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What type of vehicle do people drive? The role of attitude and lifestyle in influencing vehicle type choice

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Abstract

Traditionally, economists and market researchers have been interested in identifying the factors that affect consumers' car buying behaviors to estimate market share, and to that end they have developed various models of vehicle type choice. However, they do not usually consider consumers' travel attitudes, personality, lifestyle, and mobility as factors that may affect the vehicle type choice. The purpose of this study is to explore the relationship of such factors to individuals' vehicle type choices, and to develop a disaggregate choice model of vehicle type based on these factors as well as typical demographic variables. The data for this study comes from a 1998 mail-out/mail-back survey of 1904 residents in the San Francisco Bay Area. The dependent variable (the vehicle type the respondent drives most often) is classified into nine categories: small, compact, mid-sized, large, luxury, sports, minivan/van, pickup, and sport utility vehicle. Based on these categories, we first related vehicle type to travel attitude, personality, lifestyle, mobility, and demographic variables individually, using one-way analysis of variance and chi-squared tests. Then, a multinomial logit model for vehicle type choice was estimated. The final model (which possessed the IIA property) confirmed that the variables analyzed significantly affect an individual's vehicle type choice. These results provide useful background not only to vehicle manufacturers, but also to decision makers and planners of transportation policy related to vehicle ownership, traffic congestion, and energy consumption.

1. Introduction

The US is a highly motorized society. As such, each year nearly 200 new vehicle models are produced by domestic and foreign vehicle manufacturers, and millions of new vehicles are sold.

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There is a wide range of makes and models, and people make choices based on their own preferences and needs when choosing which car to buy. Historically, different vehicle types have been popular in various time periods: for example, small and compact cars in the mid-1970s, minivans in the 1980s, pickups/sport utility vehicles in the 1990s. What determines the preference for and choice of a certain kind of car? What characteristics do people who drive the same kind of car have in common? What can attitudes, personality, and lifestyle characteristics tell us about vehicle type choices, compared to the role of demographics?

Traditionally, economists and market researchers have been interested in identifying the factors that affect consumers' car buying behaviors to estimate market share, and to that end they have developed various models of vehicle type choice. Specifically, such disaggregate choice models as multinomial logit (e.g. Lave and Train, 1979; Manski and Sherman, 1980; Mannering and Winston, 1985; Kitamura et al., 2000) and nested logit (e.g. Hocherman et al., 1983; Berkovec and Rust, 1985; Berkovec, 1985; Mannering et al., 2002) have been used to explain vehicle type choice. These models are generally focused on vehicle attributes (such as operating and capital costs, horsepower, and fuel efficiency), household characteristics (such as number of household members, number of vehicles, and household income), and principal driver characteristics (such as age, education, and income) (Train, 1986; Golob et al., 1997). However, they do not usually consider consumers' travel attitudes, personality, lifestyle, and mobility as factors that may affect the vehicle type choice.

Of course, there are stereotypes for what kind of person drives a certain vehicle make and model, assuming that attitudes influence the vehicle type choice. However, a better understanding of the relationships between travel attitude, personality, or lifestyle factors and vehicle type choices will improve vehicle type choice models. Furthermore, although perhaps not directly susceptible to policy intervention, a better understanding of these relationships will be useful background for decision makers and transportation planners developing transportation policies related to vehicle ownership, traffic congestion, and energy consumption. For example, it is relevant to learn, as our study found, that those with strong "pro-high density" attitudes—and who therefore might be amenable to living in a neo-traditional residential neighborhood—are also more likely to be driving a sport utility vehicle (SUV) or a luxury car, neither of which are generally fuel-efficient alternatives.

The purpose of this study is to explore the travel attitude, personality, lifestyle, and mobility factors that affect individuals' vehicle type choices, and to develop a disaggregate choice model of vehicle type based on these factors as well as typical demographic variables. The data for this study comes from a 1998 mail-out/mail-back survey of 1904 residents in the San Francisco Bay Area. The dependent variable, make and model of the vehicle the respondent drives most often, is classified into nine vehicle type categories: small, compact, mid-sized, large, luxury, sports, minivan/van, pickup, and SUV. Based on these vehicle categories, we explore questions such as how travel attitude affects type of vehicle driven, what kind of person chooses a particular vehicle type, or whether mobility affects the type of vehicle driven.

The following section discusses key literature related to vehicle type choice models. Then, we describe the characteristics of our sample, the vehicle classification we used in this study, and key explanatory variables included in the vehicle type choice model. We next present descriptive analyses relating vehicle type to travel attitude, personality, lifestyle, mobility, and demographic variables individually, using one-way analysis of variance and chi-squared tests, and then a multinomial logit model for vehicle type choice is developed. Finally, conclusions and limitations are discussed.

2. Review of relevant literature

Most published studies of vehicle type choice concentrate on vehicle attributes, household and primary driver characteristics, and brand loyalty. There is little open literature on vehicle type choice focusing on travel attitude, personality, and lifestyle factors (there are doubtless numerous proprietary studies of the role of these factors in vehicle type choice). Nevertheless, the review of this topic is helpful in identifying the types of models that have been used in this area, and the explanatory variables that have previously been found to affect vehicle type choice.

Table 1 summarizes the vehicle type choice models reviewed, comparing model types, dependent variables, significant explanatory variables, and data. As mentioned before, disaggregate choice models (multinomial logit and nested logit) are generally used for the vehicle type choice, and vehicle and household characteristics generally constitute the explanatory variables in the models. These vehicle type choice models can be further divided into two categories, vehicle holdings and vehicle purchase models, depending on whether the chosen vehicle type is viewed as already owned or newly purchased. In contrast to those for vehicle purchase, the models for vehicle holdings usually include scrappage rate, transaction cost, and vehicle age as explanatory variables.

However, it is difficult to compare significant variables across the vehicle type choice models because each model has a different set of vehicle type categories such as vehicle classes and makes/models. Not surprisingly, the most common variable is vehicle price, which is significant across all models except Kitamura et al. (2000). That is, all else equal, the more a vehicle costs, the lower its choice probability. Of greatest interest to the present study is the impact of demographic variables on vehicle type choice, with income, age, gender, and number of household members positively affecting the choice probability of vehicle type in one or more models.

