INDIAN VEHICLE OWNERSHIP: INSIGHTS FROM LITERATURE REVIEW, EXPERT INTERVIEWS, AND STATE-LEVEL MODEL

Prateek Bansal
Graduate Research Assistant
Department of Civil, Architectural and Environmental Engineering
The University of Texas at Austin
pb422@cornell.edu
Phone: 512-293-1802

Kara M. Kockelman
(Corresponding Author)
E.P. Schoch Professor in Engineering
Department of Civil, Architectural and Environmental Engineering
The University of Texas at Austin
kkockelm@mail.utexas.edu
Phone: 512-471-0210

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ABSTRACT

This study reviews existing vehicle ownership models for India and describes the results of nine experts' interviews to gather insights about Indians' travel patterns and vehicle choices. According to the experts, vehicle price, fuel economy, and brand (in declining importance) are the most decisive factors in Indians' car purchase choices. This study also estimated household vehicle ownership levels across India's 35 states using Census 2011 data. One cannot generalize too much from state-level regression results for individual-level vehicle ownership choices, so there remains a pressing need to develop behaviorally defensible vehicle ownership models in Indian context.

Keywords: Vehicle Ownership; Indians' Vehicle Choices; Expert Interviews.

INTRODUCTION

Over the past few decades, India has experienced rapid urbanization on a large scale. The subsequent increase in transport demand, hampered by resource constraints and limited capacity, has deepened the divide between demand and transport supply (Srinivasan et al. 2007). The heavily strained transit systems have provoked a shift toward private vehicles, thereby worsening traffic jams, safety concerns, and gridlock on dense urban streets (Pucher et al. 2005). The primary problem is not the increase in number of vehicles but, rather, their high concentration in a few densely populated metropolitan areas. In 2001, 32% of all vehicles were in such cities though these places constitute only 11% of India's urban population (Ministry of Urban Development 2008).

Using data from the Ministry of Road Transport and Highways, Dash et al. (2013) calculated car ownership rates in India. From 2001 to 2009, ownership levels of four-wheelers (cars, jeeps, and taxis) nearly doubled: from 6.59 such vehicles per 1,000 people to 12.68. The rapid growth of vehicle acquisition rates has raised concerns about social, economic, and environmental sustainability (Chamon et al. 2008). At the same time, the growth symbolizes the desire of India's middle-class to lead more comfortable lives (Shirgaokar et al. 2012) and engage in more

economic and discretionary activities. For a highly populated (1.28 billion persons) and developing country like India (the world's fourth largest importer of petroleum after the United States, China, and Japan), understanding the factors that determine consumer behavior relating to private vehicle purchases and initiating policies for the sustainable evolution of transportation system are essential (Dash et al. 2013).

As compared to aggregate models of vehicle ownership (at zone, city or state levels), disaggregate models (at individual or household levels) better explain the behavioral relationships between demographics and other attributes and their vehicle ownership (Kumar and Krishna Rao 2006). However, due to the scarcity of disaggregate data in India, relatively few studies have developed such models (Dash et al. 2013). Additionally, culture variations, travel patterns, and mobility needs do not allow developing countries like India to adopt model specifics and parameters established in developed countries. For example, in contrast to developed countries, India has a very high share (around 75%) of two-wheelers (vs. passenger vehicles). Figure 1 suggests that while developed countries' vehicle ownership and motorization levels are relatively saturated, they are rising rapidly in developing countries like India and China (Embarq India 2012)[1]. Moreover, India's heterogeneous traffic flow conditions, with all vehicle types sharing roads with almost no lane discipline, offer a major contrast to the strict lane regulations found in nearly all developed countries. Relatively low per-capita incomes also make car ownership a symbol of luxury and status. In the absence of widespread and behaviorally-sound disaggregate models and recognizing issues in adopting models developed for other countries, planners and automobile manufacturers from developing countries like India have to look at aggregate measures (e.g., growth rates) or prioritization heuristics to make policy investment decisions (Dissanayake and Morikawa 2002).

