who depend on
10 transit can find it difficult to manage their work and life (Stuesse and Coleman 2014).

11 Most literature on automobility assumes auto-mobile people are autonomous drivers
12 who can freely drive vehicles, while auto-immobile people are those who cannot. However,
13 the literature acknowledges nuances to automobility. Some literature acknowledges
14 household carpooling as an option that provides partial automobility to non-drivers (Farber
15 and Páez 2009; Lovejoy and Handy 2008; Maldonado et al. 2016; Stuesse and Coleman
16 2014). Other research tries to account for differences in automobility among drivers by
17 employing an index such as a vehicle-to-driver ratio or the number of household vehicles
18 (Buliung et al. 2012; Giuliano 2003; Hu 2017). However, such an index does not account for
19 differences in vehicle availability, or accessibility, among household drivers. As several focus
20 group interviews document, the priority in vehicle usage varies by household driver, and
21 drivers with lower vehicle priority can be virtually autoless (Bohon et al. 2008; Lovejoy and
22 Handy 2008). Furthermore, private-vehicle transport is sometimes easily available for non-
23 drivers, particularly from other household drivers (Lovejoy and Handy 2008). Farber and
24 Páez (2009) are among the few researchers who consider passengers of private vehicles as

1 auto-mobile people.¹ But their research does not consider the different degrees of freedom
 2 experienced by drivers and passengers.

3 Some researchers examine vehicle allocation among drivers by examining auto-
 4 deficient households (i.e. households that own fewer vehicles than the number of drivers) and
 5 find that females often get less access to household vehicles than males (Anggraini et al.
 6 2008; Scheiner and Holz-Rau 2012a; Scheiner and Holz-Rau 2012b). Although some people
 7 such as Millennials prefer a less auto-dependent lifestyle, most people without cars in the
 8 U.S. give up auto ownership due to financial or physical constraints, rather than becoming
 9 auto-free by choice (Brown 2017; Klein and Smart 2017). In households where involuntary
 10 auto-deficiency persists, individuals face many limitations in activities and developing social
 11 support networks (Delbosc and Currie 2012a). Uneven vehicle allocation between genders in
 12 a household would disproportionately burden the auto-immobile gender, and the issue may be
 13 more serious for particular racial/ethnic group or for immigrants. However, the existing
 14 literature does not address gender-based household vehicle allocation by racial/ethnic group
 15 or by immigration status.

16 Hispanic immigrants, particularly recent immigrants, are less likely than their U.S.
 17 native counterparts to own a car and more likely to drive fewer miles and instead, carpool
 18 within and outside the household (Blumenberg and Smart 2014; Blumenberg and Smart
 19 2010; Casas et al. 2004; Chatman and Klein 2009; Tal and Handy 2010). Automobility of
 20 immigrants can be low, regardless of their origin, due to three major difficulties: becoming a
 21 driver, owning a private vehicle, and driving on public roads (Chatman and Klein 2013;
 22 Matsuo 2016). Becoming a driver can be difficult for those not proficient in English, and in
 23 some states, can be illegal if a person is undocumented (Liu and Painter 2012; Stuesse and

¹ In their research, those who traveled 100% as drivers or passengers of a private vehicle are defined as auto-reliant.

1 Coleman 2014). Income is a critical constraint for purchasing or leasing a vehicle.
 2 Immigrants from low-to-middle income countries may be unable to purchase a vehicle
 3 because they send a significant portion of their earnings to family or creditors in their home
 4 country (Chatman and Klein 2013). Limited access to auto loans or credit makes it even more
 5 difficult for immigrants to purchase or lease vehicles (Blumenberg and Smart 2010; Chatman
 6 and Klein 2013). Driving on public roads can be technically difficult for immigrants if the
 7 environment differs significantly from their home country (Chatman and Klein 2013). It is
 8 also emotionally and practically difficult if their vehicles are mechanically unreliable or if
 9 they lack sufficient insurance coverage (Lovejoy and Handy 2008). Furthermore, many
 10 immigrants report that they worry about policing and police harassment on road (Chatman
 11 and Klein 2013; Garni and Miller 2008; Maldonado et al. 2016; Stuesse and Coleman 2014).
 12 Under the U.S. Immigration and Customs Enforcement 287(g) Program and the Secure
 13 Communities Program, undocumented individuals held by state or local authority first on
 14 criminal grounds may be then held on civil immigration grounds (Stuesse and Coleman
 15 2014). Traffic law enforcement is often used as a tool for capturing undocumented
 16 immigrants, and sometimes results in harassment even for documented immigrants
 17 (Maldonado et al. 2016; Stuesse and Coleman 2014).

18 Hispanic immigrants often bridge their mobility gap by using their social capital,
 19 namely, carpooling within the household and with non-household members (Blumenberg and
 20 Smart 2010; Charles and Kline 2006; Liu and Painter 2012; Maldonado et al. 2016; Shin
 21 2017; Smart 2015). As a popular alternative to solo-driving, household carpooling accounts
 22 for approximately one-third of daily trips made by immigrants of all racial/ethnic groups
 23 (Blumenberg and Smart 2010).² Non-household carpooling is another popular alternative

² Blumenberg and Smart (2010) do not limit the observation to Hispanics. Their data are taken from the National Household Travel Survey of 2001.

mode, particularly among Hispanic immigrants; however, research reports that non-household carpooling presents practical difficulties and is less popular than household carpooling (Blumenberg and Smart 2014; Blumenberg and Smart 2010; Chatman and Klein 2013; Lovejoy and Handy 2008; Maldonado et al. 2016; Shin 2017; Stuesse and Coleman 2014). Household carpooling is easier than non-household carpooling for several reasons. First, carpooling requires personal interaction among members, and car-poolers need to trust each other's driving skills and punctuality (Charles and Kline 2006). **Second, household carpooling is often free of explicit charges, while non-household carpooling commonly involves compensation of some type (Lovejoy and Handy 2008). In some cases, non-household carpooling-dependents are often overcharged by drivers because of power disparities (Lovejoy and Handy 2011). Despite generally being free of charges, household carpooling still requires scheduling, which reduces convenience and flexibility for users (Teal 1987).**

Carpooling is more popular among female immigrants of all racial/ethnic groups than male counterparts (Blumenberg and Smart 2010; Shin 2017). However, research on non-immigrant U.S. females finds that females are *less* likely to use carpools and more likely to drive by themselves (Rosenbloom and Burns 1993). Rosenbloom (2006a) says this finding may be partially explained by the typical characteristics of females' jobs: Females often work in service industries that are spatially dispersed and have irregular work schedules, two factors that make it difficult to commute by alternative modes. Other research explores non-commuting trips and finds that a person with household responsibilities needs flexible and fast transportation to handle complex household errands within limited space-time constraints, a situation which leads many females to self-drive (DeLoach and Tiemann 2012; Kwan 1999). Working women often combine both work travel and non-work travel, which makes forming a carpool or relying on non-driving options even more difficult (McGuckin

and Murakami 1999; Rosenbloom and Burns 1993). Furthermore, women's safety concerns in using non-household carpooling or transit also encourages self-driving or household carpooling (Delbosc and Currie 2012b; Ferguson et al. 1994; Rosenbloom 2006a).

Then, what does the low-automobility and/or high-carpooling dependence among female immigrants mean to their life? Scheiner and Holz-Rau (2012b) summarize four inter-related hypotheses that may account for gendered automobility distribution: economic power hypothesis, social role hypothesis, preference hypothesis, and patriarchy hypothesis. Automobility of females may be lower if their personal economic resource is low or if they are subject to greater household responsibility. Or, females may prefer not to drive. But there might be a structured power relation between genders, which may strongly de-prioritize females' automobility. All but the preference hypotheses can be the consequence of low automobility, because as Hanson (2010) discusses, "gender shapes mobility, and mobility shapes gender."

Among the potential consequences of gendered influences on (im-)mobility, the most closely examined issue, and possibly the most critical one, may be access to the labor market. Feminist geographers have long discussed tight inter-relationships between mobility and economic security, and spatial entrapment of females. Namely, females with household responsibilities are typically spatially constrained in job searches and face a lower probability of getting (better-paying) jobs, a situation that has improved only slowly over time (Blumenberg 2004; Crane 2007; England 1993; Hanson 2010; Hanson and Pratt 1988; Kain 1992; Law 1999; Taylor and Ong 1995; Teal 1987; Wheatley 2013). Spatial entrapment can be even more serious if females are auto-immobile because access to private autos has a significant impact on employment rates (Ong and Miller 2005).

In a study specifically focused on immigrants but without gender consideration, Painter et al. (2007) examine employment status, residential location, and automobility to

1 explore a spatial mismatch hypothesis. They show that immigrants and Latinos are more
 2 likely to be employed if they reside in a household with a car. Parks (2004) examined
 3 gendered labor market outcomes among immigrants including Hispanics/Latinos, and their
 4 associations with carpooling dependence. She finds that females are more likely to work in
 5 the low-wage ethnic-niche industries than males, and carpooling is strongly associated with
 6 the probability of working in the ethnic-niche industries. Although these quantitative analyses
 7 have not proved causal direction between auto-immobility and labor market outcomes, some
 8 qualitative research suggests that carpooling dependence results in unfavorable labor market
 9 outcomes. For example, Bohon et al. (2008) report transportation and labor market issues for
 10 Hispanic female immigrants. They find that Hispanic female immigrants in Atlanta suburbs
 11 are unlikely to be drivers, and even when a Hispanic immigrant household obtains a vehicle,
 12 males have priority use to commute to their jobs. Hispanic female immigrants who cannot
 13 solo-drive have difficulty finding (better) work opportunities elsewhere, because they must
 14 find someone to transport them to work. An informant to Bohon et al. (2008) reports
 15 difficulty in matching jobs to Hispanic female immigrants because jobs must be found for an
 16 entire group of Hispanic immigrant women, not just one woman, so that they can carpool
 17 together. Moreover, Bohon et al. (2008) find that the lack of employer-provided
 18 transportation makes the situation even worse for Hispanic females. While jobs for Hispanic
 19 male immigrants (e.g., manufacturing and agriculture) often include employer-provided
 20 transportation, jobs for Hispanic female immigrants (e.g., hotels and restaurants) typically do
 21 not.³ Other studies find supporting evidence for the narratives provided by Bohon et al.
 22 (2008). Lovejoy and Handy (2008) also report male-prioritization in vehicle access among

³ This claim is supported Rosenbloom's discussion (2006a) about U.S. native females. In service jobs, which typically hire more females, commuting modes other than solo-driving are much less practical because employment locations are more dispersed and working hours are irregular.