The data used in our study were not collected with a vehicle type choice model in mind, so we do not have a full inventory of all households' vehicles, including their acquisition history. We have only the make, model, and year of the single vehicle driven most often by the respondent. However, in addition to the demographic characteristics normally used in vehicle type choice models, we have unique data on attitudes, personality, and lifestyle that are also relevant to vehicle choice. In this study, then, we develop models of most-often-driven vehicle class using the full range of individual characteristics available in our data set. Over a large enough sample, one would expect the distribution of vehicle types driven most often to roughly reflect the distribution of vehicle holdings (and in fact that distribution is identical for single-vehicle households). In any case, the distribution of vehicle types driven most often is arguably the most directly relevant (better even than the distribution of vehicles newly-purchased) to analyzing the consequential fuel consumption and emissions.

3. Data

The data for this study come from a 14-page mail-out/mail-back survey containing questions about attitudes toward travel, lifestyle and personality, mobility, travel liking, and demographics.

Table 1
Summary of vehicle type choice models

Reference	Data location (year)	Sample size	Model type	Dependent variable	Significant explanatory variables
Lave and Train (1979)	Seven US cities (1976)	541 new car buyers	Multinomial logit model (vehicle type purchased)	10 vehicle classes • Subsubcompact • Sports • Subcompact (A and B) • Compact (A and B) • Intermediate • Standard (A and B) • Luxury	• Purchase price/income (−) • Weight*age (+) • No. of household members (+, for subsubcompact and subcompact A) • No. of vehicles (+)
Manski and Sherman (1980)	US (1976)	1200 single-vehicle or two-vehicle households	Multinomial logit model (vehicle holdings)	Chosen alternative plus 25 alternative makes/models/vintage (randomly selected from 600 vehicle types)	• Purchase price (−) • No. of seats (+) • Vehicle weight and age (+) • Acceleration time (+) • Luggage space (+) • Scrappage rate (−) • Transaction-search cost (−) • Operating cost and low income household (−)
Mannering and Winston (1985)	US (1978–1980)	3842 single-vehicle or two-vehicle households	Multinomial logit model (vehicle holdings)	Chosen alternative plus nine alternative makes/models/vintages (randomly selected from 2000 vehicle types)	• Purchase price/income (−) • Operating cost/income (−) • Lagged utilization of same vehicle or same make (+)
Kitamura et al. (2000)	South Coast (Los Angeles) metropolitan area (1993)	1898 households	Multinomial logit model (vehicle holdings, most recent vehicle for multi-vehicle households)	Six vehicle classes • 4-door sedan • 2-door coupe • Van/wagon • Sports car • Sports utility • Pickup truck	• Age (+, for 4-door, 2-door, and van/wagon) • Male (−, for all but pick up) • College degree (+, for 4-door) • No. of household members (+, for van/wagon) • Income (+, for SUV) • Transit accessibility (+, for 4-door)

Hocherman et al. (1983)	Haifa urban area, Israel (1979)	800 households buying a new or used car	Nested logit model (vehicle type purchased)	Upper level: buying a first car or replacing an existing car	Lower level: chosen alternative plus 19 alternative makes/models/vintages (randomly selected from 950 vehicle types)	• Purchase price (−) • Operating cost (−) • Engine size (+) • Vehicle age (−) • Income (+) • Brand loyalty (+) • No. of same make cars (+) • Horsepower to weight (+)
Berkovec and Rust (1985)	US (1978)	237 single-vehicle households	Nested logit model (vehicle holdings)	Upper level: vehicle age groups • New (1977–1978) • Mid (1973–1976) • Old (1967–1972)	Lower level: 5 vehicle classes • Subcompact • Compact • Intermediate • Standard • Luxury/sports	• Purchase price (−) • Operating cost (−) • No. of seats (+) • Vehicle age (−) • Turning radius in urban (−) • Horsepower to weight (+) • Transaction (+)
Berkovec (1985)	US (1978)	1048 households	Nested logit model (vehicle holdings)	Upper level: no. of vehicles (0, 1, 2, and 3)	Lower level: 131 vehicle classes and vintages • 10 years (1969–1978) • 13 vehicle classes each year: (domestic) subcompact, compact, sporty, intermediate,standard, luxury, pickup truck, van, and utility vehicle; (foreign) subcompact, larger, sports, and luxury • All models before 1969	• Purchase price (−) • No. of seats (+) • Proportion of makes/models in class to total makes/models (+)
Mannering et al. (2002)	US (1993–1995)	654 households buying new vehicles	Nested logit model (vehicle purchased)	Upper level: vehicle acquisition type • Cash, non-cash (lease, finance)	Lower level: chosen alternative plus 9 alternative makes and models (randomly selected from 175 vehicle types)	• Purchase price/income (−) • Passenger side airbag (+) • Horsepower (+) • Vehicle residual value (+) • Consecutive purchases (+)

Note: Sign in parentheses means positive or negative effect on the choice of the associated vehicle type.

The surveys were sent to 8000 randomly selected households in three neighborhoods of the San Francisco Bay Area in May and June, 1998: Concord, Pleasant Hill, and an area defined as North San Francisco. Here, as defined by Kitamura et al. (1994), Concord and Pleasant Hill represent suburban neighborhoods, and North San Francisco represents an urban neighborhood. North San Francisco has more mixed land uses, higher residential density, and a more grid-like street system compared to the suburban examples. On the other hand, Concord has more segregated land uses and lower residential density. Pleasant Hill was selected to represent another part of the spectrum of suburban neighborhoods. Compared to Concord, Pleasant Hill has greater residential density, indicating fewer single-family homes.

Half of the total surveys were sent to North San Francisco and the other half were divided evenly between Concord and Pleasant Hill. Approximately 2000 surveys were completed by a randomly-selected adult member of the household (the person age 18 or older whose birthday was closest to the cover letter date) and returned. After screening out surveys with too much missing data on key variables, we were left with 1904 surveys for an overall response rate of 23.8% (22.2% for North San Francisco, 23.7% for Concord and 27.2% for Pleasant Hill).

