Modeling and analyzing near term transitions to alternative fueled vehicles using a spatial regional consumer choice and fueling infrastructure model

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Project Description

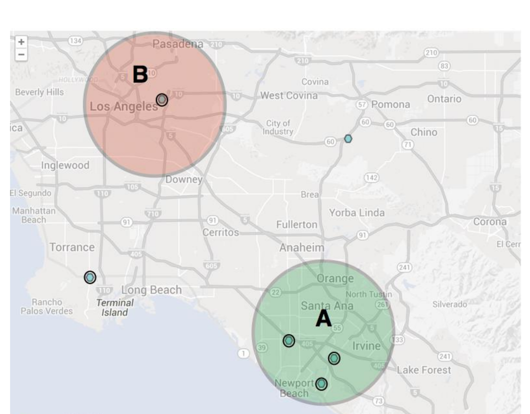
The research project focuses on developing a spatially detailed analysis of consumer choice, with an emphasis on linking consumer utility with geographic specification of the locations of alternative fuel stations and electric vehicle charging availability in specific high-interest geographic areas.

Key Research Questions

- How do the locations and numbers of hydrogen stations and public chargers influence the alternative vehicle purchases at a local level?
- How do sales for alternative fueled vehicles vary spatially?
- What are likely sales and fleet shares of hydrogen fuel cell vehicles and plug-in electric vehicles in study regions out to 2030?
- What are the optimal infrastructure locations for better AFV adoption?

Background and Motivation

- The consumer choice models developed so far operate on a rather spatially aggregated level, either at a state level
- Even though these models include 'non-monetary costs' to characterize the perceptions of consumers towards vehicle technologies, certain important details are lost while aggregating spatially
- When these details are aggregated, in nationwide or statewide models, it is assumed that the presence of these stations at a particular location will affect all the consumers, when in fact, the deployment of stations or chargers will only influence potential consumers that are near the deployed infrastructure.
- Hence, characterizing the spatial dimension of consumers and their proximity to fuel infrastructure is very important for improving the representation of vehicle purchase decisions.
- This spatial consumer choice model will better incorporate the level of utility that is provided by stations and chargers at a fine level of spatial detail, versus assuming some average level of station availability, common to other modeling approaches.

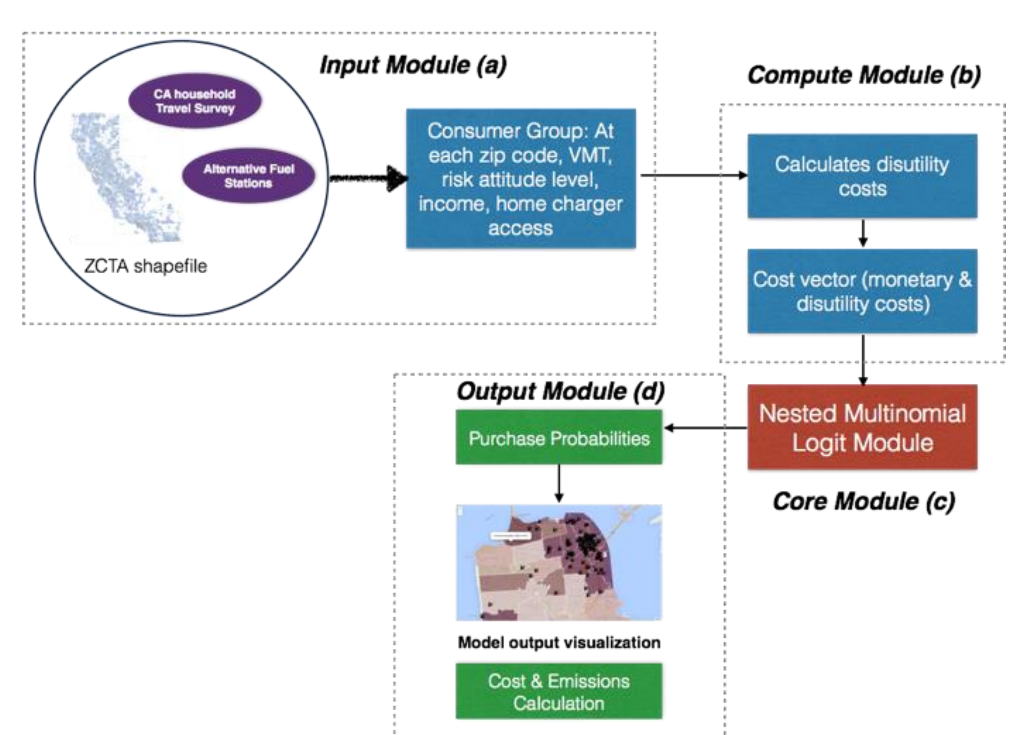


For example, a consumer living in area 'A' close to hydrogen refueling stations has a higher probability to purchase a fuel cell vehicle compared to a person living in area 'B'. This spatial utility will be quantified in the model for analysis.