1 Mexican immigrants in California, although they report cases of equal sharing as well. Ellis,
 2 Wright, and their colleagues report on a labor market outcome, finding that Hispanic
 3 immigrants, particularly Hispanic female immigrants, have strong local niching in the ethnic
 4 labor market (Ellis et al. 2007; Wright et al. 2010; Wright and Ellis 2000). Additional studies
 5 find that immigrants working in an ethnic niche are much more likely to carpool (Liu and
 6 Painter 2012; Shin 2017). While ethnic niche jobs can explain some carpooling,
 7 transportation constraints also affect the location and variety of jobs immigrants hold; future
 8 studies could clarify the causality.

9 Using nationwide travel survey data, Matsuo (2016) confirms the gendered Hispanic
 10 mobility distribution, particularly among Hispanic immigrants. Hispanic female immigrants
 11 are much less likely to be drivers than Hispanic male immigrants or female immigrants of
 12 other racial/ethnic groups. Moreover, the probability of being a driver for Hispanic female
 13 immigrants stagnates for at least a decade. Hispanic natives in the U.S. show a much
 14 narrower, but persistent, gender gap in driver status, too. Despite this low-probability of
 15 being a driver, they are still more likely to be auto-dependent. Hispanic immigrant
 16 households adopt auto-dependent lifestyles because Hispanic male immigrants generally
 17 become drivers soon after their arrival to the U.S., and drive as many miles as their non-
 18 Hispanic White counterparts or U.S. native counterparts. Moreover, when Hispanic female
 19 immigrants become drivers, they drive as many miles as (or more than) female immigrants of
 20 other racial/ethnic groups.

21 One unanswered question is whether a gender gap is observed in more broadly
 22 defined automobility, namely, whether anecdotes of male-prioritization in vehicle usage can
 23 be confirmed by data. The high driving mileage of Hispanic female immigrant drivers found
 24 in Matsuo (2016) may mean that there is a gender difference only in the fixed cost in
 25 becoming a driver. If that is the case, vehicle access within the household should be relatively

equal between genders. However, the high driving mileage average of Hispanic female immigrants may be skewed by a small number of drivers who account for most of the miles. These drivers are essentially semi-occupational drivers, who earn extra income by providing rides for others even prior to the rise of app-based ride-sharing. For example, Giuliano investigates informal transportation in Los Angeles and finds that “the majority of [informal neighborhood carpooling] drivers were female, and that they earned extra income by providing rides to neighbors for about a \$1.00 a trip”(Giuliano, cited in Blumenberg et al. 1998, pp17-18). If these drivers have an outsized effect on average driving mileage, most Hispanic female immigrant drivers may actually have much less access to vehicles.

Dataset descriptive statistics and categorization of personal-level automobility

The number of drivers and vehicles in the households

Data used for the analyses are obtained from the 2009 National Household Travel Survey. The data contain household characteristics, personal characteristics of the household members, and the characteristics of the vehicles owned by the households. Analyses focus on non-Hispanic White, Hispanic, or Black adults ages 22 to 69. Young adults ages 18 to 21 are excluded from the analyses because they are students or just starting jobs or careers, which makes their personal automobility choices differ significantly from the older cohort. Seniors ages 70 and older are also excluded because they are more likely to have physical concerns that limit automobility choice.

Table 1 summarizes the personal- and household-level characteristics of observations. Among the 176,466 U.S. Natives and immigrants included in the analysis, 86% are non-Hispanic Whites, 8% are Hispanics, and 6% are Blacks. Among Hispanics, approximately a half of them are in households with at least one adult immigrant, and a quarter of them are in

households where all adult members are immigrants. The sample size of Black immigrants is very small in the data. Most individuals in the dataset are drivers: For example, more than 95% of non-Hispanic White males and females are drivers. However, the probability of being a driver is lower for Hispanics and Blacks. Notably, 74% of Hispanic female immigrants are drivers, while 92% of their male counterparts are drivers.

Hispanic households, whether native or immigrants, are larger than non-Hispanic White counterparts; however, they are relatively lower in the number of drivers per household member. (The average number of drivers *per household* is approximately the same across native and immigrant households of non-Hispanic Whites and Hispanics.) In Hispanic immigrant households, the effective ratio of non-drivers to drivers may be even greater than the calculated value because not all drivers in these households enjoy full access to household vehicles. In addition, Hispanic immigrant households own slightly fewer active non-commercial vehicles than the number of drivers in the households (0.86 vehicles per driver). In contrast, Hispanic native households as well as non-Hispanic White native and immigrant households have little sign of vehicle sharing. These households typically own nearly one, and sometimes even more than one, vehicle per driver.

Auto-immobile households are not rare in minority households, and the share of households without any drivers or vehicles is the highest among Blacks. Among auto-immobile households with self-identified drivers, some do not have any vehicles. Specifically in Hispanic households, 2.64% of native households and 3.12% of immigrant households have no driver, and 6.09% of native households and 9.32% of immigrant households have no active non-commercial vehicle.

Personal automobility level and personal characteristics

Although driver status is an individual trait, drivers' access to vehicles is determined at the household level. This paper defines a range of personal automobility level (*autochoice*)

from zero to four, to fully account for different degrees of private auto access, including a household carpool (Figure 1).⁴ The automobility is the lowest when there is no driving or household carpooling option, and the highest when the person is a driver with full access to a household vehicle.

Drivers' access to household vehicles is determined by matching individuals and households with household vehicle records, which reveal who is the main driver of the vehicle or indicate there is no main driver (i.e., shared vehicle).⁵ In the categorization, people are first divided into drivers and non-drivers.

Non-drivers are divided into two categories based on whether they have a regular household carpooling option. Specifically, the automobility level is the lowest (zero) if there is no vehicle and/or no driver in the household. The level is one if a person is not a driver but his/her household has at least one driver and at least one vehicle. Research suggests that household carpooling is technically and emotionally easier, less costly, and more flexible than non-household carpooling or taking transit (DeLoach and Tiemann 2012; Lovejoy and Handy 2011; Neoh et al. 2017; Teal 1987). Thus, although a level one person is not a driver, the person enjoys better automobility than a person without any household carpooling option.

Drivers are divided into levels two to four, depending on the access to household vehicles. If the person does not have any primarily-accessible household vehicle, and all the household vehicles are primarily accessed by other household members, the person's automobility level is two. If the person does not have any primarily-accessible vehicle, but the household has a vehicle shared among drivers, the person's automobility level is three.

⁴ Lovejoy and Handy (2008) report that drivers without any household vehicle occasionally borrow vehicles from neighbors but this borrowing is more difficult than carpooling or getting rides. As a result, the current analyses categorize drivers without any household vehicle as automobility zero.

⁵ The complete categorization process is described in the Appendix; an overview is provided in the subsequent paragraph of this section.

Level four means that the person is a driver and has at least one primarily-accessible household vehicle.

For example, consider a household with three drivers (A, B, and C) and two vehicles (P and Q). If drivers A and B have primary access to vehicles P and Q, drivers A and B have level four automobility while driver C has level two automobility. Driver C is the most deprioritized in vehicle access and can drive only when borrowing a car from A, B, or someone else. If the household decides to share vehicle Q between drivers B and C, then they each have level three automobility. Drivers B and C are then equally de-prioritized in vehicle access compared to driver A (level four); however, equal access to another household vehicle affords them an automobility level higher than two.

The model

The personal automobility level is analyzed using the ordered Probit model. The probability of being at a specific automobility level ($autochoice=0, 1, 2, 3, 4$) is described as follows:

$$\begin{aligned}
 P(autochoice = 0|X) &= P(autochoice^* \leq \alpha_1|X) \\
 P(autochoice = 1|X) &= P(\alpha_1 \leq autochoice^* \leq \alpha_2|X) \\
 P(autochoice = 2|X) &= P(\alpha_2 \leq autochoice^* \leq \alpha_3|X) \quad \dots(1) \\
 P(autochoice = 3|X) &= P(\alpha_3 \leq autochoice^* \leq \alpha_4|X) \\
 P(autochoice = 4|X) &= P(\alpha_4 \leq autochoice^*|X) \\
 \text{w.r.t. } autochoice^* &= \beta X + \varepsilon
 \end{aligned}$$

where β is a coefficient vector of X , which includes personal characteristics, household characteristics, and environmental characteristics. Standard errors are clustered at household-level.

Five personal characteristics employed are gender (female=1 if the person is female, and 0 otherwise), worker (worker=1 if the person is a worker, and 0 otherwise), college degree (college=1 if the person has a four-year college degree or higher, and 0 otherwise), immigrant or not (immigrant=1 if the person is an immigrant, and 0 otherwise), whether the immigrant came to the U.S. as an adult (immadlt=1 if the person immigrated to the U.S. at age 16 or older, and 0 otherwise), and the number of years since immigration to the U.S.

Household characteristics employed include household family income (in natural log)⁶, racial/ethnic group of household respondent, and household size by age/gender of members. Environmental characteristics are based on the respondent's residential location: the population density of the residing census block group (in natural log), the size of the urban area, and for urban areas with populations of 1 million or more, whether the area has any rail transportation service.⁷

This paper examines the pooled data of three-racial/ethnic-groups with particular focus on three inter-group differences: (1) gender differences within each racial/ethnic group, (2) racial/ethnic group differences among males/females, and (3) racial/ethnic group differences in gender differences. To address these differences, the model includes double-interaction-terms, namely, interaction-terms with a female indicator variable and racial/ethnic group indicator variables (use Equation 2 to substitute *autochoice** in Equation 1).

$$autochoice_{WHB-All}^* = \beta_2 X + \beta_{2H} X * Hispanic + \beta_{2B} X * Black + \beta_{2f} X * female$$

⁶ The median values of each household income category (18 categories) in the National Household Travel Study are used to record each estimated household family income. For instance, \$32,500 is used as the household family income of those who report household family income between \$30,000 and \$34,999. For those reporting household family income in the highest-income category, \$100,000 or greater, \$150,000 is used as the estimated value of household family income.