4. The key variables

4.1. The dependent variable

One question on the survey asked for the make, model, and year of the vehicle the respondent drives most often, with a "not applicable" response for completeness. In a previous study on these data, Curry (2000) created a vehicle type variable based on vehicle makes and models. The makes and models were classified into ten categories mostly based on the classification scheme presented in *Consumer Reports* magazine (1956–1998): subcompact, small, compact, [2] mid-sized (at one time referred to as "medium" by *Consumer Reports*), large, luxury, sports, minivan/van, pickup, and SUV. He also assumed (as we do) that the *Consumer Reports*' classification scheme accurately reflects consumer perception, even though the definition of categories has changed from year to year. [3] That is, a make/model combination is classified according to its *Consumer Reports* designation for that model year, even if the same make and model are classified differently today. Table 2 shows some other vehicle classification schemes found in the academic literature and in statistical reports. These schemes are focused on vehicle size, vehicle function, or both. Similar to the *Consumer Reports* classification system, most schemes of vehicle classification first group vehicles by size, and then special categories such as sports, pickup, and SUV are added.

[2] *Consumer Reports* distinguished compact and mid-sized cars by saying that compact cars are "models that offer practical transportation for a small family", while mid-sized cars are models that are "bigger and roomier than compacts but priced about the same" (*Consumer Reports*, April 1991, p. 246).

[3] Some vehicle categories used by *Consumer Reports* have entered and dropped out in particular time periods. For example, the "subcompact car" classification has not been used since 1980, while "sports car" and "SUV" were created in 1984 and 1990, respectively. In particular, the size of a "mid-sized car" has not been consistent across all time periods, especially in periods without a "compact car" category (1980–1983 and 1995–1998).

Table 2
Vehicle classification schemes

Item	Source	Vehicle classification	Basis
Academic literature	Kitamura et al. (2000)	4-door sedan, 2-door coupe, van/wagon, sports car, sports utility, pickup truck	Function
	Lave and Train (1979)	Subsubcompact, sports, subcompact-A, subcompact-B, compact-A, compact-B, intermediate, standard-A, standard-B, luxury	Size
	Berkovec and Rust (1985)	Subcompact, compact, intermediate, standard, luxury/sports	Size
	Murtaugh and Gladwin (1980)	Minicompact, sports-specialty, subcompact, sporty, compact, sports sedan, intermediate, large 1, large 2, luxury	Size
	Golob et al. (1997)	Minicompact, subcompact, compact, mid-sized, full-sized, sports, compact pickup, full-sized pickup, minivan, full-sized van, compact SUV, luxury, full-sized SUV	Size
Statistical reports	NPTS (FHWA, 1997)	Automobile (including wagon), van, SUV, pickup, other truck, RV, motorcycle, other	Function
	NTS (BTS, 1999)	Minicompact, subcompact, compact, mid-sized, large, two-seater, small pickup, large pickup, small van, large van, small utility, large utility	Size & function
	EPA (1996)	Two-seater, minicompact, subcompact, compact, mid-sized, large, station wagon (small & mid-sized), pickup (small & standard by 2wd & 4wd), van (cargo & passenger type), special purpose vehicle (2wd & 4wd)	Size & function
	Consumer Reports (Consumers Union, 1995)	Small, mid-sized, large, luxury, sports, minivan, SUV, pickup	Size & function

Notes: Vehicle function generally refers to engine size, wheel drive, and specialty.
BTS: Bureau of Transportation Statistics; EPA: Environmental Protection Agency; FHWA: Federal Highway Administration; NPTS: Nationwide Personal Transportation Survey; NTS: National Transportation Statistics.

In this study, the nine vehicle categories currently used in *Consumer Reports* define the values of the dependent variable for the vehicle type choice model. The first five categories are classified in order of vehicle size and the other categories are added to represent specialized vehicles. Certain vehicles in other categories such as "minicompact" or "subcompact" were included in the "small" category, and "sedan" or "wagon" types were reclassified into categories based on each vehicle's size. These nine categories are obviously less detailed than specific make/model combinations, but the sample size is not large enough to permit analysis at that level of detail.

Fig. 1 presents the distribution of vehicle types in our sample. The "small" (19.5%) and "mid-sized" (18.5%) categories are the largest, while the "large" (2.8%) and "luxury" (3.0%) categories are the smallest. While classifying the sample vehicle makes and models into the nine categories, some cases with missing values of either makes or models could not be fit into an appropriate category, and these were classified as "unspecified". From an original sample of 1904 cases,

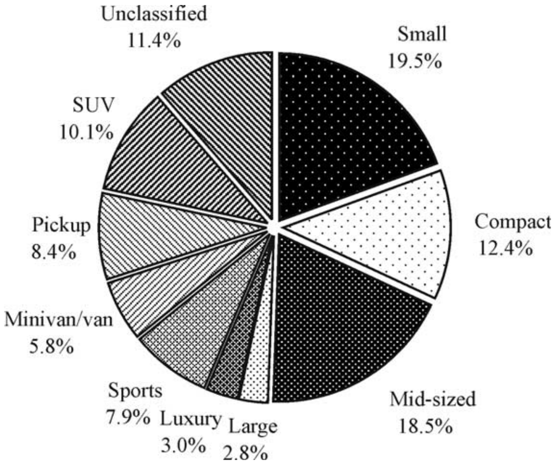

Fig. 1. Sample distribution of vehicle types ($N = 1904$).

217 (11.4%) could not be classified into one of the nine types, including 29 (1.5%) missing cases, 68 (3.6%) "unspecified" cases, 9 (0.5%) other means cases (such as motorcycle and bus), and 111 (5.8%) "not applicable" (do not drive or do not have a vehicle available) cases. All unclassified cases were of necessity excluded from this study.

4.2. The explanatory variables

The key explanatory variables used in the models can be grouped into seven categories: objective mobility, subjective mobility, travel liking, attitudes, personality, lifestyle, and demographics. The two mobility categories and the travel liking category of variables had similar structures. In each case, measures were obtained both overall and separately by purpose and mode, for short-distance and long-distance travel. The short-distance purposes measured in the survey were: commute, work/school-related travel, grocery shopping, to eat a meal, for entertainment/social/ recreational activities, and for the purpose of taking others where they need to go. The short-distance modes measured were: personal vehicle, bus, train/BART (heavy rail)/light rail and walking/jogging/bicycling. Long-distance measures were obtained for the work/school-related and entertainment/social/recreational purposes, and for the personal vehicle and airplane modes. The standardized factor scores measuring attitudes, personality, and lifestyle were developed in a previous study (Redmond, 2000; Mokhtarian et al., 2001). Each category is briefly described below.