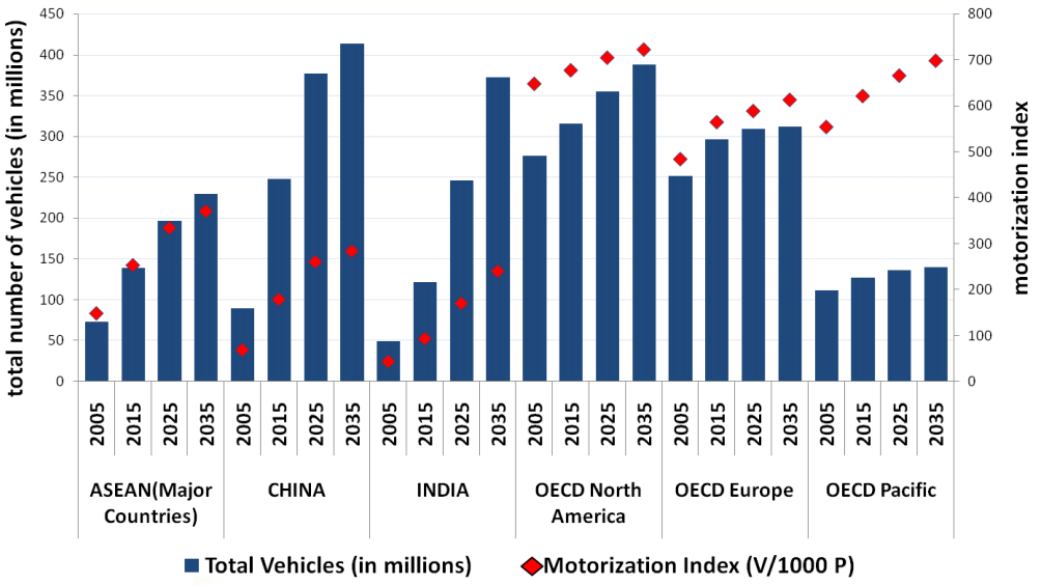

Figure 1 Number of Vehicles and Motorization Rates by Region

Source: Embarq India (2012); V/1000 P = vehicles per 1,000 persons

This study provides a comprehensive review of disaggregate-level research studies that investigate the effects of demographic and built environment characteristics on vehicle ownership rates across India. It is important that researchers, policymakers, and automobile manufacturers appreciate the limitations of existing vehicle ownership models and the need for new models in an Indian context. Indian travel choice experts were also interviewed (via a detailed email questionnaire), and those findings are summarized here to provide further insights about current and future vehicle ownership choices in India (e.g., two-wheelers vs. four-wheelers, used vs. new vehicles, conventional vs. electric cars, and compact cars vs. sport utility vehicles [SUVs]). Experts' perspectives on different policy and practice scenarios (e.g., better enforcement of safety laws and improvements in travelers' lane-keeping), prospects for car-sharing programs, barriers to and policies for electric vehicle sales, and Indians' fuel type usage are also summarized here.

Research personnel at many key Indian institutions were contacted, confirming that household travel survey data cannot be readily obtained for Indian cities. In the absence of such data, this study estimated household two-wheeler (scooters, motorcycles, and mopeds) and four-wheeler (cars, jeeps, and taxis) ownership levels for all states across India using least-squares regression techniques, with as many explanatory variables as one can find at this level of aggregation, as presented in this article.

DISAGGREGATE VEHICLE OWNERSHIP MODELS FOR INDIA

Vehicle ownership models can be used to develop policies affecting congestion, infrastructure, emissions, equity, and safety. They help anticipate the most plausible effects before a policy is instituted. Banerjee (2011) sheds light on such outcomes in her study of Surat City. For example, increasing the two-wheeler's price is expected to significantly diminish the mobility of low-income households in India, causing social inequity issues. Instead, policies that encourage two-wheeler ownership may be useful in India because such vehicles are relatively spaced and fuel-efficient, but safety aspects need further investigation (Banerjee 2011).

In the Indian context, it is important to understand the factors affecting two-wheeler ownership-not just because of their high usage levels, but also due to their distinct impacts on system performance measures, such as parking, congestion, energy consumption, and air quality. This article separately reviews studies examining only car-ownership models and those having both car and two-wheeler ownership models. Table 1 summarizes the data, response variables, and choice models used in all past disaggregate vehicle ownership models developed for India.

Car Ownership Models

Kumar and Krishna Rao (2006) conducted a stated and revealed preference study for the Mumbai Metropolitan Region of Maharashtra and developed a multinomial logit (MNL) car ownership model (alternatives considered 0, 1 and 2 cars). The SP experiment's results suggest a very high unwillingness of Indians to share their home addresses and incomes, a key reason behind the relatively low response rate of 17.3%[2]. They found car ownership to rise with household income and fall with car prices, family size, and home ownership, ceteris paribus. Respondents were interested in owning a car for recreational and shopping trips rather than for

work commutes. After comparing the results of their stated and revealed preference data, the authors concluded that stated preference approaches appear to be successful in modeling vehicle ownership decisions of households in India.

Chamon et al. (2008) used 29,631 Indian households' expenditure data in 2004, across urban and rural areas. It appears they used expenditures as a proxy for income, but they did not reveal any further details and estimated a binary probit model with two alternatives: own at least one car, vs. own no cars. Based on their probit model results, they projected[3] that 11 percent and 34 percent of Indian households will own at least one car in 2030 and 2050, respectively. Additional details about their model results were not provided.