⁷ Population and the presence (or lack) of rail service are used to categorized urban areas through the variable URBANSIZE in the National Household Travel Survey. URBANSIZE has six categories, 01 to 06, that correspond to urban areas with (01) 50,000 to 199,999 people, (02) 200,000 to 499,999 people, (03) 500,000 to 999,999 people, (04) 1 million or more without subway or rail, and (05) 1 million or more with subway or rail, and (06) not in an urban area. I construct indicator variables for each category to control the effects of urban area size and rail.

$$+\beta_{2Hf}X * Hispanic * female + \beta_{2Bf}X * Black * female + \varepsilon$$

...(2)

Results

Gender differences and racial/ethnic group differences in the associations between factors and automobility

Table 2 reports signs and significance of the selected results for each subgroup as well as the model performance (full regression results are shown in Appendix). Since ordered Probit model does not allow direct interpretation of the magnitude of coefficients, quantitative impacts are evaluated in the next subsection. The first column of Table 2 shows the estimated effective coefficients and effective inter-group differences for non-Hispanic White males. In other words, the signs and significance of baseline coefficients, and the post-estimation test results of the signs and significance in inter-group differences of the baseline coefficients. The second column shows the effective coefficients for non-Hispanic White females, namely, the post-estimation test results of the sum of baseline coefficients and corresponding female interaction terms. The third column shows the effective coefficients for Hispanic males. The fourth column shows the effective coefficients for Hispanic females (i.e., the sum of baseline coefficients and their interaction terms with Hispanic, female, and Hispanic female indicator variables). The fifth and sixth columns show the effective coefficients for Black males and Black females, respectively.

The top section of Table 2 compares the difference in personal automobility level between natives and immigrants; however, this comparison is not conducted for Blacks because the sample size of Black immigrants is too small to obtain reliable results for differences related to immigration status. The first row compares automobility of immigrants who came to the U.S. *before* age 16 and staying in the U.S. for 15 years or longer, and U.S. natives of the same racial/ethnic group. The second to fifth rows compare immigrants who

came to the U.S. *after* age 16 and U.S. native counterparts. The second section of Table 2 shows how personal automobility level associates with household composition, namely, the number of male and female adults, whether the household has children age 16 or 17, and whether the household has children younger than age 16. The differences in coefficients between the male and female adult counts are also reported. The third section shows the signs and significance of coefficients of household income for each demographic group. The last section shows the associations with worker status and educational attainment. Specifically, the section shows two differences in personal automobility level: the differences between workers without college degree and non-workers without college degree, and differences between workers with college degree and workers without college degree. The first comparison shows the signs and significance of effective coefficients for workers (and its corresponding interaction terms). The second comparison shows the signs and significance of sum of effective coefficients of a college degree indicator variable and a college-worker interaction term (and their corresponding interaction terms).

How quickly and to what degree immigrants gain automobility differs significantly between genders. Hispanic male immigrants quickly add automobility while Hispanic female immigrants are persistently lower in automobility than their native counterparts. Compared to their native counterparts, Hispanic male immigrants who came to the U.S. after age 16 and have been in the U.S. for less than five years are significantly lower in automobility.

However, five years post-immigration, their automobility level does not differ significantly from their native counterparts. Furthermore, Hispanic immigrants who came to the U.S. during their childhood show significantly *higher* automobility than their native counterparts.

Gender difference in post-immigration automobility adjustment is also observed for non-

Hispanic Whites; however, non-Hispanic White male immigrants take longer to increase

automobility compared to Hispanic male immigrants. Non-Hispanic White male immigrants

1 who came to the U.S. as adults take 15 years or longer to have automobility not significantly
 2 different from their native counterparts. Non-Hispanic White and Hispanic female

3 immigrants are significantly lower in automobility than native counterparts, even if they
 4 immigrated to the U.S. during childhood or have stayed in the U.S. for more than 15 years.

5 Household member composition has associations with automobility, and the
 6 associations suggest that male adults are more likely than female adults to be prioritized in
 7 vehicle usage. First, people in households with many other adults are generally more likely to
 8 share vehicles or depend on others' mobility regardless of the demographic group. However,
 9 the number of female adults in the household is much less likely to affect the automobility of
 10 male adults of all racial/ethnic groups. In contrast, both non-Hispanic White and Hispanic
 11 females seem to be lower in automobility when the household has more male and/or female
 12 adult. Interestingly, non-Hispanic White female adults are more likely to be lower in the
 13 automobility when their households have more female adults than male adults. The
 14 automobility of Black females is affected only by the number of female adults in the
 15 household. Literature about U.S. populations (seemingly focused on non-Hispanics)
 16 documents relationships between preference in self-driving and household duties. These
 17 relationships likely account for the difference in coefficients of male and female adult counts
 18 for non-Hispanic White and Black females. If females in these households are
 19 disproportionately responsible for the household errands, the female with primary household
 20 duties will secure her own vehicle while other female adults remain optional drivers or
 21 household carpool passengers. In other words, the number of female adults affects the
 22 automobility of female members. This reasoning is much less likely to apply to Hispanic
 23 female adults because previous research suggests, both statistically and anecdotally, that they
 24 face severe hurdles in becoming a driver (Bohon et al. 2008; Maldonado et al. 2016; Matsuo

2016). If the female adult is not a driver and cannot easily become a driver, she will stay at
 automobility level one when there is one driver with vehicle regardless of the driver's gender.

Having children age 16 or 17 years is not associated with personal automobility level,
 for all the demographic groups (Table 2). In other words, children of driving age do not seem
 to be active drivers who equally share the vehicles or take a primary driving role in the
 household. Having children younger than 16 years old is significantly positive for non-
 Hispanic White females, Hispanic males and females, and Black females. Having children
 under the driving age is likely to add demand for rides in a household, and the finding
 suggests that non-Hispanic White and Black females provide rides for children. However, the
 need to "chauffer" one's children does not seem to affect automobility level decisions for
 non-Hispanic White and Black males. For Hispanics, in contrast, both males and females in
 households with children under age 16 are likely to have higher automobility than Hispanics
 in households without any children. In Hispanic households, male adults seem to share the
 duty of chauffeuring children, possibly because the gender division of child-care labor is
 weaker among Hispanic households. However, considering literature on the travel behavior
 of Hispanic immigrants (Bohon et al. 2008, Lovejoy and Handy 2008, Maldonado et al 2016
 among others), it is more likely to be the result of females' hurdles in adding automobility.
 Instead of becoming drivers and securing their own vehicles for chauffeuring children,
 Hispanic females may transport their children by other modes and only ask male members or
 neighbors for assistance when they seriously need a ride.

Automobility level is higher if the person belongs to a higher-income household. In
 addition, when household income is controlled, the automobility level is higher if the person
 is a worker (Table 2). Moreover, for non-Hispanic White males, Hispanic females, and Black
 females, the automobility level is even higher if the person is a worker with a college degree.
 The automobility of non-Hispanic White females, Hispanic males, and Black males is not

significantly different between workers with and without college degrees. The finding confirms what the theory of automobility suggests: automobility level, worker status, and income are inter-related and have positive associations. People with higher mobility are more likely to get (better-paying) jobs, thanks to a larger search radius and ability to commute. Simultaneously, people who are employed or have a high potential for earning a high wage (i.e. college-educated) are more likely to become drivers and secure their own vehicle because their opportunity cost for travel time is much higher than for those who are unemployed and/or not college-educated. In addition to the personal value of time, household income is also important because a wealthier household may be able to afford an extra vehicle even for a person with low value-of-time. In Hispanic households (and possibly for Black households), automobility of male members is already high when they are workers, and so, there may be little room for additional automobility increases associated with a college degree when household income is controlled.

Predicted automobility distribution by racial/ethnic group and by immigration status

The lists of coefficients from the ordered Probit model do not provide a full picture of the overall personal automobility distribution of each demographic group. Thus, I predict automobility level as it relates to specific socioeconomic status, using the estimated coefficients in the model. The predicted values are calculated mainly for working-class adults in a suburban neighborhood in a large metropolitan area, where access to personal-vehicle transportation is critical. Specifically, the predictions are made for workers without college degrees with household income of \$30,000. The households consist of one male adult, one female adult, and one child younger than 16 years. The households are assumed to live in a metropolitan area in census region 2 (Midwest), where the population is one million or more and does not have rail service. Their residential census block group's population density is set at 3,000 people per square mile.

The top chart of Figure 2 shows the predicted automobility distribution for male and female U.S. natives of all three racial/ethnic groups. The predicted probabilities of being in each automobility level (zero to four) are shown from the bottom (the darkest gray, level zero) to the top (the lightest gray, level four). The bottom chart of Figure 2 shows the corresponding results for immigrants who immigrated to the U.S. 5 to 10 years ago, and who were age 16 or older when they immigrated. (This bottom chart omits predicted values about Black immigrants due to the small sample size of Black immigrants.)

Among natives, only Hispanics show noticeable gender difference in automobility. Most Hispanic males (85.9% of them) are drivers with primary access to vehicle (level four), and the probability is slightly higher than that for non-Hispanic White males and females (Figure 2, top chart). Hispanic native females have significantly lower automobility than their male counterparts, both in terms of the probability of being drivers and the priority in accessing household vehicles. Among Hispanic native females, 74.1% of them have automobility level four, and more than 10.0% of them are non-drivers. Black native males and females are lower in automobility than non-Hispanic White males and females, as well as Hispanic males, but the gender difference is smaller than that of Hispanic natives.