4.2.1. Mobility

Objective mobility

In addition to separate questions on one-way commute time and distance, this group of questions asks about the amount of travel by mode and purpose in terms of distance and frequency for short- and long-distance trips. These responses can only be considered estimates of the amount of travel rather than accurate measures. For long-distance trips, respondents were asked to record the number of trips they took in the calendar year 1997, in each mode–purpose category, by region of the world. These responses indicated number of trips directly, and were also converted into approximate distances by measuring from a central position in the Bay Area to a central location within the destination region. Then, we created three different measures of distance: total miles (the simple sum of the estimated miles for each reported trip in the category), log of miles (the natural logarithm of one plus the total number of miles in the category), and sum of the log-miles (obtained by taking the natural logarithm of one plus the number of miles of each trip in the category *separately*, and summing across all trips in the category).

The latter two measures represent a diminishing marginal contribution of distance, with the last one giving some weight to trips as well as distance. The sum of the natural log of miles for each trip gives more weight to a larger number of trips traveling the same number of miles, compared to the natural log of the total miles. For example, the natural log of total travel for nine trips to Western States ($\ln[9 \times 700 + 1] = 8.75$) is roughly the same as that for one trip to Asia ($\ln[1 \times 7500 + 1] = 8.92$). However, summing the natural log of each trip (the third measure) results in values of 58.97 ($= 9 \times \ln[700 + 1]$) for the Western States trips and 8.92 ($= 1 \times \ln[7500 + 1]$) for the Asia trip. This reflects the idea that each trip comes with a certain amount of "effort overhead" that is not directly proportional to its length, and thus the nine Western States trips carry greater weight than the single Asia trip (adapted from Curry, 2000).

The hypothesized relationships of objective mobility to vehicle type are indirect, with mobility serving as an indicator or proxy for an underlying cause or effect. For example, those who travel a lot by airplane may be more likely to drive a comfortable or expensive car (luxury category) because both characteristics are indicative of a high-income lifestyle, or because frequent flyers may place a higher value on comfort and time while traveling. One could also speculate that vehicle type affects objective mobility as well. However, a previous study (Redmond and Mokhtarian, 2001; Mokhtarian et al., 2001) of objective mobility using the same data set found that actual amounts of travel (e.g. weekly miles traveled) are significantly affected not by vehicle type but by travel attitudes, personality, and lifestyle in addition to demographic variables such as income and household size.

Subjective mobility

We are interested not only in the objective amount an individual travels, but also in how that amount of travel is perceived. One person may consider 100 miles a week to be a lot, while another considers it minimal. For each of the same overall, purpose, and mode categories for short- and long-distance, respondents were asked to rate the amount of their travel on a five-point semantic-differential scale anchored by "none" to "a lot". The previous study (Collantes and Mokhtarian, 2002) that modeled these variables shows that objective mobility is strongly positively related to subjective mobility, accounting for more than 50% of the variance explained by each model. Thus, we expect that subjective mobility has effects on vehicle type that are similar to those of objective mobility. It can also be hypothesized that those who perceive they do a lot of travel may be more likely to use a larger, more powerful, and/or more luxurious car (pickup, luxury, sports, and SUV categories) in order to accomplish their travel more comfortably.

4.2.2. Travel liking

These questions ask how much respondents enjoy traveling itself (distinguished in the survey instructions from the activity at the destination), for each of the same overall, purpose, and mode categories for short- and long-distance. All responses are rated on a five-point scale ranging from "strongly dislike" to "strongly like". The hypothesized relationship of travel liking to vehicle type is ambiguous. Those who dislike travel may be more likely to use a larger and more comfortable car (large and luxury categories) to make the unpleasantness of travel more palatable, whereas those who like their travel may prefer similar kinds of cars, to make their travel even more enjoyable.

4.2.3. Attitudes

The survey contained 32 attitudinal statements related to travel, land use, and the environment, to which individuals responded on the five-point Likert-type scale from "strongly disagree" to "strongly agree". These 32 variables were then distilled, through factor analysis, into six underlying dimensions: travel dislike, pro-environmental solutions, commute benefit, travel freedom, travel stress, and pro-high density. (For details on the definition of these and the personality and lifestyle factors, see Redmond, 2000 or Mokhtarian et al., 2001. When discussing results below, we provide further information on the nature of the significant factors.)

Alternate hypotheses are plausible. On the one hand, an individual may enjoy traveling *because* she drives a luxurious car, or a fun car (sports or SUV categories). Or, an innate love of travel may prompt a person to buy a car that supports that feeling. On the other hand, those who dislike travel may be more likely to use a larger car (large, luxury, and SUV categories) because they seek to be more comfortable and to minimize travel fatigue even for short-distance trips. Those who have the freedom to travel anywhere they want and relatively low travel stress may be more likely to use a more powerful car or a leisure car (sports and SUV categories). Those who strongly support pro-environmental policies are more likely to prioritize reducing mobile source emissions and therefore to drive a smaller car (small and compact categories). Those who like living in high-density areas may choose a smaller car (small and compact categories) because they have accessible public transit and restrictions on parking, making them less likely to commute by car. Those who recognize benefits of commuting may be more likely to use a more comfortable or versatile car (luxury category) that allows them to do other activities such as playing CDs while driving.

4.2.4. Personality

Respondents were asked to indicate how well (on a five-point scale from "hardly at all" to "almost completely") each of 17 words and phrases described their personality. Each of these traits was hypothesized to relate in some way to one's orientation toward travel, or to reasons for wanting to travel for its own sake. These 17 attributes reduced to four personality factors: adventure seeker, organizer, loner, and the calm personality. We expect that adventure seekers may be more likely to use a powerful car (sports and SUV categories) that fits their self-image and/or allows them the flexibility needed for a variety of activities and outdoor adventures. Conversely, calm people may be less likely to use such car types, which are typically associated with more aggressive drivers. Loners are probably less likely to use a family car (minivan/van category).