Car and Two-Wheeler Ownership Models

Srinivasan et al. (2007) and Gopisetty and Srinivasan (2013) used Chennai Household Travel Survey data (collected between December 2004 and May 2005) to understand car and two-wheeler ownership. While both studies used the same datasets, the first focused on understanding demographic, mobility-related, and land use factors affecting vehicle ownership increases over five years using two separate ordered probit models, and the later study accounted for simultaneity[4] in two-wheeler and car ownership levels, as well as trip frequencies and vehicle ownership levels using a three-stage least squares (3SLS) model.

Srinivasan et al. (2007) found that two-wheeler and car ownership rise with household income; and the latter is also positively affected by lagged-income. Having a credit card in one's name was controlled for (as an explanatory variable) and it positively affected car (but not two-wheeler) ownership, most likely due to the holder's access to loans and other financing options. The number of household workers positively affected two-wheeler ownership, but had no direct effect on car ownership (although such effects are also picked up through the presence of the income and income-related variables). Consistent with Dash et al.'s (2013) findings, households with more children (below five years of age) were more likely to own a car, presumably due to safety concerns and the importance of meeting their relatively complex travel needs. Households with female drivers were also more inclined to buy a car. As the average work distance of all household workers increased, the propensity to purchase two-wheelers rose, while the tendency to purchase four-wheelers fell, perhaps due to two-wheeler's higher fuel economy. Households noting more frequent maintenance ("personal business trips") activities and respondents in urban areas tended to purchase two-wheelers. This could be due to congestion and parking issues. Home ownership also increased the car-ownership probability. Of course, both home ownership and vehicle ownership are major economic and social status symbols in India, so wealthy households with cars generally own a home and vice versa (though this home-ownership effect is in some conflict with Kuman and Rao's [2006] statistical result). It is surprising that accessibility to buses/transit was predicted to have no effect on trip frequencies or vehicle ownership levels. Households with a grocery store nearby (within 500 meters) were estimated to be less likely to acquire cars, as compared to other households. Cell phones and peer pressure positively influenced vehicle ownership in general. However, if local vehicle ownership of two-wheelers was substantial (more than seven of every 10 households in the neighborhood), car ownership fell. Additionally, households without cars were found to have the greatest inclination towards

buying a car. Since 70 percent of households surveyed did not have a car at the time of the survey (2004-05), the authors expected a rapid increase in car ownership, due to rising incomes.

Gopisetty and Srinivasan's (2013) results with those same data indicate a rise in car ownership with the number of college graduates in the household, reflecting greater car affordability, presumably greater need, and perhaps a higher value placed on comfort. Respondents living in urban areas indicated a higher propensity to buy two-wheelers, but not cars, perhaps due to congested roadways and parking's limited availability. Moreover, poor road-surface conditions appeared to motivate two-wheeler purchases over four-wheeler purchases, presumably due to more affordable vehicle maintenance costs. Additional results related to endogeneity suggest that trip frequency has a negative effect on car ownership, but not on two-wheeler ownership, perhaps because frequent trip-makers face higher operating cost of cars and more often encounter congestion and parking issues. Surprisingly, two-wheeler ownership was estimated to be negatively associated with trip frequencies, perhaps due to more-efficient trip making by two-wheelers.

Banerjee et al. (2010) conducted a survey in Surat, a typical city in western India, to analyze their choices across new and used motorized two-wheelers and cars, and across different car-size segments. This is the only study in an Indian context that explain the factors affecting the choice of new versus used vehicles, as well as the size categories of these choices. Banerjee et al. used an MNL model with 18 vehicle choices (both new and used options for two-wheelers and 8 car-size segments). Their results suggest that small cars are preferred in general, but compact cars and SUVs are the most popular. They inferred that consumers should not want larger cars (like SUVs) due to congestion and parking issues in India; however, Indians still prefer them, and not because of their higher seating capacity, but rather due to their symbolic status. This finding supports a market potential for small luxury cars in India. Nonetheless, more interior space in larger vehicles was attractive for the bigger households. Furthermore, the study found that consumers' choices are highly sensitive to operating costs, as compared to vehicle purchase price. For this reason, respondents stated that new vehicles were preferred over used ones. Banerjee et al. also explored the effect of attitudes and perceptions on consumer choices. They concluded that the cost and utility of a vehicle surpass the importance of perception biases, such as status symbolism. Their findings undermine the importance of advertising in influencing purchasing decisions. Other qualitative results of their survey suggest that an individual's vehicle choice is highly influenced by peer experiences of and peer reports on a vehicle as opposed to his or her own experiences and research. And the most expensive vehicle in an Indian household is generally used by highest income earner or the oldest male member of the household. Apart from a vehicle's price and operating costs, availability and cost of spare parts was given as an important factor in vehicle type choice.

Padmini and Dhingra (2010) developed MNL models to estimate car and two-wheeler ownership levels for residents of the Pune metropolitan area using revealed-preference, home-interview survey data. They also investigated the respondents' willingness to shift their mode choice from a private vehicle they already owned to region's metro (subway) system. Padmin and Dhingra used prediction success tables to check models' goodness of fit.