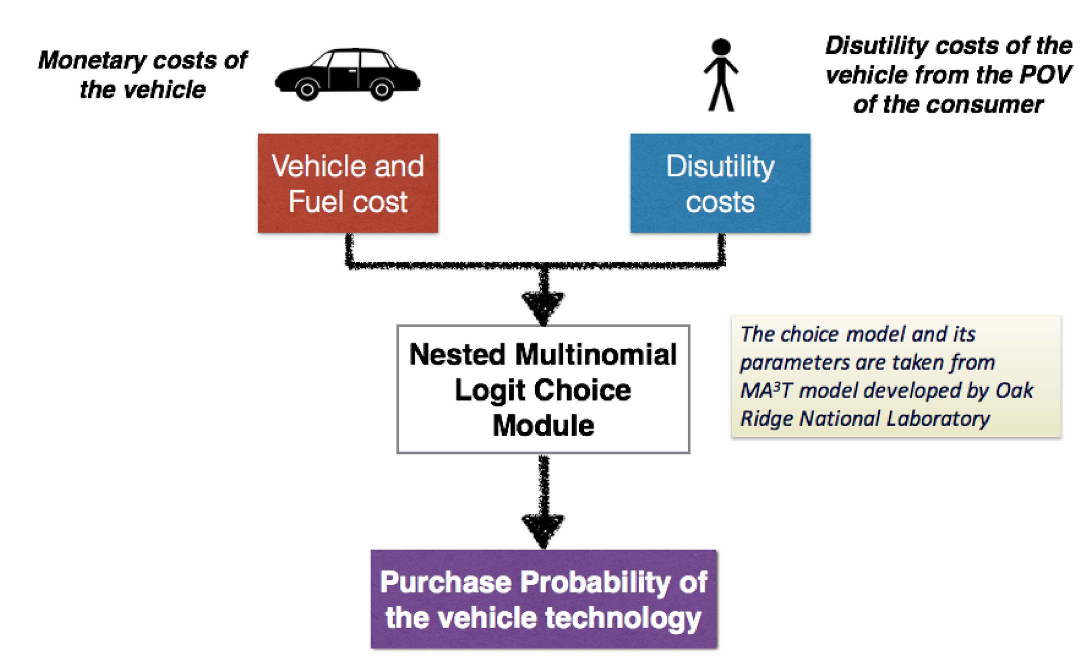
Methodology

- Consumer groups will be segmented and characterized based upon demographic and geographic factors such as income, population density, travel distances, housing type, geographic location, risk attitudes, and infrastructure availability.
- Disutility costs for each vehicle technology for each consumer group is estimated.
- The costs are fed into a nested-multinomial choice module to predict purchase probability of each consumer group.
- Instead of developing a market share for an entire region, vehicle sales is estimated for each micro-region (which vary by infrastructure availability and consumer segments)
- The regional vehicle sales is then aggregated across all of these micro-regions (i.e. zip code regions).

Model Structure



Decision-making Module



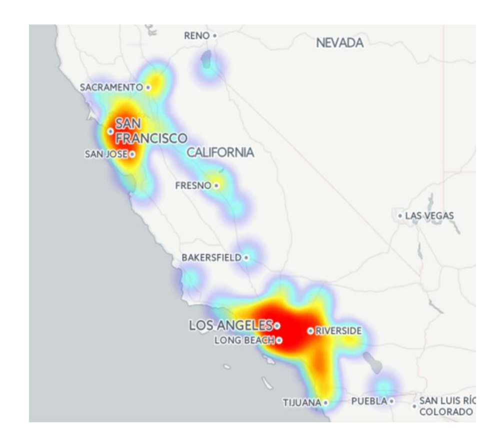
Disutility Cost Components in the model

Disutility Cost Component	Description	Dependent Characteristics
Refueling inconvenience cost (for non-electric vehicles—eg. FCVs)	The combined time and inconvenience cost to refuel a vehicle	Annual miles driven, fuel economy, vehicle storage, station availability, value of time
Range Limitation Cost (BEVs)	The estimated generalized cost incurred by a BEV owner due to limited range of battery electric vehicles in conjunction with the owners VMT pattern	Daily VMT, annual miles driven, infrastructure availability, anxiety cost (consumer-specific, based on their risk attitude)
Model availability cost	Estimated cost of consumer perception based on make and model diversity available in the market	Cumulative vehicle sales
Risk Premium	The risk premium perceived by the consumer based on their ability to take risk	Cumulative vehicle sales
Income related disutility	Perception of incremental vehicle price (difference from gasoline vehicles)	Household income, vehicle price

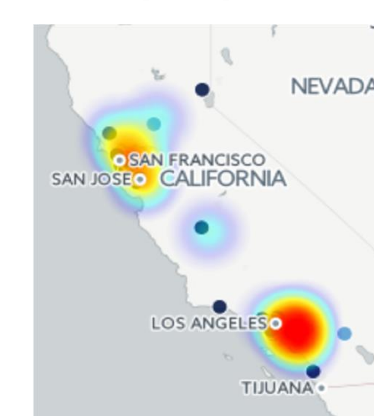
AFV Purchase Per Person

- Main indicator of fuel cell vehicles is the presence of hydrogen stations. Whereas the main indicator of battery electric vehicles is the presence of home and/or workplace charging.