The gender gap in automobility is even more substantial for immigrant Hispanics than that for native Hispanics. Under the assumed conditions, only 55% of Hispanic female immigrants have automobility level four, compared to 83% of male counterparts (Figure 2, bottom chart). The low probability of a Hispanic female immigrant having level four automobility is also remarkable when compared with non-Hispanic White female immigrants. Approximately 77% of non-Hispanic White female immigrants have automobility level four, which is 1.4 times of the corresponding probability for Hispanic female immigrants. Moreover, the automobility of non-Hispanic White female immigrants is not significantly lower than their male counterparts: in fact, the probability of level four

1 automobility for Non-Hispanic White female immigrants is 3.5% *higher* than for their male
 2 counterparts.

3 Figure 3 illustrates the predicted post-immigration adjustment that occurs for Hispanic
 4 immigrants, with comparisons to Hispanic U.S. natives. The top and bottom charts of Figure
 5 3 show the predicted values for males and females, respectively. In each chart, the first four
 6 columns show the results of immigrants who immigrated at age 16 or older, as based on
 7 length of stay in the U.S.: from the left to the right, the length of the stay in the U.S. is less
 8 than five years, 5 to 10 years, 10 to 15 years, and 15 years or longer, respectively. The fifth
 9 column shows the result for the immigrants who were younger than age 16 when they
 10 immigrated, and have stayed in the U.S. for 15 years or longer. The last column shows the
 11 result for Hispanic U.S. natives.

12 Hispanic male immigrants quickly become drivers and secure access to household
 13 vehicles. Within five years of immigration to the U.S., 89.1% of Hispanic males become
 14 drivers (automobility levels two through four), and more than 80% of these drivers secure
 15 their own vehicle (72.5% out of 89.1%) (Figure 3, the top chart). The automobility level
 16 increases steadily as immigrant Hispanic males stay longer in the U.S. Indeed, after 10 years
 17 of stay in the U.S., more than 95% of Hispanic male immigrants are predicted to become
 18 drivers (levels two through four) and more than 90% of these drivers secure a vehicle (87.2%
 19 out of 96.2%).

20 Hispanic female immigrants are much less likely to be drivers than their male
 21 counterparts, and even if they are drivers, they are much less likely than males to enjoy
 22 priority access to household vehicles (Figure 3, bottom chart). In addition, although Hispanic
 23 female immigrants increase their automobility as they stay longer in the U.S., the adjustment
 24 is slow. Within five years post-immigration, 69.5% of Hispanic female immigrants are
 25 predicted to become drivers, and 65% of these drivers secure their own vehicle. After 10

1 years of stay in the U.S., 80% of Hispanic female immigrants are drivers, and less than three-
 2 quarters of the drivers have their own vehicle. Hispanic females who immigrated before age
 3 16 have higher personal automobility than those who immigrated to the U.S. at age 16 or
 4 older, and 88% of them become drivers. However, even among those who immigrated at a
 5 younger age, 80% of these female drivers have their own vehicle while 91% of male
 6 counterparts do.

7 This gender gap in automobility has a significant association with worker status and
 8 educational attainment. Figure 4 illustrates the predicted gender difference in automobility of
 9 Hispanics by worker status and educational attainment. The top chart shows predicted values
 10 for U.S. natives, and the bottom chart shows the values for immigrants who immigrated at
 11 age 16 years or older and have been in the U.S. for 5 to 10 years. Each chart has three sets of
 12 two columns. From left to right, the first set of columns shows results for *non-workers*
 13 *without college degrees*; the second set shows baseline results of *workers without college*
 14 *degrees*; and the third set shows *workers with college degrees*. In each set, values for males
 15 appear on the left and values for females on the right.

16 As Table 2 suggests, workers are higher in automobility than non-workers, and
 17 workers with college degrees are higher in automobility than workers without college
 18 degrees. Thus, as the theory suggests, having a faster and more flexible transportation option
 19 is positively associated with better labor market outcomes. Furthermore, being a worker and
 20 having higher human capital together are likely to result in higher value of time, and higher
 21 value of time, in turn, adds incentives to increase automobility.

22 What is interesting in the findings is that the increase in automobility is particularly
 23 high for females, and the gender gap narrows for workers, especially for workers with college
 24 degrees (Figure 4). For example, among Hispanic immigrants who have been in the U.S. for
 25 5 to 10 years (Figure 4, bottom chart), the gender gap in the probability of having the highest

1 automobility level is 32.6% for non-workers, 28.0% for workers without college degrees, and
2 20.7% for workers with college degrees. Among the U.S. native Hispanics (Figure 4, top
3 chart), the corresponding gender gap is 16.5% for non-workers, 11.8% for workers without
4 college degrees, and 6.5% for workers with college degrees. This narrowing effect observed
5 under the fully controlled condition may be even greater in practice because household
6 income would increase as the number of (college-educated) household workers increases, and
7 the income effect is stronger for females than males.

8 Although the gender gap in the automobility narrows, it persists even among workers
9 with college degrees, and even among U.S. natives. The gender gap in automobility is
10 observed both in the probability of being a driver and the probability of enjoying priority
11 access to household vehicles. For Hispanic female immigrants, both the probability of being a
12 driver and the proportion of level-four automobility among drivers steadily increases if these
13 immigrants are workers and have college degree. With regard to Hispanic female immigrant
14 workers with college degrees, 84.4% of them are drivers, and three-quarters of these drivers
15 have their own vehicle. Although the automobility of female college-educated workers is
16 much higher than less educated workers or non-workers, it is lower than male counterparts.
17 Among Hispanic male immigrant workers with college degrees, 95.4% are drivers and almost
18 90% of these drivers have their own vehicle. Among U.S. natives, the probability of being a
19 driver for Hispanic female workers with college degree reaches 93.7%; however, the share of
20 Hispanic female workers with college degree with the highest automobility is still lower than
21 the corresponding figures for Hispanic male workers with college degree (81.4% compared to
22 87.9%). Among U.S. native Hispanic male workers with college degrees, 96.5% of them are
23 drivers and 91.1% of drivers have their own vehicles.

24 Last, such a wide gender gap among Hispanic immigrants is not observed among non-
25 Hispanic White immigrants. Figure 5 illustrates the predicted racial/ethnic difference in

1 automobility between non-Hispanic White and Black males and females by worker status and
2 educational attainment. The top chart shows predicted values for non-Hispanic White U.S.
3 natives, the middle chart shows the values for non-Hispanic White immigrants who
4 immigrated at age 16 or older and have been in the U.S. for 5 to 10 years, and the bottom
5 chart shows the values for Black U.S. natives. Black immigrants are not included in the figure
6 again, because the sample size issue. As in Figure 4, each chart has three sets of two columns.
7 From left to right, the first set of columns shows results for *non-workers without college*
8 *degrees*; the second set shows baseline results of *workers without college degrees*; and the
9 third set shows *workers with college degrees*. In each set, values for males appear on the left
10 and values for females on the right.

11 The gender gap in automobility among native and immigrant non-Hispanic Whites,
12 and Black natives is marginal or non-existent if they are workers (Figure 5). Among the
13 native and immigrant non-Hispanic White workers, females are slightly higher in
14 automobility than male counterparts. For example, among non-Hispanic White immigrants,
15 90% of male workers with and without college degree are drivers, and approximately 92% of
16 female counterparts are drivers. Among these worker-drivers, 82% of males secure their own
17 vehicles, and 84% of females secure their own vehicles.⁸ The findings confirm literature
18 showing that most working women prefer self-driving to handle the complex needs of
19 commuting and traveling for household errands or potentially for safety reasons (Delbosc and
20 Currie 2012b; Ferguson 1997; Rosenbloom 2006b; Rosenbloom and Burns 1993). With
21 regard to Blacks, automobility of female workers is slightly lower than that of male workers,

⁸ Among males, 81.7% of worker-drivers without college degrees are automobility level four, and 83.9% of worker-drivers with college degrees are automobility level four. The corresponding ratios for females is 79.3% and 79.2%, respectively

1 but within a small margin: 3% difference in the share of drivers and 5% difference in the
 2 share of level four automobility (Figure 5, bottom chart).

3 With regard to female non-workers, their automobility is slightly lower than their
 4 male counterparts, particularly for non-Hispanic White immigrants and Black natives. For
 5 example, among non-Hispanic White immigrants, the probability of being a driver is 5%
 6 lower for females than for males, and the probability of drivers having their own vehicles is
 7 also approximately 5% lower for females than for males (Figure 5, middle chart). The gap is
 8 substantially smaller than the gap observed for Hispanic non-worker immigrant counterparts
 9 (Figures 4 and 5). The difference in the gender gaps between Hispanic and non-Hispanic
 10 White non-worker immigrants originates mainly from lower automobility of Hispanic female
 11 immigrants. A comparison of Figures 4 and 5 shows that the automobility of Hispanic male
 12 immigrants are slightly higher than that of non-Hispanic White male immigrant counterparts.
 13 Hispanic female immigrants are, in contrast, much lower in automobility than non-Hispanic
 14 White female immigrants.

15 Comparing Hispanic and non-Hispanic White female immigrants, Hispanic females
 16 are less auto-mobile than non-Hispanic White female counterparts, regardless of their worker
 17 status and educational attainment level. An interesting difference between these females is
 18 that while attaining a college degree has a noticeable impact on the automobility of Hispanic
 19 female workers, the degree has no impact on the automobility of non-Hispanic White female
 20 workers. Among non-Hispanic White female non-workers, 89% of natives and 78% of
 21 immigrants staying in U.S. for 5 to 10 years are drivers, which is already greater than the
 22 corresponding figures for Hispanic females (79% and 61%, respectively). If non-Hispanic
 23 White females are workers, the probability of being a driver and having one's own vehicle
 24 increases, which confirms previous research findings about U.S. native working mothers.
 25 Namely, working women with children are more likely to choose self-driving to fulfill the

1 complex and extensive travel needs for jobs, household errands, and child-related trips. In
 2 contrast, Hispanic females (both natives and immigrants) seem to need additional reasons, or
 3 empowerment, to add automobility; such as significantly higher wage potential than what is
 4 typical for female workers in the ethnic niche labor market. High educational attainment may
 5 give them an opportunity to escape from the vicious cycle of low-automobility and low-labor
 6 market outcomes.