Shirgaokar et al. (2012) also used MNL models to understand how various factors (like home and work locations, socio-economic variables, and trip characteristics) influence middle-class'

purchases of cars (including jeeps and taxis) and motorized two-wheelers. They used household travel survey data, collected by the Mumbai Metropolitan Regional Development Agency (MMRDA) in the Greater Mumbai Region (GMR), and concluded that better transit services would reduce the need for vehicle ownership that Indians feel. They found that vehicle ownership utilities increase when the household head is married and fall when he/she makes longer-distance trips (especially for two-wheeler ownership, due to congestion and safety concerns). A preference for a car (over a two-wheeler) is stronger in the presence of children (under age 5), a college-educated primary wage earner, higher per-capita income, larger household size, and bigger house ownership. A preference for two-wheelers (over cars) is stronger when the primary wage earner is male and travels more often. Specifically, younger people are estimated to prefer two-wheelers, while older Indians are more inclined toward cars, perhaps due to increase in purchasing power and change in perception about safety and comfort with one's age. Car ownership tended to fall for those living on the urban periphery with high job densities at their work locations, ceteris paribus. This pattern reversed for two-wheeler ownership. Car owners living in urban cores, but working in suburbs, and two-wheeler owners living and working in the suburbs, were both estimated to derive higher vehicle utility. This implies that cordon pricing may help contain India's car market, but not its two-wheeler market.

Dash et al. (2013) developed a disaggregate model for private vehicle ownership using India's Consumer Expenditure Survey data collected by the Nation Survey Sample Office (NSSO) from July 2009 to June 2010. Due to the high likelihood of erroneous income data[5] in developing countries, the study they used household *expenditures* as proxy for income and economic standing. Similar to Chamon et al. (2008), theirs was a nation-wide vehicle ownership model. Dash et al. considered the following four vehicle choices in their MNL model: no motorized private vehicle, only two-wheelers, only cars, both two-wheelers and cars in the household. They found that per-capita expenditures, the presence of children, and household size all have a positive association with two-wheeler and car ownership. Rural households are more inclined to own cars than are urban households, provided they can afford one, thanks to their longer travel distances, better parking options (more unused land), and less frequent transit options. As expected, the presence of young adults (18 to 35 years) increased probability of household owning two-wheelers only. They may have obtained better insights if their data was included: vehicle make and model, number of vehicles owned, fuel type of vehicles owned, distances traveled by each vehicle owned, and average time spent traveling by each household member.

This exhaustive review of the literature suggests that Indian vehicle ownership models exist for the regions of Mumbai, Chennai, Pune, and Surat. Surprisingly, however, there appears to be no individual- or household-level vehicle ownership models available/publicly accessible for key metropolitan areas like Delhi (India's capital city), Bangalore (India's "Silicon Valley"), and Kolkata (India's third most-populous metro area). Hence, there is a need to develop vehicle ownership, vehicle preference, and vehicle use models for at least key Indian cities.

Table 2 Summary of Past Disaggregate Vehicle Ownership Models for India

Previous Studies	Data Description	Sample Size	Response Variables	Choice Model
Kumar & Krishna Rao (2006)	Stated & reveled preference surveys in **Mumbai** Metropolitan Region (MMR) (2004-2005)	357 & 923 households in stated & reveled preference surveys, respectively	Car ownership (0, 1, or 2 cars)	MNL model
Srinivasan et al. (2007)	**Chennai** Household Travel Survey data (December 2004 – May 2005)	1,200 households	Increase in household's car and two-wheeler ownership over 5 years	Ordered probit model (OP)
Chamon et al. (2008)	**All India** consumer expenditure data, National Sample Survey Office, Govt. of India (2004)	29,631 households	Car ownership (own a car or not?)	Binary probit model (BP)
Banerjee et al. (2010)	Travel survey of households in **Surat** (Gujrat 2009)	128 households that had acquired new or used vehicles after April 2009, & 68 households that did not	18 vehicle classes (new & used two-wheelers, plus 8 car's size segments)	MNL model
Padmini & Dhingra (2010)	Home Interview Survey (revealed preference) data of **Pune** (2008)	3000 households	Car & two-wheeler ownership	MNL model
Shirgaokar et al. (2012)	Household travel survey for Greater **Mumbai** Region (GMR), collected by Mumbai's Metropolitan Regional Development Agency (2005-2006)	65,992 households across 35 urban areas plus 1,200 villages. 1.5% sample of the total population within the GMR	Three vehicle choice (no vehicle, only two-wheelers, & at least one car)	MNL model
Dash et al. (2013)	**All India** consumer expenditure data, National Sample Survey Office, Govt. of India (2009-10)	89,503 households	Household's car & two-wheeler ownership in single model	MNL model
Gopisetty & Srinivasan (2013)	**Chennai** Household Travel Survey data (December 2004 – May 2005)	1,200 households	Joint estimation of household's car and two-wheeler ownership, & trip frequency	Three-stage least squares (3SLS)