4.2.5. Lifestyle

The survey contained 18 Likert-type scale statements relating to work, family, money, status and the value of time. These 18 questions comprised four lifestyle factors: status seeker, workaholic, family/community-oriented, and a frustrated factor. Several hypotheses can be made.

Frustrated people may be less likely to use a more powerful car (sports and SUV categories) because such cars may be a symbol of confidence and control. Family-oriented people are presumably more likely to use a family car (minivan/van category). Status seekers are more likely to drive an expensive car (luxury and sports categories) because such cars are common status symbols in modern society.

4.2.6. Demographics

The demographic variables include neighborhood, gender, age, education and employment information, and household information such as number of people in the household, their age group, and personal and household income.

5. Descriptive analyses

We conducted descriptive analyses using one-way analysis of variance (ANOVA) and chi-squared tests to identify statistical differences among groups classified by vehicle type. The ANOVA test was used for continuous or quasi-continuous variables such as the travel attitude, personality, lifestyle, mobility, and travel liking variables, while the chi-squared test was used for categorical variables such as gender or neighborhood. (Although the five-point subjective mobility and travel liking scales are, strictly speaking, purely ordinal variables, it is common practice to treat such variables as effectively continuous, i.e. ratio-scaled, by assigning them equally-spaced integer values, combining them into composite scales through simple addition or more complex approaches such as factor analysis, and so on—see e.g. Babbie, 1998.) The Bonferroni multiple comparisons test was additionally conducted for the variables that had statistical differences among vehicle type groups based on the ANOVA test, to identify which categories are significantly different from other categories.

Here, we briefly summarize the key characteristics associated with each vehicle type, focusing on the variables that are significantly different among vehicle type groups at a level of $\alpha = 0.05$ (see Choo and Mokhtarian, 2002 for a more detailed discussion). All vehicle type groups, except the mid-sized car group, have distinct characteristics with respect to the key variables. The mid-sized car group tends to be "middle-of-the-road" in its characteristics. Also, no significant differences across vehicle types were found with respect to the commute time and commute distance variables. The distinct characteristics for each vehicle category are as follows:

- *Small car*. Small car drivers tend to have stronger pro-environmental (supporting environmental solutions to improve air quality and reduce congestion) and pro-high density (preferring higher-density residential locations like urban neighborhoods) attitudes, and a weaker travel freedom (representing the ability to "go anywhere I want to") attitude. They tend to be loners (who "like being alone"), and not workaholics (who put a high priority on work) or status seekers (who seek higher social status related to wealth and want to display their wealth). Additionally, small car drivers tend to perceive themselves as traveling less for short-distance trips in a personal vehicle than others do, and are less likely to enjoy personal vehicle travel. In terms of demographic characteristics, the small car driver group has higher than average proportions of North San Francisco residents, females, people age 40 or younger, and people with 4-year college degrees. It also has higher proportions in clerical or professional jobs, and lower incomes. In particular, small car drivers are overrepresented in single-vehicle and single-adult households.

- *Compact car*. Compact car drivers tend to have a weaker travel freedom attitude, and travel less for long-distance trips by personal vehicle. They tend to perceive that they travel less by personal vehicle and overall short-distance. Similar to small car drivers, the compact car driver group has higher proportions in professional jobs and single-vehicle households. In addition, they are overrepresented in middle income categories, and especially in single-adult households.
- *Mid-sized car*. Mid-sized car drivers have no distinct travel attitude, personality, lifestyle, mobility, or travel liking characteristics. On demographic traits, mid-sized car drivers are more likely than average to be females or homemakers, and to have higher incomes or larger households.
- *Large car*. In contrast to small car drivers, large car drivers tend to have weaker pro-environmental and pro-high density attitudes. They are also more likely to be Concord residents, males, older or retired people, and part-time employees. Interestingly, large car drivers are overrepresented among less educated or lower income people. They are also overrepresented in multi-vehicle or older-adult households. We speculate that the large cars driven by these groups may tend to be second-hand.
- *Luxury car*. Luxury car drivers are more likely to be status seekers, and to travel long-distance by airplane a lot. They are more likely to be North San Francisco residents, males, and older or retired people. In particular, luxury car drivers are overrepresented among highly educated or higher income people. Similar to large car drivers, the luxury car driver group has higher than average proportions in multi-vehicle or older-adult households.
- *Sports car*. Sports car drivers are more likely to be adventure seekers (who are "adventurous", "risk-taking", and "variety-seeking"), and less likely to be calm ("patient" and less "aggressive"). They are more likely than average to have 4-year college degrees or lower incomes. Additionally, sports car drivers are overrepresented in two-worker or younger-adult households.
- *Minivan/van*. Minivan drivers tend to have a weaker pro-high density attitude. They tend to be calm, and not to be loners. Minivan drivers tend to perceive that they travel more by personal vehicle and overall short-distance than others do. Further, they tend to enjoy traveling by personal vehicle more than average. In terms of demographics, minivan drivers are more likely to be Concord residents, females, homemakers, or age 41–64. They also tend to have higher household incomes as well as lower personal incomes. Minivan drivers are overrepresented in multi-vehicle households or larger households with children.
- *Pickup*. Pickup drivers tend to have a weaker pro-high density attitude, and are more likely to be frustrated (feel less in control and less satisfied with their life) and workaholic. Their short-distance travel is higher than average, while their long-distance travel by airplane is lower. Likewise, pickup drivers tend to perceive their long-distance travel by airplane as lower than others do. Demographically, pickup drivers are more likely to be Pleasant Hill residents, males, and age 41–64. They are also overrepresented among lower education levels, full-time employees, service-related jobs, middle incomes, and two-vehicle households.
- *SUV*. SUV drivers tend to have a stronger travel freedom attitude, and are less likely to be frustrated. They tend to enjoy short-distance traveling by personal vehicle. Demographically, SUV

drivers are more likely to be Pleasant Hill residents and age 40 or younger. They are also overrepresented among highly educated or higher income people. Similar to minivan drivers, the SUV driver group has a higher than average proportion in larger households with children.