7 In sum, even when socioeconomic status is controlled and the residential environment
 8 is not transit-friendly, Hispanic females, particularly Hispanic female immigrants, are
 9 predicted to be much lower in the automobility than their male counterparts or their non-
 10 Hispanic White female counterparts. This lower automobility arises not only from the lower
 11 probability of being a driver but also from the lower priority in accessing household vehicles.
 12 Even when Hispanic immigrant females become drivers, they are less likely to enjoy full
 13 mobility of driving and may remain dependent on others' mobility. This large gender gap is
 14 specific to Hispanics, particularly for those who immigrated as adults, but is persistently
 15 observed even among U.S. natives. Non-Hispanic native and immigrant Whites are high in
 16 automobility, and the gender gaps within these groups are much smaller compared to their
 17 Hispanic counterparts. Blacks, whether native to the U.S. or immigrant, are lower in
 18 automobility than non-Hispanic Whites with comparable characteristics. However, the gender
 19 gap for Black natives is much narrower than the gap found for native and immigrant
 20 Hispanics. The gender gap in automobility narrows, but does not disappear, when Hispanic
 21 females are working and have college degrees, and even if they are U.S. natives.

23 **Conclusion and discussion**

24 The analyses confirm the low automobility of Hispanic females, particularly
 25 immigrants. Hispanic female immigrants are low in personal automobility both in the

probability of being drivers and in drivers' priority access to household vehicles. This paper further finds that the gender gap in the automobility is specific to Hispanics, and persists even if immigrants stay long in the U.S., are (college-educated) workers, or are U.S. natives.

Why do Hispanic immigrants have such a strong gendered automobility distribution?

Among the four hypotheses proposed by Scheiner and Holz-Rau (2012b), the result of my analysis seem to strongly support the patriarchy hypothesis in addition to the economic power hypothesis and social role hypothesis. If the disparity were simply caused by economic power relations, the gender gap should be almost non-existent (as it is for non-Hispanic Whites) for Hispanic college-educated workers who are likely to have escaped from gendered ethnic labor market. With regard to the social role hypothesis, this paper suggests that Hispanic males share the household responsibilities that involve driving rather than sharing vehicles with female members to handle those tasks on their own. Moreover, in the U.S. context, research about non-Hispanics as well as non-Hispanic White samples in this paper show that higher household responsibility often results in higher automobility because the frequent and complex trip-making of chauffeuring children increase the needs for self-driving (England 1993; Rosenbloom and Burns 1993). The analysis has no suggestion as to whether Hispanic females prefer to remain non-drivers. However, considering male household members' high automobility, living environment, and the persistency of gendered disparities post-immigration and among natives, patriarchy seems to exist among Hispanics. More investigation seems warranted to explore the details.

The persistently low automobility among Hispanic female immigrants spatially limits them, even more severely than the traditionally discussed spatial entrapment of females, and may have serious consequences in labor market outcomes. As Liu and Painter (2012) discuss, access to reliable private automobile transport is an effective way for low-income workers to overcome employment barriers and achieve economic objectives. Low automobility may

1 contribute to Hispanic female immigrants' unemployment or to locally-concentrated
2 gendered ethnic employment. As a result, Hispanic female immigrants may be trapped in a
3 vicious cycle of low-labor market value and low-automobility: low-automobility deprives
4 them of higher paying jobs or skill-building opportunities, and with lower (observed) labor
5 market values, Hispanic female immigrants remain de-prioritized in increasing their
6 automobility. One possible way to make the first step towards escaping from this vicious
7 cycle is higher education. Although it does not seem to be a silver bullet, analysis suggests
8 that both native and immigrant Hispanic female workers with college degrees are noticeably
9 higher in automobility than those who without college degrees, even when household income
10 is controlled. This additional contribution of educational attainment, other than the effects
11 through increasing household income, is particularly strong for Hispanic females, both
12 natives and immigrants. Another possibility is enriching the transit service and/or car-sharing
13 to make them auto-free rather than auto-less. Hispanics are helping each other partly in this
14 way; they create community carpools to support autoless members. However, the focus group
15 interviews and case studies suggest that the intra-community carpool system is imperfect, and
16 Hispanic females with low-automobility still suffer from negative employment and quality-
17 of-life outcomes of low-automobility.

18 One interesting remaining question is how this low automobility relates to household
19 duties and persistent disparities. If a male driver in the Hispanic immigrant household with
20 immobile females takes care of household errands and driving duties, it may not be too
21 problematic. However, as the patriarchy hypothesis suggest, the spatial and labor market
22 entrapment may, in turn, strengthen the gender division of household labor, further
23 discouraging the ability of females to advance their education or gain automobility. As
24 Hanson (2010) discusses, gender shapes mobility, and mobility shapes gender. Lower

1 automobility may have long-lasting consequences, which may lead to remaining gender
2 disparity in automobility among U.S. native Hispanics.

3 Some limitations of this paper arise from using the National Household Travel Survey
4 data of 2009. One limitation is not being able to detect causal relationships between labor
5 market outcomes and personal automobility, or the reasons for the gender gap in automobility
6 among Hispanics. The National Household Travel Survey data employed in the analyses are
7 not panel data and lack narratives of the inter-personal relationships among household
8 members. Future research is anticipated to explore whether and how much Hispanic
9 (immigrant) females are deprived of economic opportunities due to this de-prioritization in
10 adding personal automobility, and why the gender gap in automobility is observed even
11 among U.S. native Hispanics. A second limitation is that potentially the most-severely auto-
12 immobile population, undocumented Hispanic immigrants, is unlikely to be included in the
13 survey. Although the survey is conducted both in English and Spanish, members of the
14 undocumented population are much less likely to respond to a governmental survey. Thus,
15 the result of this paper may be understating the gender gap in automobility among Hispanics.

16 A third limitation of the paper arises from the use of data collected between 2008 and 2009
17 because the automobility of Hispanic households may have changed since then. On the one
18 hand, the serious economic recession that started in 2008 overlaps with the observation
19 period, which may have exaggerated the gender gap in automobility. High unemployment
20 rates during the period may limit the vehicle affordability for low-income households, and as
21 a result, lowered automobility for de-prioritized members. On the other hand, auto-
22 immobility issues among Hispanics may have become even more serious in the ensuing
23 decade. Given tougher immigration policy and negative political, social, and cultural attitudes
24 towards Hispanic immigrants in some regions of the U.S., they may face more practical
25 difficulties in driving or finding drivers. Last, increased use of ride-sharing services since

2008 may have impacts. Further research using updated data is anticipated to explore changes or persistency in auto-immobility, particularly among Hispanic females.

Appendix

Determining personal automobility level

The automobility level (*autochoice*) categorization is based on the personal and vehicle data in National Household Travel Survey Person File and Vehicle File. First, I specify active drivers among adults and active non-commercial vehicles. Active drivers are adults age 18 or older who satisfy following criteria: the person is a self-claimed driver (*DRIVER*=1) who do not have any medical condition that prevents from driving (*CONDRIVE* $\neq$ 1) , and drove previous year (*YEARMILE*>0). In considering the number of household drivers, I use the count of active drivers rather than the recorded variable of household driver count (*DRVRCNT*) because *DRVRCNT* sometimes includes non-acting drivers. Active non-commercial vehicles are vehicles that satisfy following criteria: the vehicle is a regular four-wheeled vehicle (*VEHTYPE*=01, 02, 03, 04, 05, 06) that does not have commercial license plate (*VEHCOMM* $\neq$ 1), and was used the previous year (*BESTMILE*>0). In considering the number of household vehicles, I use the count of active non-commercial vehicles in the household rather than the record of household vehicle count (*HHVEHCNT*). The primary driver of the active non-commercial vehicles are specified using the variable *WHOMAIN*, which records the person ID number of the main driver. Shared vehicles are the vehicles without main driver records (*WHOMAIN*=99). Using the active driver data, active non-commercial vehicle data, and main driver data of the vehicles, I determined the personal automobility levels as described in Figure 1.

Full regression results

Table A-1 shows full regression results of the model. The first column shows the coefficients of baseline explanatory variables (i.e., coefficients for non-Hispanic White males). The second and third columns show racial/ethnic difference among males. The second column shows the coefficients for interaction-terms with a Hispanic indicator variable, and the third column shows those for interaction-terms with a Black indicator variable. The fourth column shows gender differences in coefficients among non-Hispanic Whites, namely, the coefficients for female interaction-terms. The fifth and sixth columns show the coefficients for double interaction-terms. They show racial/ethnic differences in gender difference in coefficients for Hispanics compared with non-Hispanic Whites and for Blacks compared with non-Hispanic Whites, respectively.

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Conflict of interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

Authors' contribution

M Matsuo: Content planning, literature search and review, data construction and analysis, manuscript writing and editing.