INSIGHTS FROM EXPERT INTERVIEWS

In total, 38 Indian travel choice experts were contacted in September 2014, and nine of them responded to the interview questionnaire. Among these nine, five had obtained doctoral degrees in transportation engineering (three are professors and the other two are post-doctoral fellows), and the remaining four experts had obtained master's degrees (were working in leading travel demand modeling firms). The following subsections summarize the insights gathered from these expert interviews. These run the gamut, from vehicle ownership and fueling decisions, to used and electric vehicles, as well as suggestions for future research.

Factors Affecting Purchases of Cars and Two-Wheelers

According to the experts, key car-ownership advantages for Indians include a perception of greater safety (from traffic accidents and crime en route), social status, and comfort, with key concerns being parking availability and roadway congestion. Indians mainly consider price, fuel economy, and brand (in decreasing order of importance) when making car-purchase decisions (across makes and models). For instance, all nine respondents ranked price as the number 1 criterion, and seven ranked fuel economy second. According to the experts, brand consciousness rises with household income. High-income households prefer costlier brands, like Mercedes or BMW, middle-income households prefer Japanese cars with good resale value (e.g., Toyota and Honda), whereas lower-middle income households prefer the relatively affordable brands (e.g., Maruti Suzuki). Compact cars are the most common vehicle-body choice in India, due to ease of maneuvering and parking. Since overloading vehicles is a regular issue (i.e., multiple children are placed on two-wheeled and three-wheeled motorized vehicles, along with their adult riders), the presence of children in a household is not yet a big factor in determining car type purchased. Across the SUV spectrum, vehicles manufactured by Mahindra and Mahindra are most popular. More recently, families and companies offering transport for their employees have shown high interest in SUVs. Experts also think that individuals' preferences for car type are changing rapidly, thanks to recent increases in purchasing power. A lower-priced and fuel-efficient SUV can cause a shift away from compact car purchases because SUVs are quite useful when driving from small towns and rural areas into big cities (sometimes offering an alternative to public transit, for many workers' combined commutes). In terms of two-wheeler purchases, experts note that Indians rank fuel economy, price, engine power, and brand as top features (in decreasing order). Moreover, younger males prefer two-wheelers with more engine power, but typically do not want to pay more than they do for conventional two-wheelers.

Fuel Choices

As with Indians' vehicle purchases, price is a key determinant in fuel choice. Historically, diesel has been less expensive than gasoline in India because the national government subsidizes diesel to aid low-income taxicab and three-wheeler operators (which all run on diesel). Gasoline is the most used fuel type in India, but long-distance travelers prefer diesel to reduce operating costs. The gap between gasoline and diesel prices has been narrowing since January 2013, when the government announced a very modest monthly increase of $0.008 (0.5 rupees) per liter in diesel prices to reduce oil companies' losses. Likely due to this factor, the share of diesel vehicles fell to 53 percent in 2013-14, from a peak of 58 percent reached in the prior year (The Economic Times 2014). An expert also endorsed the preference shift towards gasoline due to this deregulation of diesel's price.

India's Electric Vehicle (EV) Market

Higher purchase costs, poor charging infrastructure availability, and lack of consumer awareness (about the benefits of EVs) are the major hurdles for EV penetration in India, according to the experts surveyed. India's earlier fleets of EVs had maintenance issues, which is an issue that needing to be addressed before significant adoption is expected by experts. To encourage EV adoption, the Indian government may pursue the following initiatives: provide subsidies and tax incentives for EV purchase, sublease EVs at competitive rates for short-term use, lower electricity costs for EV charging during off-peak hours, partner with businesses to provide charging infrastructure at workplaces and/or major parking stations, and provide means of recycling the outdated vehicles as the technology improves.

Some of these strategies have already been implemented in India. In 2010 and 2011, the Government of India reduced the EV excise duty from 8% to 4%. Delhi, Rajasthan, Uttarakhand, and Lakshadweep states do not levy value-added tax (VAT) on EVs. In fact, the Delhi Government provides the highest incentives for EVs, with tax rebates amounting to 29.5% of the cost (Finpro 2013). Major manufacturer Mahindra Reva introduced plans, like battery leasing and exchange of petrol-fuelled vehicles with its Reva-i electric cars in Bangalore. In spite of these endeavors, the current Indian vehicle fleet is comprised of only about 0.4 million electric two-wheelers and a few thousand electric cars (Daniels 2014). As suggested by experts, we investigated the National Electric Mobility Mission Plan (NEMMP), which suggests that government and industry players plan to invest over 230 billion rupees ($4B USD) to create a market for 5 to 7 million EVs (3.5 to 5 million pure electric two-wheelers, 1.3-1.4 million hybrid electric four-wheelers, and 0.2-0.4 million pure electric four-wheelers) by 2020, resulting in annual fuel savings of 677-769 million gallons (Ministry of Heavy Industry 2013).

