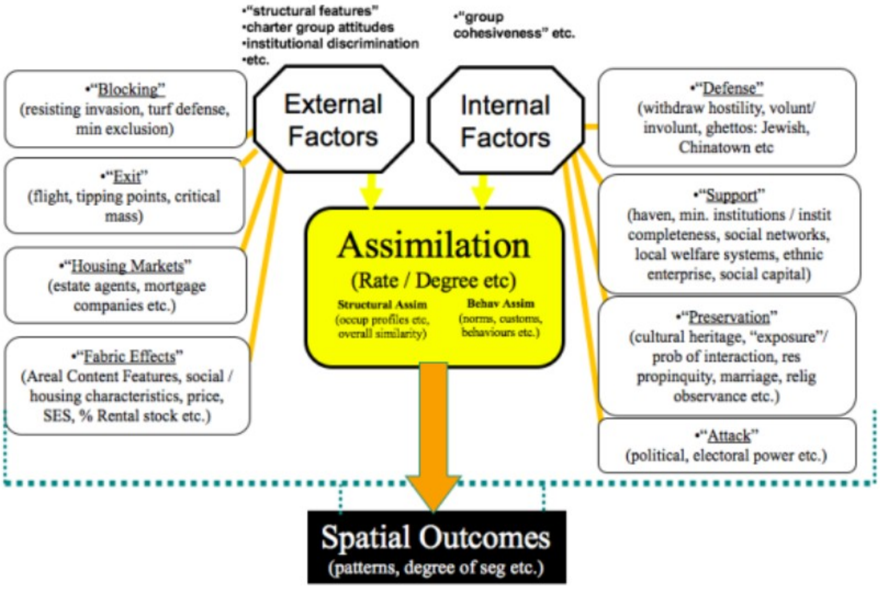
DISCRETE CHOICE MODELS APPLIED TO ALTADENA RECONSTRUCTION



DCM generated for a segregated neighborhood. Image credit Myriam Mahiques.

While qualitative mathematical models are recommended for analyzing urban morphologies, it is equally important to integrate quantitative models, as they are vital for achieving more comprehensive analytical outcomes.

Discrete Choice Models[1] (DCM) are a type of quantitative econometric models within Random Utility Theory (RUT) used to predict individual choices among a finite group of alternatives. The model assigns a value (utility) to each possible outcome in order to make rational decisions. The decision-making process is then modeled as a probabilistic selection based on the utility that each alternative offers to the individual. These models are applied to analyze and predict behaviors in multiple fields, such as marketing, transportation, finance, environmental and health economics, the most famous being transportation in California, developed by the econometrician Daniel McFadden, who shared the Nobel Prize in Economic Sciences with James Heckman in 2000.

The principle behind the theory of Stochastic Utility is the assumption that individuals will make the choice that maximizes their subjective utility, and that such utility can be modeled as a linear function of observable features in the world[2]. The random (stochastic) part is incorporated to account for unobservable factors affecting selections, thus allowing for probabilistic predictions.

McFadden argues that "From the standpoint of the observer unmeasured psychological factors introduce a random element in economic decisions. The result is a probabilistic theory of choice which has many features in common with psychophysical models of judgement" (D. McFadden, p. 198, 1981)[3].

