Agent Based Evolutionary Model of Travel Mode Choice

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Introduction

The different objectives in travel mode choice leads to the urge of applying game theory for making decisions based on finding the equilibrium of the traveler's choices. But is it possible to predict such phenomena? and what could game theory predict exactly?

What is Game Theory?

Game theory is a branch of applied mathematics that derives mathematical models to predict the outcome of competitive interactions between two or more rational decision makers. It can be for:

- common interest (coordination game)
- competing interest (rivalry)

Defining games

A game consists of four parts:

- Players

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- Strategies

Defining games

A game consists of four parts:

- Players
- Actions
- Strategies
- Payoffs

Normal form

A normal form represents a list of what players get on function of their actions.
Example: Prisoner's Dilemma

Example (Prisoner's Dilemma)

1/2	Confess	Refuse
Confess	2,2	0,3
Refuse	3,0	1,1

Table: Prisoner's Dilemma

Extensive form

An extensive form game includes timing of moves. Players move sequentially, represented as a tree. These are examples of games that can be represented in the extensive form:

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- Poker

Nash Equilibrium

Definition

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- pure strategy: only one action is played.
- mixed strategy: more than one action is played with positive probability.

Sub-game perfection and Backward Induction

A subgame Nash equilibrium is an equilibrium such that the strategies of players constitute a Nash equilibrium in each subgame of the game. It may be found by backwards induction.

Backward Induction

Backward induction is an iterative process for solving finite extensive form games. First, one determines the optimal strategy of the player who makes the last move of the game. Then, the optimal action of the next to last moving player is determined taking the last player's action as given. The process continues in this way backwards in time until the actions have been determined.

Backward Induction

By using simple methods of game theory, we can solve for what would be a confusing array of outcomes in a real-world situation. Using game theory as a tool for analysis can be very helpful in sorting out potentially messy real-world situations, from mergers to product releases.

Evolutionary game theory

Evolutionary game theory was introduced by John Maynard Smith in 1982. The main assumption of evolutionary game theory is that strategies with greater payoffs at a particular time would tend to spread more and thus have better chances of being present in the future.

Methodology

There exists many models for analyzing data of travel mode choice. In this section, three main models that have been dominant are explained briefly:

- logit models
- probit models
- discriminant models

Utility theory

According the utility theory, the utility U_i of alternative mode i is expressed as the sum of a deterministic component V_i and a random component ϵ_i capturing the uncertainty:

$$U_i = V_i + \epsilon_i \tag{1}$$

Model and Analysis

this section is divided into two main sections:

- Travel mode choice game

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- Agent based model of the game

Mode Choice Evolutionary Game

Travel choice mode model

Our proposed model is an evolutionary agent based model of artificial agents playing the travel mode game.

Agent Based Modeling

Agent based modeling is a methodology used to build models of real world systems that are made up of individual units that repeatedly interact among themselves and their environment.

Travel choice mode model

Evolutionary agent based models are defined by their agents. An agent represents the decision maker or a traveler, and they have individual variables and instructions.

Agent Variables:

- Strategy (car/public)

Agent Instructions:

- To play

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Model Description

A population n-of-players (agents) that repeatedly play the travel mode choice game. However, having only two strategies instead: private cars and public transport. The revision rule in this model is: An agent looks at other random agents and adopt their strategy if their payoff is greater than the agent's.

Experiment

We are using NetLogo software to simulate our model using an artificial environment. After simulating the model for 100 repetitions using NetLogo's Behavioral Space tool, we got the following results:

Results (From NetLogo)

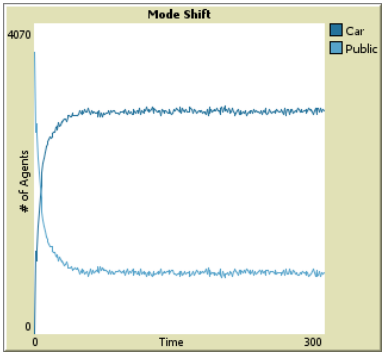

Figure: Distribution of Agents

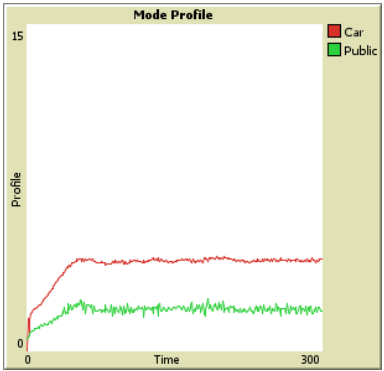

Figure: Mode Profiles

Results (From Data)

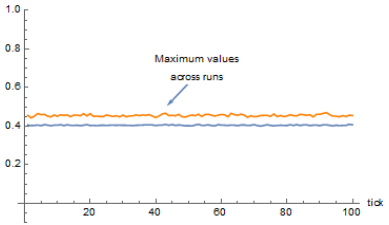

Figure: Proportion of Car strategists

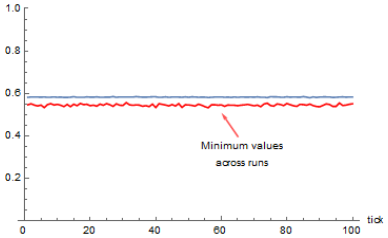

Figure: Proportion of public transport strategists

Conclusion

Finally, the goal of this study was to build a model of travel mode choice that is capable of embedding evolutionary game theory to understand the behavior of travelers and the various characteristics included. Game theory seems to be useful in modeling the relationship between travel modes and Nash equilibrium. Therefore, We are writing a scientific paper based on this work.

Future Work

We can use concepts from machine learning models and artificial intelligence studies, as well as neural networks and genetic algorithms to represent the decision making process of travelers.