The Market for Used Vehicles

According to one expert, maintenance costs are relatively low for vehicles in India, as compared to labor and parts costs in more industrialized countries. This feature, along with less economic ability to purchase new vehicles, causes consumers to hold their cars and two-wheelers longer. Related to this, an expert suggested that the International Journal of Hydrogen Energy estimated the average service life of a passenger car in India to be about 20 years (versus 16 years in the U.S.), with 9,300 miles of annual travel (which is similar to average annual U.S. use). According to cartoq.com, an average diesel car engine lasts 248,000 miles in India, whereas an average gasoline car engine lasts just 124,000 miles (versus an average light-duty vehicle lifetime of about 160,000 miles in the U.S.). However, there is a growing set of consumers (with greater purchasing power) who aspire to own the latest models, leading to a larger pool of used cars. India's used car market is becoming more formal and organized, but it may take another 5 to 10 years to catch up to U.S. conditions. Used cars often head to persons in one of three groups: 1) first-time car buyers from lower- and middle-income classes, who cannot afford a new car, 2) new drivers who are not very confident in their driving, and 3) taxi companies. Whereas, two-wheelers are generally handed down to children before they are sold off and thus kept for much longer than cars. If the used car market becomes increasingly organized and prevalent, Indians' propensity to purchase used cars over new two-wheelers may increase, since used cars are likely to be affordable for someone, who had been planning to buy a new two-wheeler.

Safety Laws

One safety expert suggested that overloaded informal modes (e.g., jitney vans with capacity for 8 actually carrying 15 persons), which transport children to and from school, have a good safety record. It will be interesting to study the mobility needs that are met by overloaded trains, buses, cars, two-wheelers and three-wheelers in India. With improvements in vehicle technologies, experts expect airbags, anti-lock braking systems, and electronic stability control systems to become mandatory on new car sales in India before long. They noted that India's new *Transport and Safety Act* (Ministry of Road Transport and Highways 2014) has various safety law amendments. For example, front and rear seat belts are now to be required in all new cars sold, roadworthiness tests will be conducted for all cars and two-wheelers every five years, posted speed limits will be required on all streets, penalties will soon exist for hand-held mobile-device use, and a unified driver licensing system will be in place, among other polices. It is hoped that such policies will provide many valuable safety benefits to Indians.

Top Strategies for Foreign Manufacturers in India

The questionnaire also asked for recommendations for major manufacturers from developed countries. Many hope to increase car sales in India, and experts believe they should emphasize highly fuel-efficient, low-priced cars, and set up a large base of service centers, to gain market share. Collaboration and partnerships with leading Indian manufacturers can also help in better understanding the Indian market. Moreover, ground clearance and suspension should be good enough to drive on India's roads with their elevated speed breakers.

Research Questions

Finally, experts were also asked to suggest several topics for further research and exploration in the Indian context. For example, the *relationship between Indians' purchases of two-wheelers and cars* is worth exploring. Four experts think that, if Indians can afford a car, they will buy it irrespective of two-wheeler prices, since it is a status symbol. If two-wheelers negatively affect car adoption rates, the Indian government may devise policies to encourage purchase of two-wheelers to slow adoption of four-wheelers. Experts provided mixed comments about such policies (assuming that two-wheeler ownership negatively affects car-ownership in India). Two experts intuitively argued that investment in public transit is the way forward for India, rather than subsidizing two-wheelers, but two others found it an appropriate strategy to contain India's burgeoning car market, with a worry about safety (since two-wheelers have much higher fatality rates [Fagnant and Kockelman 2015]).

Exploring *the potential for carsharing programs* in India is another meaningful research avenue. Experts agree that carsharing business models should work in large cities with an educated and mobile population (e.g., Bangalore). If carsharing prices are low enough[6] to compete with rental cars and the overall (daily) cost of car ownership (and use), these programs may take off across the nation. However, fleet managers need to incentivize better treatment of shared/rental vehicles or penalize those who abuse the vehicles. Initial target populations may be younger consumers (e.g., 25-35 years old) and households who can just afford a car, but do not yet have one.

It also is worth exploring the *impact of a fuel-price-hike on vehicle ownership.* Experts feel that Indians' vehicle ownership decisions are not significantly sensitive to fuel prices, yet are sensitive to fuel economy, which suggests inconsistent behavior. Of course, driving miles may fall, as fuel prices rise; and some experts believe that lower-income households will then shift

from two-wheelers to public transport, while car owners shift to more fuel-efficient two-wheelers. However, two-wheeler sales are not likely to increase, since most Indian car owners already own at least one two-wheeler.