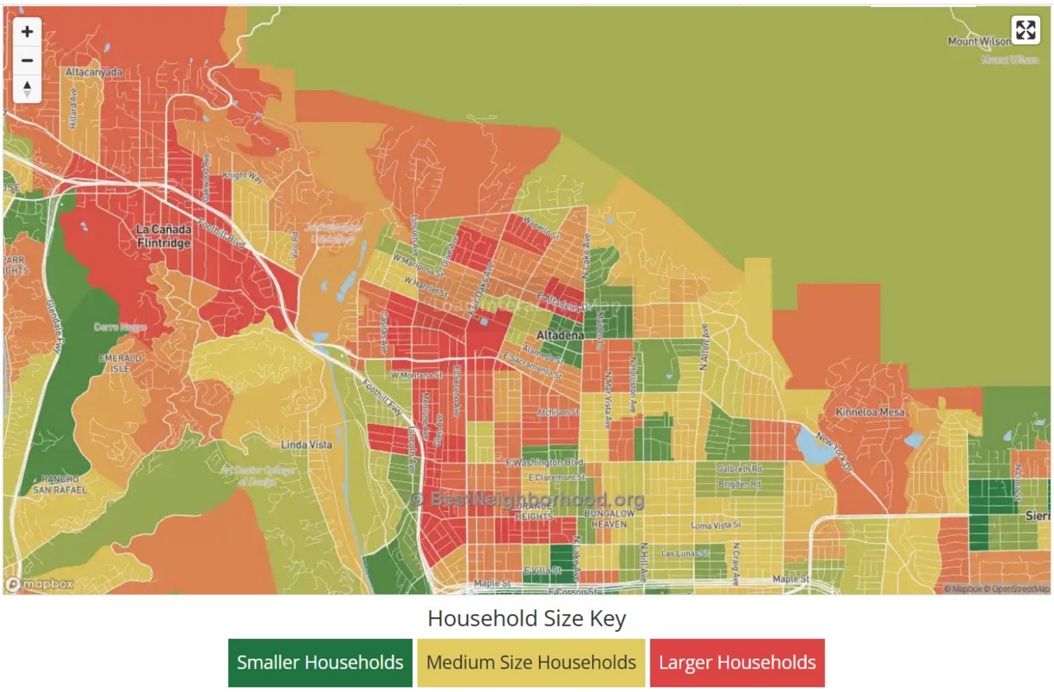
---

[1] For more information see Discrete Choice Models in Quickonomics. April 2024. They are also called Random Utility Models. https://quickonomics.com/terms/discrete-choice-models/

[2] See Discrete Choice and Random Utility Models. Publication date not available. https://www.pymc.io/projects/examples/en/latest/generalized_linear_models/GLM-discrete-choice_models.html

[3] We understand that McFadden is referring here indirectly to mathematical psychology, whose computational models explain psychological phenomena such as perception, cognition, decision-making and behavior through mathematical equations and simulations that test experimental data to achieve more precise (quantifiable) hypotheses and validate them empirically.

McFadden recognizes that individual choices are not based solely on rationality; preferences, influenced by evaluations and perceptions choices attributes, play a vital role. Perceptions would produce inconsistencies in a binary reductionist model of "yes" or "no" decisions; by incorporating psychophysical and perceptual characteristics, the model becomes more realistic and effective in predictions. The same is true for a single user representation model, which provides a precarious description of individual behavior that also depends on their education and family size (D. McFadden, p. 199-200, 1981).[4]
This point demonstrates the difficulty of using the concept of identical users (consumers) as the basis of the selection behavior model, hence more complex formulas are needed: "Suppose we introduce a population of consumers in which tastes vary explicitly. For example, we might consider a population of consumers with quadratic utility functions whose coefficients are distributed in the population according to some specific parametric probability distribution (….) The parameters of the aggregate demand function will then be the parameters of the underlying probability distribution of taste coefficients" (D. McFadden, p. 200, 1981). The quotation denotes a parallelism with the cultural preferences of a social group in the built environment, with housing being the "utilities" with assigned value(s) within urban forms.



Altadena household map. Image from bestneighborhood.com

In our field of architecture and urbanism, although we do not work with formulas, we can interpolate the Random Utility Theory and the Discrete Choice Model to optimize the reconstruction of the urban fabric after a catastrophe. Advances in artificial intelligence allow us to input data to obtain predictive results based on users' behavior and cultural preferences. This quantitative method is based on statistics and is complemented by qualitative experimental techniques such as fractal morphologies analysis, interviews, photographs.
To implement the theory in post-catastrophe reconstruction design, we have worked on the city of Altadena using Discrete Application Models with formulas developed by artificial

[4] McFadden's reference here is specific to models of transport use.

intelligence according to multiple attributes that we have selected in order to compare the preferences of social groups.
As previously noted, it is essential that the model takes into account the diverse variables associated with users and refrains from limiting its design to a single representative population group.
We have started with the following data:

According to the 2020 Altadena census, racial demographic results were[5]:

46.2% White
28.4% Latinos or Hispanics, any race
17.2% Afro Americans
7.1% Asians
1.1% Other

Composition of dwellings in Altadena (before the wildfires):

. 87.5% Single family dwelling
. 4.7% Attached row homes
. 4.3% Duplex, apartments
. 3.6% Large apartment complexes
It indicates that SFD housing is the overwhelmingly prevalent option across the community.