6. Modeling vehicle type choice

6.1. Model specification and estimation

In the previous section, we explored whether the explanatory variables individually are statistically different among vehicle type groups. In reality, however, the relationship of one variable to vehicle type can be affected by other variables. The relationship of one variable to vehicle type may be significant in isolation, but disappear or diminish in importance when the impact of a related variable is accounted for. Conversely, a simple pairwise relationship may appear insignificant due to the counteracting influences of other variables, but become significant when those other variables are controlled for. Thus, we developed a disaggregate discrete choice model to estimate the probability of choosing each vehicle type based on the collective effect of factors such as travel attitude, personality, lifestyle, travel liking, and demographic variables. Since the dependent variable, vehicle type driven most often by the respondent, consisted of nine mutually exclusive categories, a multinomial logit model was developed for vehicle type choice. The statistical software package LIMDEP (Greene, 1995) was used to estimate the model.

All variables were considered as potential explanatory variables in the initial model specification, even though some variables were not significantly different across vehicle type groups based on the individual analysis using ANOVA and chi-squared tests. We also chose the pickup truck alternative as the base alternative in the model, in view of its relatively distinct characteristics against most other vehicle types. Based on the initial model specification, statistically insignificant variables were eliminated in stages, and then variations on the subsequent specifications were tested to obtain a final model having all significant explanatory variables (possibly excepting the alternative-specific constants (ASCs), which should be included to correct for sampling bias even if they are not significant, Manski and Lerman, 1977; Cosslett, 1981). When initial estimations suggested that some variables had a similar impact on more than one vehicle type, we then constrained those coefficients to be equal for the sake of parsimony and to increase the degrees of freedom available in the sample.

Through this procedure, the final model with eight ASCs and 40 alternative-specific variables (ASVs), representing 22 different variables, was developed. As shown in Table 3, all explanatory variables were statistically significant and conceptually interpretable. Additionally, as a goodness-of-fit test statistic, the χ^2 value of 1225.2 shows that the final model significantly differs from the equally likely model (in which all coefficients are equal to zero) at $\alpha \ll 0.005$.

The ρ^2 value of the final model is 0.177, indicating that the model explains 17.7% of the information in the data. Compared to the ρ^2 value of 0.108 for the market share model (the model containing only constant terms), the final model explains substantially more information, and the χ^2 value of 688.5 indicates there is a significant difference between the two models at $\alpha \ll 0.005$. Further, the ρ^2 value of 0.177 of the final model falls within the range of other models found in the

Table 3
Final multinomial logit model for vehicle type choice (base alternative = pickup)

Explanatory variables	Small	Compact	Mid-sized	Large	Luxury	Sports	Minivan/van	SUV
Travel attitudes								
Travel dislike					0.461 (2.74)			
Pro-high density	0.491 (6.11)	0.491 (6.11)	0.491 (6.11)		0.694 (5.62)			0.694 (5.62)
Personality								
Organizer			0.181 (2.22)					
Calm							0.333 (2.45)	
Lifestyle								
Frustrated					−0.507 (−2.25)			−0.238 (−2.26)
Workaholic	−0.222 (−2.43)					−0.425 (−3.22)		
Status seeking					0.756 (4.12)	0.445 (3.81)		
Objective mobility								
Sum of log-miles by airplane for LD					0.004 (2.85)			
Subjective mobility								
Overall SD						0.208 (2.28)		
Overall LD		−0.182 (−2.35)						
Personal vehicle for LD						−0.221 (−2.90)		
Travel liking								
Personal vehicle for SD	−0.151 (−2.00)							
Demographics								
Age	−0.324 (−3.31)					−0.367 (−2.64)		−0.582 (−4.51)
Education	0.258 (3.65)	0.364 (5.09)	0.258 (3.65)		0.364 (5.09)	0.364 (5.09)	0.258 (3.65)	0.364 (5.09)

Household income			0.203 (4.09)		0.449 (3.49)			0.292 (4.59)
Personal income	−0.169 (−3.37)							
No. of people < 19			0.240 (2.98)				0.904 (9.44)	
No. of people > 64			0.350 (2.74)	0.901 (5.07)	0.830 (3.54)			
Female (dummy)	2.419 (9.03)	2.176 (8.20)	2.419 (9.03)	2.176 (8.20)	2.703 (6.70)	2.176 (8.20)	2.176 (8.20)	2.176 (8.20)
Urban (dummy)	0.667 (4.81)				0.826 (2.48)			
Employed (dummy)			−0.579 (−3.03)		−0.989 (−2.42)		−0.799 (−3.16)	
Sales (dummy)			0.621 (3.01)		0.978 (2.27)			
Constants	0.697 (1.40)	−1.127 (−3.06)	−1.582 (−4.19)	−2.278 (−10.46)	−5.931 (−7.42)	−1.273 (−2.03)	−2.113 (−5.82)	−1.674 (−3.10)
No. of observations	1571							
Log-likelihood at 0	−3451.8							
Log-likelihood at market share	−3183.5							
Log-likelihood at convergence	−2839.2							
ρ_o^2 (adjusted ρ_o^2)	0.177 (0.174)							
ρ_c^2 (adjusted ρ_c^2)	0.108 (0.105)							
χ_o^2	1225.2							
χ_c^2	688.5							

Note: The number in parentheses indicates the t-statistic for that coefficient (at a level of $\alpha = 0.05$, the critical t-value = 1.96).
SD = short distance, LD = long distance.

literature, such as a ρ^2 of 0.126 found in Lave and Train (1979) and 0.249 in Kitamura et al. (2000). [4]

Turning to the explanatory variables in the final model, the results are similar to those of the individual tests discussed in the previous section. One difference from the previous results is that two travel attitude and personality variables are significant for mid-sized cars. Some demographic variables are significant for many vehicle type alternatives, which is natural considering that the base alternative is the pickup. Additionally, the negative signs on all the ASCs except the one for small cars (which is not significant) show that the average impact of all *unmeasured* variables is to reduce the probability of choosing that vehicle type alternative. Especially, the ASC for luxury cars has a much higher magnitude than those for the other vehicle type alternatives, suggesting that the choice of luxury cars is least well-explained by the available variables.