More cars on the road raise congestion, but improve a state's and nation's productivity. One needs to explore the validity of this argument. If the statement holds true, it raises an important policy question as to whether the government should discourage car purchases in India. Experts think that policy-makers should estimate and compare the changes in Equity, GDP and other performance metrics due to investment in public transit versus the nation's automotive industry. Even if automobile investment is assumed to be more economically productive (and national and state governments encourage it), city governments should take actions to discourage it by investing in transit and non-motorized infrastructure.

Most experts think that a *hike in parking prices* is a key policy for reducing car use in India. This belief needs formal evidence before recommendation, and the experts interviewed were not aware of any published literature for the India context.

Lane-use discipline requirements are unlikely to emerge in India anytime soon, due to significant speed differences among bicycles, auto rickshaws, two-wheelers, buses, and cars. However, it would be interesting to see the impacts of lane-use discipline in India. Two experts could suspect that, in such a scenario, two-wheelers will lose their utility to move through the gaps and cars may become equally navigable in India's congested settings, causing more Indians to acquire a car rather than a two-wheeler.

MODELS OF VEHICLE OWNERSHIP USING STATE-BASED CENSUS DATA

Year 2011 demographics for all 35 states of India were obtained from India's Planning Commission (2014), Ministry of Statistics and Programme Implementation (2011), and Census (2011). Two linear regression models were developed with the percentages of households owning at least one two-wheeler and at least one car as the two response variables. Initial model specifications included all explanatory variables, and models were re-estimated using stepwise elimination (by removing the covariate with the lowest statistical significance) until all p-values were less than 0.32, which corresponds to a minimum t-stat of 1.0. A maximum permitted p-value of 0.10 (for statistical significance) was not used here due to the very limited sample size (n=35). If district-level census data had been available (n=640), statistical significance would be greater (and p-values smaller). Either way, practical significance is generally of more interest to policymakers and planners than statistical significance. This study considers an explanatory variable to be practically significant if its standardized coefficient[7] exceeds 0.5 (so that a 1 standard deviation change in that variable is responsible for at least a 0.5 standard deviation change in the response variable). Table 2 shows the results of regression models, estimated using ordinary least squares (OLS) techniques in SPSS V.16 software.

The positive association of population density with two-wheeler ownership and its negative association with car ownership are intuitive. More populous areas tend to have more frequent transit service, more congestion, and less convenient parking and thus lower car ownership and higher two-wheeler ownership[8], ceteris paribus in this model. It also appears that states with a

higher proportion of occupied housing units tend to have lower car ownership shares. Results suggest that states with a higher fraction of full-time workers tend to have higher car ownership levels, perhaps because full-time employees can better afford cars. The effect of average household size is not accounted for here (due to missing data in public reports), but it (and other variables) may affect some of these relationships. (For example, if smaller households are common in densely developed states, then a lower share of households with cars does not necessarily mean a lower number of cars per capita. The 4+ person household variable used here can pick up some of these effects, but not all.)

Since data on educational attainment and household or per-capita income variables are not publicly available, this study considers the percentage of households owning computers as a partial proxy. The results suggest that states with more computer-owning households tend to have higher rates of two-wheeler and car ownership. States with a higher share of large households (4+ members[9]) are estimated to have higher car ownership, ceteris paribus. This result is intuitive because larger households may regularly need a car (rather than a two-wheeler) to accommodate all household members, in order to visit their relatives, special events, and other family activities. States with higher shares of households having 2+ more married couples in them (e.g., parents living with their daughter and her husband) are estimated to have higher rates two-wheeler ownership, everything else constant.

Everything else constant (in Table 2's OLS model specifications), states with higher shares of rural populations tend to have more car-owning households (as a share of all households) and fewer two-wheelers. This finding is consistent with those of Dash et al. (2013) and is logical because those residing in rural areas need to travel greater distances for access to education, medical care, markets, legal resources, and so on; and many Indian villages do not have regular bus service for such travel.

With just six or fewer covariates, each regression model still managed to attain a reasonable fit, with adjusted R-square values of 0.75 for two-wheeler ownership and .89 for car ownership rates, as shown below, in Table 2. In terms of practically significant variables, standardized coefficients suggest that the share of households living in rural areas is a key (very practically significant) variable for predicting ownership of two-wheelers and four-wheelers, while computer ownership rates are a very good predictor of car ownership rates, and variables of population density and the share of households with multiple married couples are practically significant in predicting rates of two-wheeler ownership. It is unfortunate that better covariates (like distributions or simply averages of age, income and educational attainment) are not publicly available. Hopefully, such data will soon be commonplace in a country as complex and globally important as India.