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Table 1: Descriptive statistics of the data

	Non-Hispanic Whites			Hispanics			Blacks		
	Natives	Immigrants		Natives	Immigrants		Natives	Immigrants	
		(All-imm HHs ^a)			(All-imm HHs)			(All-imm HHs)	
Person Statistics									
Obs. Total (Age 22 to 69)	144,106	7,422	(2,451)	7,396	7,011	(3,426)	9,699	832	(429)
Male	66,151	3,097	(1,096)	3,368	3,030	(1,544)	3,687	342	(173)
Female	77,955	4,325	(1,355)	4,028	3,981	(1,882)	6,012	490	(256)
Immigration Status									
Immigrant as an adult		4,275	(1,803)		4,962	(2,673)		584	(344)
Staying in US 10-15yrs		651	(332)		904	(524)		85	(54)
Staying in US 5-10yrs		487	(215)		1,021	(604)		85	(54)
Staying in US 0-5yrs		323	(179)		387	(215)		52	(33)
Driver									
Male	96.5%	97.7%	(97.4%)	93.5%	92.0%	(91.5%)	86.3%	92.7%	(90.2%)
Female	95.9%	94.4%	(92.8%)	89.7%	74.2%	(70.6%)	83.9%	85.0%	(81.6%)
Worker									
Male	72.4%	78.8%	(77.5%)	73.8%	79.3%	(79.9%)	60.0%	75.1%	(78.0%)
Female	59.7%	58.0%	(55.0%)	60.3%	46.1%	(45.5%)	56.1%	68.0%	(69.5%)
College Grads									
Male	42.7%	58.8%	(64.9%)	31.0%	19.3%	(20.8%)	25.6%	47.7%	(48.6%)
Female	39.8%	46.5%	(50.9%)	30.9%	18.1%	(20.0%)	28.7%	41.4%	(40.6%)
Workers with College Degrees									
Male	33.6%	48.5%	(53.5%)	25.8%	16.1%	(17.2%)	18.5%	40.4%	(43.4%)
Female	26.9%	30.8%	(32.4%)	22.6%	12.0%	(13.2%)	20.0%	30.8%	(30.1%)
Household Statistics									
Num. of Households	105,904	8,593	(1,908)	4,809	6,191	(2,650)	7,902	788	(331)
Avg. Household Size	2.56	2.86	(2.31)	3.00	3.72	(3.40)	2.52	3.16	(2.77)
Num of Male Adults (18+)	0.80	0.92	(0.65)	0.76	0.88	(0.85)	0.59	0.77	(0.67)
Num of Fem Adults (18+)	1.08	1.12	(1.05)	1.14	1.20	(1.13)	1.15	1.18	(1.14)
One Adult HH	27.1%	15.2%	(50.5%)	25.4%	14.1%	(29.8%)	39.7%	22.0%	(46.5%)
HHs with Child 16-17	4.20%	5.68%	(3.41%)	5.62%	8.30%	(8.28%)	4.42%	7.78%	(8.87%)
HHs with Child U16	18.7%	26.6%	(17.4%)	33.1%	48.7%	(45.0%)	22.1%	42.4%	(38.2%)
Num. of Drivers per HH									
%HHs without Driver	0.93%	0.44%	(1.36%)	2.64%	3.12%	(5.28%)	5.85%	3.81%	(6.34%)
Non-Driver per Driver (if any)	0.28	0.38	(0.34)	0.55	1.03	(1.13)	0.47	0.67	(0.69)
Num. of Actv Non-Com Veh in HH ^b									
%HHs w/o Actv Non-Com Veh	1.93%	1.52%	(3.93%)	6.09%	9.32%	(9.85%)	13.25%	10.79%	(15.71%)
Active Non-Cm Veh per Dr (if any)	1.10	2.16	(1.00)	0.97	0.86	(0.89)	0.94	0.88	(0.81)
Avg. Pop D. of Residence	2,943	4,689	(5,749)	5,729	8,816	(9,431)	4,992	9,292	(11,062)
Household Income									
Mean	66,959	80,973	(67,015)	59,326	41,721	(34,221)	43,520	61,263	(48,967)
Median	52,500	67,500	(47,500)	47,500	27,500	(22,500)	27,500	47,500	(37,500)
HHs by Urban Area Type									
Urban Size 1: Pop 50k-200k	14.9%	11.7%	(11.2%)	11.0%	9.1%	(9.1%)	14.2%	8.9%	(6.7%)
Urban Size 2: Pop 200k-500k	9.5%	9.1%	(9.8%)	7.4%	5.6%	(5.7%)	13.8%	10.0%	(9.2%)
Urban Size 3: Pop 500k-1million	7.8%	8.9%	(9.2%)	12.6%	9.7%	(9.2%)	8.8%	5.5%	(5.8%)
Urban Size 4: Pop 1m + No Rail	16.6%	22.8%	(22.8%)	28.2%	26.0%	(23.7%)	21.0%	19.4%	(17.1%)
Urban Size 5: Pop 1m + with Rail	8.4%	20.2%	(25.5%)	14.5%	33.0%	(37.2%)	14.9%	42.7%	(49.5%)
Urban Size 6: Not in an Urban Area	42.9%	27.3%	(21.5%)	26.4%	16.6%	(15.1%)	27.3%	13.6%	(11.6%)
HHs by Census Region									
Census Region 1	14.7%	17.6%	(18.8%)	6.6%	7.2%	(7.5%)	6.4%	25.2%	(32.4%)
Census Region 2	12.1%	5.1%	(4.6%)	4.0%	1.8%	(1.9%)	4.7%	2.3%	(1.2%)
Census Region 3	54.9%	47.6%	(45.2%)	51.3%	51.2%	(54.8%)	78.3%	63.2%	(58.7%)
Census Region 4	18.3%	29.8%	(31.3%)	38.1%	39.8%	(35.8%)	10.6%	9.3%	(7.6%)

Source: National Household Travel Survey 2009

a: If all adult members (18+ yrs old) are immigrants, the household is considered to be all-immigrant household

b: Active non-com. veh. are cars, vans, SVUs, and trucks without commercial license plates that are used in the previous year.

Table 2: Selected results of the ordered Probit model of the pooled data:
Effective coefficients and effective differences between groups

		Non-Hisp Whites		Hispanics		Blacks	
		Male	Female	Male	Female	Male	Female
Effective differences in automobility by immigration status							
Immigrant as a child	vs. Native	NS	NS	(+)	(-)	Omitted because the sample size of Black immigrants is very small	
Immigrant as an adult 15+yr	vs. Native	NS	--	++	--		
Immigrant as an adult 10-15yr	vs. Native	-	--	NS	--		
Immigrant as an adult 5-10yr	vs. Native	--	--	NS	--		
Immigrant as an adult 0-5yr	vs. Native	--	--	--	--		
Effective coefficients of the household member count							
Male adult (a)		--	--	--	--	--	NS
Female adult (b)		(-)	--	NS	--	NS	--
Diff. in Coeffs (b-a)		++	--	++	NS	++	--
HH with Children 16-17		NS	NS	NS	NS	NS	NS
HH with Children U16		NS	++	+	+	NS	++
Effective coefficients of the household income							
		++	++	++	++	++	++
Effective differences in automobility by work status and education							
Worker / No Degree	vs. Non-Wkr / No Degree	++	++	++	++	++	++
Worker / College degree	vs. Wkr / No Degree	++	NS	NS	++	NS	++
Model performance							
Observations		166,440					
df		147					
Wald Chi2		17,858					
Log Pseudo Likelihood		-92,968					
Pseudo R2		0.111					
++ / -- p<0.01, + / - p<0.05, (+) / (-) p<0.1							

++/- p<0.01, +/- p<0.05, (+)/(-) p<0.1

Table A-1 Full regression results

Ordered Probit	(1)					
	Baseline coefficients	Hispanic interaction terms	Black interaction terms	Female interaction terms	Hispanic & female interaction terms	Black & female interaction terms
y: autochoice (0-4)						
Race/ethnicity Dummy		-1.333*** (0.340)	-1.922*** (0.381)			
Female Dummy				-0.749*** (0.141)	0.111 (0.397)	0.673 (0.450)
Immigrant	-0.0197 (0.0435)	0.135* (0.0739)	0.0151 (0.153)	-0.0116 (0.0596)	-0.198** (0.0967)	0.214 (0.215)
Imm. at 16yr old or older	0.0756 (0.0665)	-0.0146 (0.0925)	0.127 (0.194)	-0.229*** (0.0844)	-0.0126 (0.116)	-0.241 (0.264)
Immigrant 10 to 15 yrs	-0.254** (0.104)	0.135 (0.140)	-0.0122 (0.290)	0.152 (0.127)	-0.200 (0.166)	-0.247 (0.358)
Immigrant 5 to 10 yrs	-0.450*** (0.109)	0.149 (0.137)	0.563* (0.318)	0.206 (0.132)	-0.152 (0.163)	-0.509 (0.356)
Immigrant 0 to 5 yrs	-0.651*** (0.108)	-0.00432 (0.159)	0.331 (0.394)	-0.0292 (0.135)	0.186 (0.187)	-0.392 (0.431)
Worker	0.304*** (0.0169)	0.167*** (0.0506)	0.238*** (0.0570)	0.293*** (0.0221)	-0.274*** (0.0623)	-0.274*** (0.0736)
College	0.248*** (0.0252)	0.0898 (0.103)	0.0965 (0.106)	0.0209 (0.0311)	0.213* (0.123)	0.0229 (0.128)
Worker*College	-0.136*** (0.0290)	-0.107 (0.117)	-0.113 (0.128)	-0.146*** (0.0378)	0.0646 (0.147)	0.165 (0.155)
ln(HH Income)	0.342*** (0.00956)	0.0470* (0.0258)	0.194*** (0.0292)	0.0625*** (0.0118)	0.00843 (0.0298)	-0.123*** (0.0338)
Num. of Male Adult in HH	-0.249*** (0.0138)	0.119*** (0.0363)	-0.0264 (0.0467)	0.165*** (0.0177)	-0.0973** (0.0436)	0.0600 (0.0577)
Num. of Female Adult in HH	-0.0257* (0.0147)	0.0282 (0.0363)	0.00120 (0.0472)	-0.134*** (0.0188)	0.0413 (0.0454)	-0.0195 (0.0571)
HHs with Children 16-17 yr old	0.0363 (0.0265)	0.0710 (0.0759)	-0.0393 (0.0960)	0.00319 (0.0333)	-0.0994 (0.0880)	-0.0222 (0.112)
HHs with Children U16	-0.0103 (0.0148)	0.100** (0.0441)	0.0416 (0.0560)	0.177*** (0.0183)	-0.198*** (0.0519)	-0.0665 (0.0661)
One-Adult HH Dummy	0.0543* (0.0295)	-0.00994 (0.102)	-0.151 (0.0921)	0.260*** (0.0385)	-0.213* (0.122)	-0.266** (0.109)
ln(Pop Density)	-0.0675*** (0.00548)	0.00327 (0.0185)	-0.0919*** (0.0242)	-0.00388 (0.00691)	-0.0216 (0.0221)	0.0406 (0.0283)
Urban Size 2	0.0439 (0.0271)	0.112 (0.103)	-0.0113 (0.0940)	-0.0207 (0.0345)	0.0113 (0.123)	0.114 (0.114)
Urban Size 3	0.0667** (0.0285)	0.0681 (0.0905)	0.0164 (0.110)	-0.0322 (0.0364)	0.0619 (0.105)	0.126 (0.130)
Urban Size 4	0.0624*** (0.0238)	0.112 (0.0783)	0.0195 (0.0869)	-0.0459 (0.0305)	-0.0734 (0.0921)	0.0353 (0.106)
Urban Size 5	-0.0776*** (0.0268)	0.0653 (0.0820)	0.0603 (0.0996)	-0.0919*** (0.0339)	0.0749 (0.0968)	0.0875 (0.118)
Urban Size 6	-0.0132 (0.0218)	0.0669 (0.0829)	-0.131 (0.0952)	-0.0871*** (0.0278)	0.0472 (0.0989)	0.230** (0.113)
Census Region 2	0.392*** (0.0241)	0.349** (0.146)	0.0613 (0.142)	-0.164*** (0.0303)	0.00447 (0.160)	0.220 (0.163)
Census Region 3	0.362*** (0.0172)	0.359*** (0.0814)	0.136 (0.100)	-0.0797*** (0.0220)	0.153* (0.0911)	0.388*** (0.117)
Census Region 4	0.172*** (0.0211)	0.367*** (0.0823)	0.373*** (0.119)	0.0636** (0.0274)	0.114 (0.0924)	0.201 (0.137)
Constant cut1	1.191*** (0.113)					
Constant cut2	1.731*** (0.113)					
Constant cut3	2.178*** (0.113)					
Constant cut4	2.365*** (0.113)					
Wald Chi2	17,858					
Log Pseudo Likelihood	-92,968					
Pseudo R2	0.111					
Observations	166,440					