In the following subsections, we first describe the results for each explanatory variable (discussion by row of Table 3), focusing on its sign and magnitude for a specific vehicle type alternative. Then, we analyze some key significant variables by vehicle type (discussion by column), to develop a profile of typical drivers of each kind of vehicle.

6.2. Significant variables

Two travel attitude factors, travel dislike (representing agreement with statements such as "traveling is boring" and "travel time is generally wasted time") and pro-high density, are significant in the model. Those who have a stronger dislike for travel are more likely to drive luxury cars, perhaps to ameliorate the unpleasantness of travel. Interestingly, the pro-high density attitude factor has a positive sign both for smaller cars (small, compact, and mid-sized cars) and for expensive cars (luxury cars and SUVs), with the larger magnitude occurring for the second category. Those who have a stronger pro-high density attitude (who tend to live in the urban neighborhood of North San Francisco) may be more likely to drive smaller cars due to their greater maneuverability in tight traffic and parking situations. On the other hand, in our sample those who have a stronger pro-high density attitude are also likely to have higher incomes, so they tend to drive expensive cars.

Two of the personality factors, organizer and calm, turn out to be significant in the model. Interestingly, the organizer personality factor is significant (and positive) only for mid-sized cars. Organizers (who like to be in charge) may be more likely to be mid-level manager types, and hence to drive moderate cars rather than smaller, larger or specialty cars. The calm personality factor is significant (and positive) only for minivans. That is, calmer people are more likely to drive minivans, suggesting the settled status and maturity of parenthood.

All lifestyle factors except family/community oriented are significant in the model. Not surprisingly, the frustrated lifestyle factor has a negative sign for luxury cars and SUVs, although not driving an expensive car is more likely an indicator of being frustrated for other reasons (or a contributory cause of being frustrated), than a direct consequence of being frustrated. The workaholic lifestyle factor has a negative sign for small and sports cars, perhaps because work-

[4] These two models have multinomial logit structures and their dependent variables are vehicle type categories (not makes/models), similar to our final model.

aholics are likely to be career-oriented with potentially higher incomes. Additionally, the status seeking lifestyle factor has a positive sign for luxury and sports cars, as status seekers are likely to think of their cars as a status symbol.

The model also contains four mobility variables and one travel liking variable. For objective mobility, the sum of the natural log of the miles traveled by airplane for long-distance trips has a positive sign for luxury cars, with both variables being likely consequences of high incomes rather than representing direct causality. For subjective mobility, an interesting contrast between short and long distance appears. Those who think they travel a lot for short distance overall are more likely to drive sports cars, whereas those who think they travel a lot by personal vehicle for long distance are less likely to drive sports cars. Similarly, those who think they travel long distance a lot overall are less likely to drive compact cars. The implication is that compact and sports cars are desirable for traveling around town, but less comfortable or practical for long trips. The result for compact cars may also partially represent an income effect (although, since income was also allowed to enter the model directly and was not significant for the compact car type, we conclude that it is not *purely* an income effect). Those who like traveling by personal vehicle for short distance are less likely to drive a small car. Again, the direction of causality is ambiguous: those who like traveling by car may be more motivated to invest more money in a vehicle, but the degree of liking for travel by car may be somewhat influenced by the degree of comfort and amenities offered by one's current vehicle.

Ten demographic characteristics turn out to be significant in the model, in logical ways. The sign and magnitude of each variable are similar to the results of the individual tests. The respondent's age is negatively associated with driving small or sports cars, or SUVs, as expected. Education has a positive sign for all vehicle type categories except large cars, indicating that drivers of pickups (the base category) and large cars tend to be less-educated than drivers of the other vehicle types. The household income variable has a positive sign for expensive cars such as luxury cars and SUVs, while the personal income variable has a negative sign for small cars. The number of people in the household under age 19 has a positive sign and highest magnitude for minivans, with a smaller positive coefficient for mid-sized cars. On the other hand, the number of people age 65 or older has a positive sign for larger cars such as large and luxury cars. Similar to education, the female variable has a positive sign for all vehicle type categories. That is, all else equal, females are significantly less likely to drive pickups (the base alternative) than any other vehicle type. As expected, the urban neighborhood variable has a positive sign for small and luxury cars. The employed variable has a negative sign for mid-sized or luxury cars, and minivans. This indicates that unemployed people such as homemakers and retired people may tend to drive family vehicles or bigger and more comfortable cars. The sales variable has a positive sign for mid-sized and luxury cars, indicating the need for a comfortable vehicle in an occupation often involving a lot of travel. The coefficient for luxury cars has the higher magnitude of the two, suggestive of the need to appear successful in a sales occupation.

6.3. Vehicle type profiles

Focusing now on each vehicle type (discussion by column), the propensity to drive small cars is higher for those who have a stronger pro-high density attitude, while those who are workaholics or do not enjoy personal vehicle travel for short distance are less likely to choose small cars.

Additionally, the probability of driving a compact car is higher for those who have a stronger pro-high density attitude, and lower for those who perceive that they have a lot of overall long-distance travel. Interestingly, the likelihood of driving mid-sized cars is higher for those who have a stronger pro-high density attitude or tend to be organizers. Those who have higher household incomes are also more likely to choose mid-sized cars, but are even more likely to drive luxury cars and SUVs.

In contrast to the individual tests, no travel attitude, personality, lifestyle, mobility, or travel liking characteristics are significant to choosing large cars. Luxury car drivers, on the other hand, tend to have stronger travel dislike or pro-high density attitudes, to be status seeking, or not frustrated. With respect to the mobility variables, those who travel long-distance by airplane a lot also tend to drive luxury cars.

Looking at sports cars and SUVs, those who tend to be status seekers, not workaholics, or younger are more likely to drive sports cars. Sports car drivers also tend to perceive their overall short-distance travel to be a lot but their long-distance personal vehicle travel to be lower. The propensity to drive SUVs is higher for those who have a stronger pro-high density attitude, and lower for those who are frustrated. Conversely, those who tend to be calm are more likely to drive minivans.