Table 2: OLS Regression Results for Predicting the % of Households Owning Two-wheelers and Cars (n_{obs} = 35)

Response Variable % of Households Owning Two-Wheelers	**Coef. Estimate**	**Std. Error**	**Stand. Coef.**	**t-stat.**	**p-value**
Constant	62.61	16.242	--	3.85	0.001
Pop density (persons per square km)	0.003	0.001	**0.501**	3.44	0.002
HHs own computer (% of HH)	0.666	0.292	0.334	2.28	0.030

HHs with 2 or more married couples (% of HH)	1.278	0.292	**0.507**	4.38	0.000
Percent of population in rural areas	-0.562	0.103	**-0.928**	-5.46	0.000
R-Square = 0.784 and Adj. R-square = 0.747					
Response Variable % of Households Owning Cars	**Coef. Estimate**	**Std. Error**	**Stand. Coef.**	**t-stat.**	**p-value**
Constant	-10.69	10.55	--	-1.01	0.320
Pop density (persons per square km)	-0.00052	0.00026	-0.245	-2.28	0.030
Occupied housing units (%)	-0.193	0.102	-0.153	-1.88	0.070
Full-time workers (% of Pop)	0.153	0.072	0.171	2.14	0.041
HHs own computer (% of HH)	0.896	0.082	**1.035**	10.9	0.000
HHs with 4 or more members (% of HH)	0.107	0.070	0.114	1.52	0.138
Percent of population in rural areas	0.147	0.034	**0.560**	4.28	0.000
R-Square = 0.919 and Adj. R-square = 0.899					

Note: Standardized coefficients of practically significant variables are shown in **bold**.

CONCLUSIONS

This paper summarizes existing household- and person-level models of Indians' vehicle ownership decisions, while finding that raw, disaggregate data (or household travel survey data) to develop one's own vehicle ownership and use models are almost impossible to obtain, without disseminating a new survey. Due to the fact that more than 75 percent of all vehicles are two-wheelers and the fact that India offers rather unusual demographics and travel behaviors, one cannot substitute results of data sets and behavioral models developed for other parts of the world. Moreover, most of the disaggregate vehicle ownership models available in the literature (except Dash et al.'s [2013] national examination) are at the level of single regions. Moreover, existing studies do not offer any disaggregate vehicle ownership models for key Indian metropolitan areas, like Delhi, Bangalore, and Kolkata. In such a diverse country, it is not reasonable to generalize the results of vehicle ownership models developed in other regions of India to these major cities.

Questionnaire-based interviews of travel and vehicle choice experts for India provided multiple valuable insights about factors affecting purchase of cars and two-wheelers, Indians' fuel choices, the electric vehicle and used-vehicle markets, strategies for non-domestic manufacturers in India, and amendments to safety laws. Such conversations also raised a series of relevant research questions affecting current and future vehicle ownership decisions, travel choices, and policies in the Indian context. These research questions include the potential for carsharing programs in India, lane use discipline requirements, the car-ownership impacts of changes in fuel and parking prices, and the relationship between two-wheeler and car ownership rates). In essence, the Indian automotive market provides complex and unexplored policy-related research avenues that will require thoughtful investigation.

In the absence of disaggregate household travel survey data for India, this study developed two OLS regression models to estimate household ownership rates of two-wheelers and cars. It is worth noting that the share of households residing in rural areas and computer ownership rates (if income and education variables are not available), and have practically significant effects on car-ownership shares. However, due to the issues with data aggregation (and thus the potential for "ecological fallacies"), one cannot generalize too much from state-level regression results for individual-level vehicle ownership choices (Schwartz 1994). A need for new disaggregate level vehicle ownership models in key regions of India (which still do not have such models) is clear.

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ENDNOTES

1) Although India and China have low motorization indices, the total number of vehicles present in both countries is remarkable.

2) Kumar and Krishna Rao (2006) contacted 2063 respondents (using skilled interviewers, in face-to-face settings), and only 357 valid and completed surveys were obtained.
3) These estimates are based on a projected per-capita income growth of 6.5% per year, from 2005 to 2030, and 5.2% per year from 2030 to 2050.

4) In a trip production model, vehicle ownership is an important explanatory variable, but the reverse causality or endogeneity (the effects of trip frequency on vehicle ownership decisions) is generally neglected in conventional models, which assume that the longer-term vehicle ownership decision is an exogenous input to trip generation, but that may not be the case.

5) In developing countries, people are averse to disclosing their income information, and may understate it due to tax-related concerns. Moreover, seasonal fluctuation in the incomes of agriculture-based households is relatively high, as compared to variations in their expenditures.
6) It is worth noting that insurance is less expensive and maintenance/repair labor costs are lower in India than in developed countries.

7) A standardized coefficient is the number of standard deviations change in a dependent variable per one standard deviation increase in the explanatory variable. Explanatory variables with higher standardized coefficients are more practically significant.

8) Two-wheelers need less space than cars and so are easier to drive (and park) in congested settings.

9) A household size of 4 persons was chosen as the threshold here, because 3 people can (and often do!) travel together on two-wheelers in India.

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