Errors are clustered by household, robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Figure 1

Fig.1 Processes to determine the personal automobility level (0 to 4)

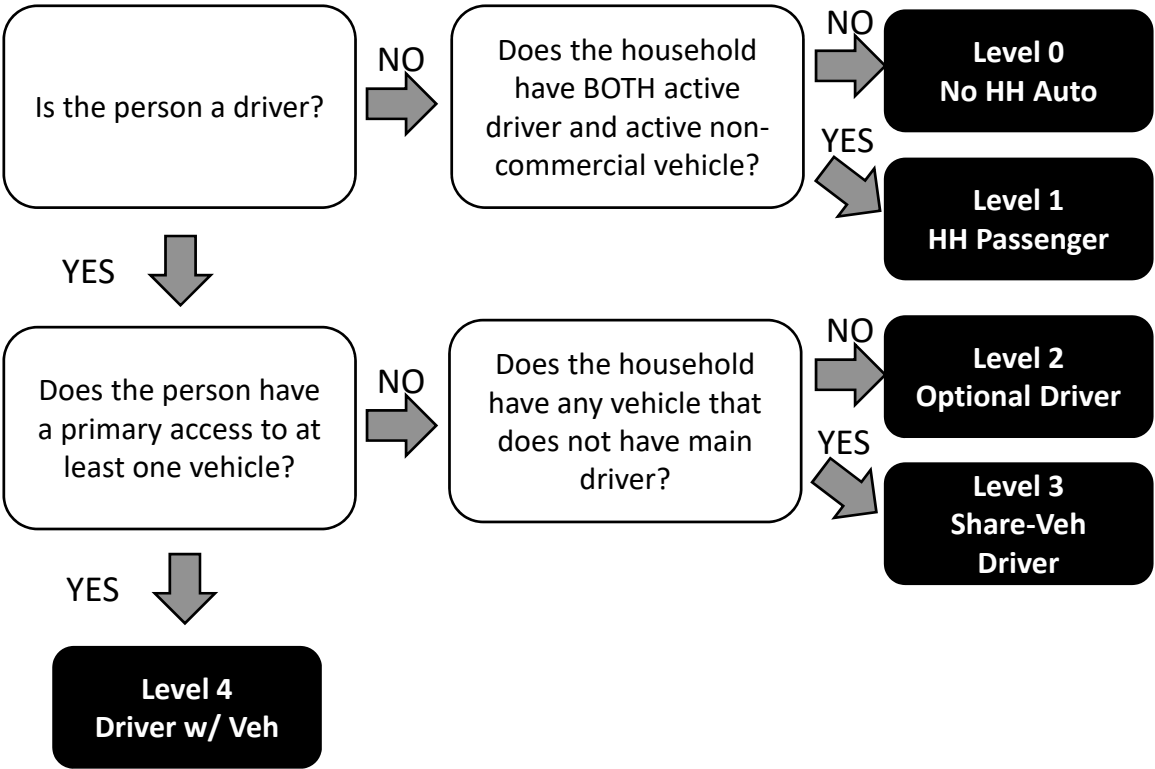


Figure 2

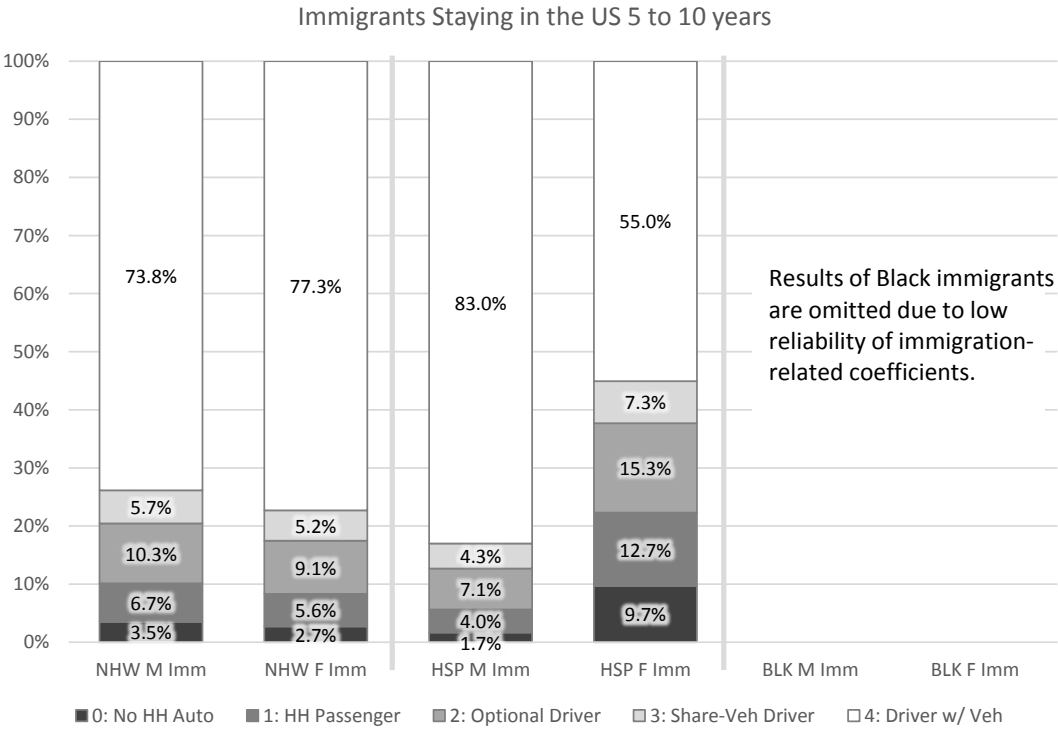
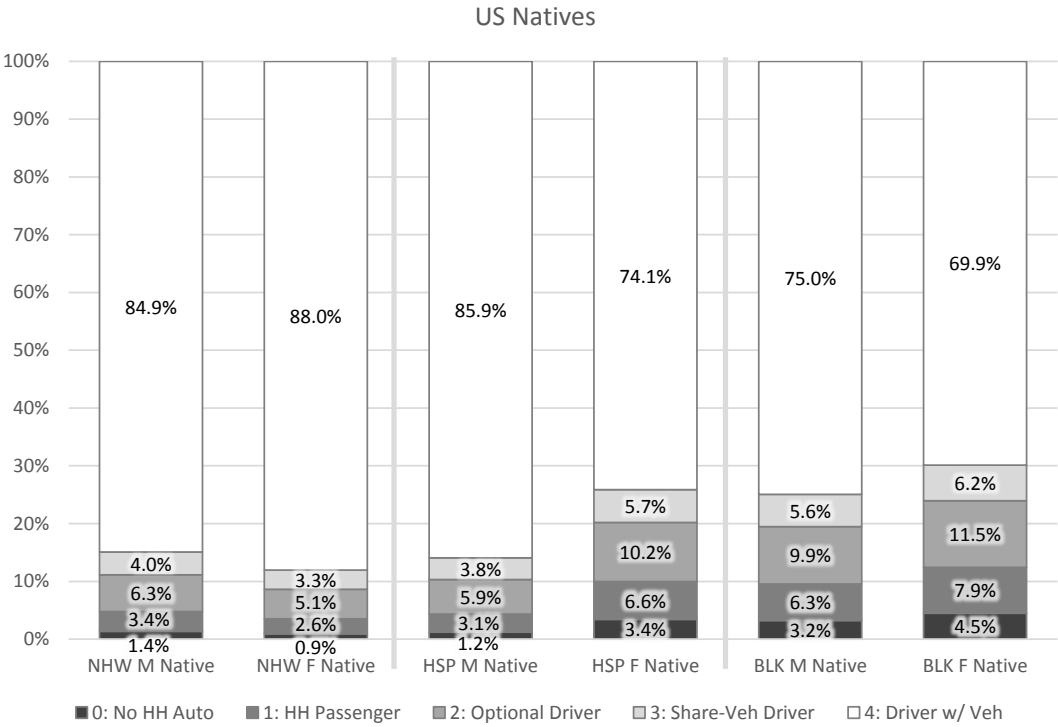