6.4. IIA testing

We examined whether the Independence from Irrelevant Alternatives (IIA) assumption of the multinomial logit model is violated for our specification or not by using two types of tests for IIA: the Hausman–McFadden and nested logit (NL) structure tests (Hausman and McFadden, 1984). The former set of tests could not be completed due to the (near) singularity of the $V(r)$–$V(f)$ matrix, which is a common empirical occurrence (Small and Hsiao, 1985), especially when IIA holds (and therefore $V(r)$ and $V(f)$ are expected to be very similar). The latter tests were conducted on 17 conceptual nested structure models (see Choo and Mokhtarian, 2002 for more detailed information) with two or three levels based on vehicle size (e.g., grouping small and compact or compact and mid-sized into one nest), and vehicle specialty (e.g., grouping sports, minivan/van, pickup, and SUV or sports and SUV into one nest). Fifteen of those NL models had inclusive value (IV) parameters statistically equal to one, and the remaining two had IV parameters significantly greater than one, violating theory and requiring that the models be discarded. Thus, the IIA test results for the NL models strongly suggest that no NL models are superior to the final MNL model. That is, the IIA property of the final model holds. Despite conceptual similarities among the nine vehicle types modeled, this is not necessarily surprising considering the fact that all of our explanatory variables are ASVs. Allowing a variable to be alternative-specific is recommended as one potential solution to IIA violations of a multinomial logit model (McFadden et al., 1977; Ben-Akiva and Lerman, 1985), since doing so tends to reduce correlations of the unobserved portions of utility across alternatives.

7. Summary and conclusions

Differing from the traditional vehicle type choice models previously developed by economists and market researchers, this study identified travel attitude, personality, lifestyle, and mobility factors that affect individuals' vehicle type choices (the type the respondent drives most often), using data from a 1998 mail-out/mail-back survey of 1904 residents in three neighborhoods in the San Francisco Bay Area. Here, similar to the *Consumer Reports* classification scheme, vehicle type was classified into nine categories based on make, model, and vintage of a vehicle: small, compact, mid-sized, large, luxury, sports, minivan/van, pickup, and SUV.

Tests of individual variables against vehicle type, using one-way ANOVA and chi-squared tests, show that all vehicle type groups, except the mid-sized car group, have distinct characteristics with respect to travel attitude, personality, lifestyle, mobility, and demographic variables. Interestingly, the mid-sized car group tends to be "middle-of-the-road" in its characteristics. On the other hand, no significant differences across vehicle types were found with respect to the commute time and commute distance variables.

Furthermore, we developed a disaggregate discrete choice model (specifically, a multinomial logit model) for vehicle type choice to estimate the joint effect of the key variables on the probability of choosing each vehicle type. The final model (with the pickup vehicle type as base) includes 40 significant ASVs representing travel attitude, personality, lifestyle, mobility factors, and demographic variables together with the eight ASCs.

This study has some limitations. The available data did not have detailed information on all the vehicles in a household, including their acquisition history. Most importantly, we did not have data on vehicle characteristics (e.g. price, capacity, horsepower) readily available. Thus, it is possible that the novel variables we have included are partially capturing the effects of those excluded variables. However, the sizable proportions of unexplained information in the data, both in our model and in those with more traditional variables, plus the fact that our included variables are highly subjective whereas the excluded variables are objective, suggests that it is quite possible that the two sets of variables are capturing relatively different kinds of dimensions. Clearly, it would be useful to design and execute a study in which both kinds of variables are measured and included in a vehicle type choice model, so that their relative separate and joint (interactive) contributions can be formally assessed. It would also be desirable to explore segmentation of the vehicle type market, identifying clusters of drivers who weight various dimensions differently, and analyzing how those taste variations affect vehicle choice.

In any case, our empirical results do support the contention that travel attitudes, personality, and lifestyle are important to vehicle type choice, in ways that are relevant to transportation planners and policy-makers as well as vehicle manufacturers. For example, as mentioned in the Introduction, it is of interest to know that those who might be most likely to live in higher-density mixed use urban areas are also more likely to drive luxury cars or SUVs (used collectively by about 15% of our sample who reported driving a car), indicating that a taste for urban living may not be as strongly associated with a desire for fuel-efficient transportation as new urbanist proponents might wish. The further association of luxury car drivers with a status-seeking lifestyle is no surprise, but suggests that that market segment will be less amenable to policies designed to curtail the consumption of transportation or fuel. Perhaps more important is the finding that a dislike for travel in general is associated with driving a luxury car, possibly to make an undesirable activity more pleasant. This could have the slightly ominous implication that the worse travel conditions get, the more some people will try to compensate not by curtailing travel, but by increasing consumption through acquiring a more expensive (and typically less fuel-efficient) vehicle. The finding that those who think they do a lot of long-distance travel are less likely to drive compact cars carries a similar implication.

Beyond the specific results of this study, the general conclusion is that future models of vehicle type choice can be substantially more powerful with the inclusion of travel attitudes, personality, lifestyle, and mobility factors such as the ones analyzed here. On the other hand, there are logical reasons why such variables are not more often included in travel behavior models. One reason is that their inclusion makes a survey substantially longer. Second, the design and analysis of an attitudinal survey (using techniques such as factor analysis) involves skills that are not necessarily standard among travel modelers. Third, the objection is often raised that attitudes and other subjective variables cannot be easily forecast, and hence future demand as a function of those variables also cannot be forecast. These barriers are legitimate, and currently limit the extent to which the inclusion of attitudinal and related variables is practical for large-scale demand forecasting models. However, first, this does not negate their usefulness for providing insight into behavioral relationships beyond what is possible with purely objective variables alone, and thus at a minimum they have an important role to play in behavioral modeling (if not demand forecasting) studies such as the present one. Second, we believe that the concept of forecasting attitudes has been rejected without ever having been seriously attempted. We do not consider it impossible *a priori*, and suggest that efforts devoted to this end could prove rewarding. Steg et al. (2001) and Outwater et al. (2003) offer independent initial approaches to the inclusion of subjective variables into large-scale travel demand forecasting models. Although additional work is needed to refine the variable measurement, forecasting, and modeling steps of the process, their work points to a way forward that could be pursued with the appropriate motivation.

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