BEV per person

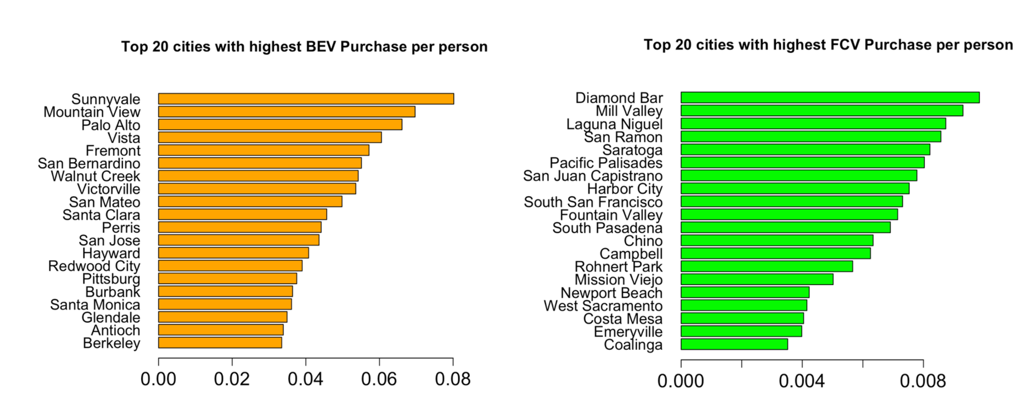


FCV per person



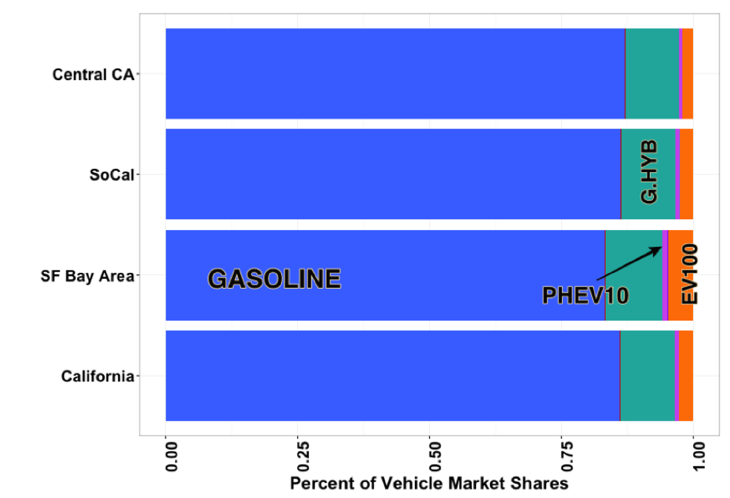
AFV Purchase—Top Cities in CA

- 12 out of 20 top cities with highest BEV purchase per person are located in the San Francisco bay area.
- 11 out of 20 top cities with highest FCV purchase per person are located in Southern California.



Purchase Probability per region in 2020

- Battery electric vehicle purchase probability in the San Francisco Bay Area is 76% higher than the state average. This is mainly due to better workplace charging access and higher share of high income population.



Ongoing Effort

Current work involves devising a better method for estimating infrastructure availability for hydrogen and public chargers in the spatial context. The proposed method is a function of following attributes:

- Number of nearby stations offering a specific fuel
- Distance to these stations
- Number of stations typically used by a consumer
- Reliability of stations

Model Needs

In order to better calibrate the model , historic vehicle sales data at zip code or census tract level is needed. Currently, DMV provides total vehicle sales data at County level, but not disaggregated by technologies or vehicle classes.

Additional Research Plans

- *Infrastructure investment decisions:*

Once the framework to calculate consumer purchase probabilities on a spatial scale is established, the model can be further developed to calculate optimal station siting decisions for alternative fuel stations, based on which locations would have the greatest impact on future alt fuel adoption.

- *Integration with Travel Demand Model:*

The everyday travel distances and destinations of consumers plays a huge role in deciding what kind of vehicle they would be more willing to purchase. The detailed data from the CSTDM (California Statewide Travel Demand Model) will be a valuable addition to this framework, and it will add a whole new dimension and refine the consumer purchase decisions, based on their daily travel distance, as well the appropriate location of fuel/charging stations in the region.

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