Figure 3

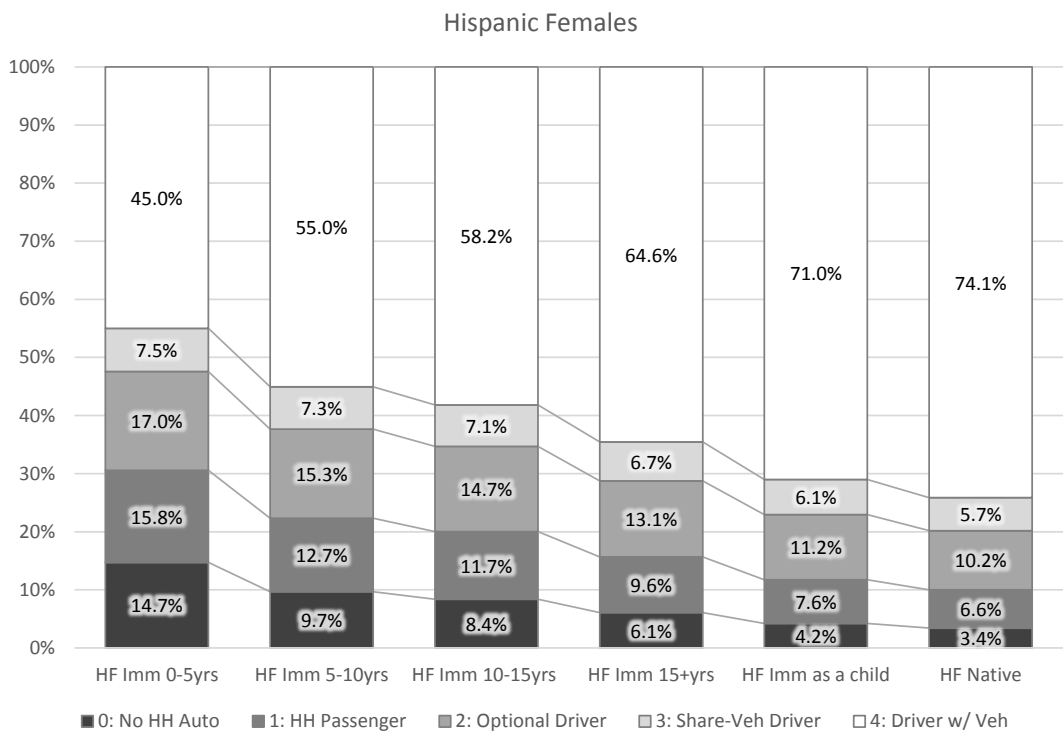
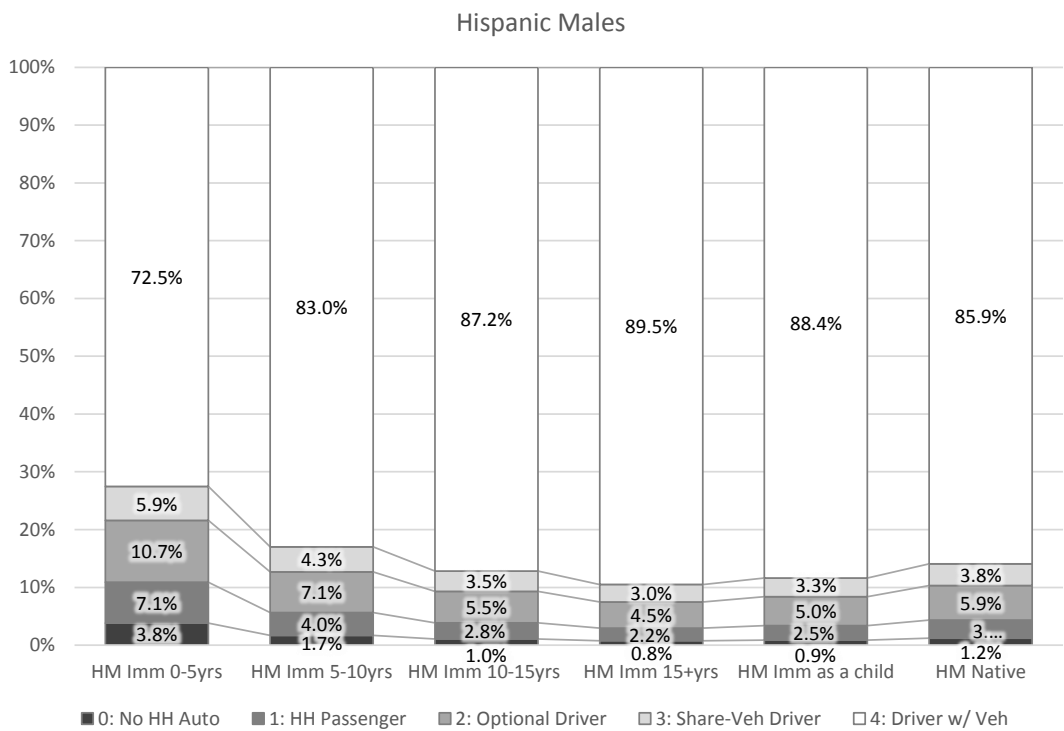


Figure 4

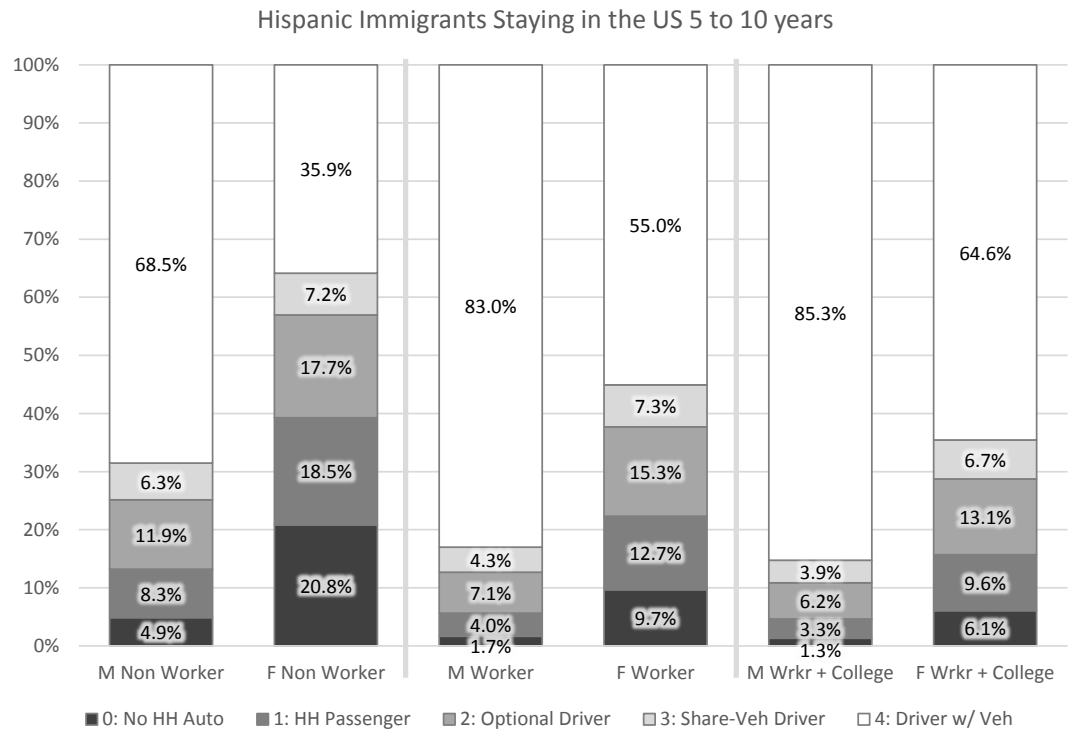
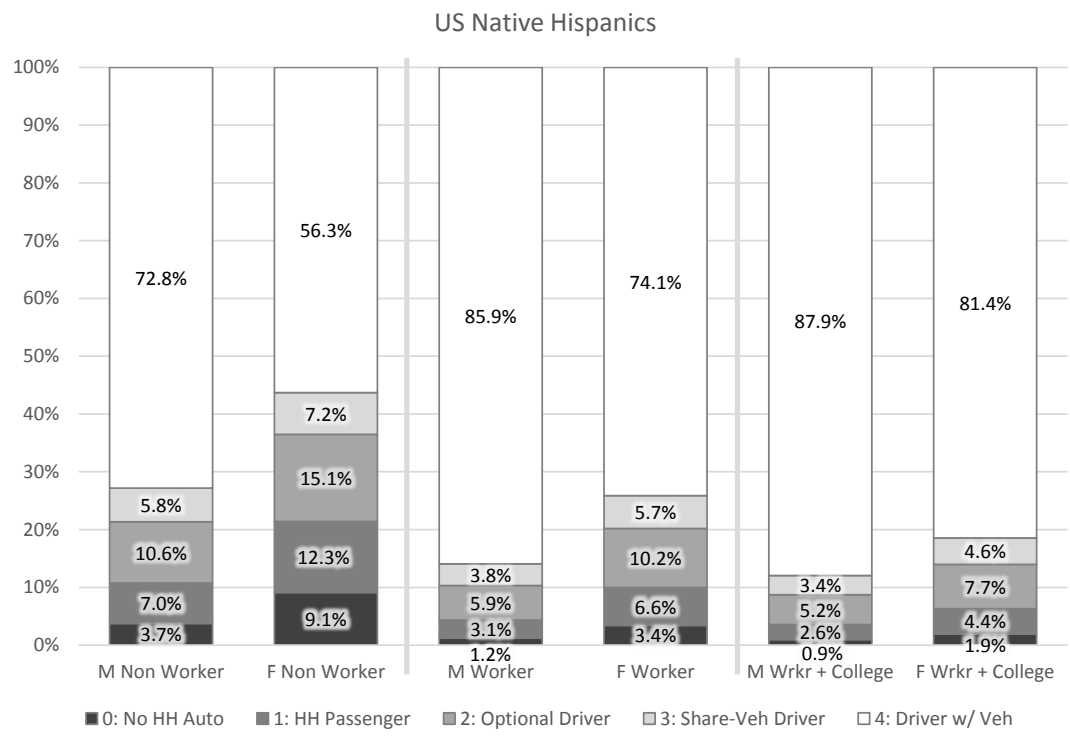


Figure 5

Fig. 5: Predicted gender differences among non-Hispanic White natives and immigrants and Black natives in personal automobility by worker status and educational attainment level