We ran the DCM for the **black population** first as follows:

<u>Key facts based on census data</u>

. Altadena median household income +- $129k
. Altadena owner-occupied rate +- 78.3%
. Altadena racial mix Black/African American 18%
. Altadena Black ownership 75% among Black households with strong place attachment in a generational pattern.
(The DCM should reflect the stay on site preference).

Possible alternatives for reconstruction:

1. Owner. SFD built on the same lot.
2. Owner. SFD with ADU
3. Renter. ADU-small house rental
4. Renter. Small multifamily of 2 up to 4 units
5. Renter. Large multifamily of 5 + units
6. Relocate to an off-site new development

Formula:

$$U_{ij} = \alpha_j^{(B)} + \beta_{cost}\,Cost_j + \beta_{space}\,Bedrooms_j + \beta_{access}\,Access_j + \beta_{tenure}\,TenureFit_j + \beta_{time}\,Time_j + \varepsilon_{ij}$$

Results:

[5] The census presents other additional values such as 15.7% multiracial and 12.8% other races. We have preferred to give the percentages of the largest racial groups.

Alternative	Predicted probability (Black households)
Owner — SFD	**46.1%**
Owner — SFD + ADU	**24.8%**
Renter — ADU	10.4%
Renter — MF small	6.6%
Renter — MF large	3.7%
Relocation	8.5%

Under the attributes presented above, that include culture, time of reconstruction, current choices, income, quantity of bedrooms, we have determined that Black households in Altadena strongly prefer owning single family homes, it means that they prefer to stay and rebuild, with some ADUs options to generate income. Renting and relocating are comparatively less likely choices.
We also ran the DCM for the **white and latino population** first as follows:

Preliminary data:

. Overall Altadena is a high ownership (+- 78%) community.
. Latino ownership in Altadena sits above the L.A. county Latino rate, approximately 45% of the total ownership statewide.
. Altadena's socioeconomic baseline (median household income +- $129k)
. Place-level housing character is dominated by single family residences.
. Local socioeconomic differences (Latino residents in Altadena are more likely to be lower-income vs Whites).

Possible alternatives for reconstruction:

1. Owner. Single Family Dwelling
2. Owner. ADU (Owner living in a home with an ADU)
3. Renter. ADU (Small ADU rental)
4. Renter. Multifamily apartment

Formula

$$V_{ij} = \alpha_j + \beta_{cost} \cdot \mathrm{Cost}_j + \beta_{beds} \cdot \mathrm{Bedrooms}_j$$

Results

Alternative	White probability	Latino probability
Owner — SFD	0.4669 (46.7%)	0.1860 (18.6%)
Owner — ADU	0.2562 (25.6%)	0.3067 (30.7%)
Renter — ADU	0.1898 (19.0%)	0.2511 (25.1%)
Renter — MF	0.0870 (8.7%)	0.2562 (25.6%)

Under the attributes presented above, the white householders have strong preference for Owner-SFD with ADU ownership as a second option. Low baseline probability for large multifamily renting.
Latino householders have more distributed choices, ownership and rentals are similar; there is an important difference with the White percentage of multifamily renter. Latino ownership is much lower than White ownership. This indirectly encodes the income and culture.
Further analysis should be done if we take into account the unauthorized immigrants - tenants without rights- some of them living in sub-rented bedrooms providing an extra income to the homeowners.

A primary characteristic of RUT or RUMs is their behavioral basis. Rather than providing binary or deterministic predictions, these models generate probabilities for each possible choice that can be updated according to varying conditions. This approach can be applied in architectural and urban design to assist in evaluating different master plans options.

Bibliography

Forde, Nataniel. "Discrete Choice and Random Utility Models". In: PyMC Examples. Ed. By PyMC Team. https://www.pymc.io/projects/examples/en/latest/generalized_linear_models/GLM-discrete-choice_models.html

McFadden, Daniel. Econometric Models of Probabilistic Choice. En Maski, C. and McFadden, D., Eds., Structural Analysis of Discrete Date with Econometric Applications, MIT Press, Cambridge, 198-272. 1981.

For more information see Altadena Demographics
https://bestneighborhood.org/demographics-in-altadena-ca/

Arq. Myriam Mahiques
August 2025