ETM 530

Decision Making in Engineering and Technology Management

Team Project

Hierarchal Decision Model for Mode of Transportation from Portland, OR to San Francisco, CA

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1.0 Introduction

Our world is a mobile world. The days have passed that it would take weeks, sometimes even months, to traverse a continent. Now a person has many choices in mode of travel from one destination to another. The method that an individual chooses is based on many different criteria. Our model seeks to help people trying to choose a method of travel from Portland, OR to San Francisco, CA. We have developed the model and in this paper, discuss the testing methods used to verify the model's validity. In our report, we describe the methodology we used in the project and the attributes used in the model. We compared and contrasted the attributes and the significance of each to help the decision makers decide on the best mode of travel based on the criteria given in the model.

2.0 Methodology

With the evolution of different transportation technologies, evaluating the optimum method of travel has come down to personal preference and a set of criteria. To determine what method is optimum, a Hierarchal Decision Model (HDM) was developed and used for three separate cases. These cases exemplify a wide variety of criteria that can be input into the model and evaluated to determine the best mode of transportation. The final transportation methods for selection in the model are:

- Car
- Bus
- Train
- Plane

Several criteria were chosen based on what considerations a person may have to make based on their particular situation. Included in the model that was developed are the following criteria:

- Travel Cost
- Length of Travel Time
- Number of Departure Times
- Amount of Luggage
- Number of Stops

Some criteria were purposefully left out of the scope of this model as including it in this model would not accurately accommodate all cases. To better focus the scope of the model, we excluded sights to be seen along the way based on the method of travel used. The sights along the way do not always weigh on people's decision when choosing a travel method from one destination to another. A person's perceived comfort was also excluded from the model because criteria to determine comfort of one person over another were not available. The model only considers a single traveler and does not consider additional travel companions such as other adults, children, or pets. Because there are many return travel options that a person could choose from such as length of stay in destination, the scope was limited to one-way travel only. A Monday departure was assumed for all modes of travel. There are numerous options on Mondays because

it is a common day for pleasure travelers to return or for business travelers to leave, meaning there are in total many departures at any destination point. The specific date entered into the ticket field was 3/18/13.

The scope of focus for the model was to determine the best means of transportation based on criteria that all people must consider when choosing a mode of transportation.

2.1 Travel Cost

Cost of travel varies greatly from one method to another. Cost can even vary within a particular mode of transportation. This is especially true for air travel.

Travel costs were determined using the travel websites [1] [2] [3]associated with the various modes of transportation for bus, train, and plane. It was assumed that all travelers are prepared with their own food for meals due to dietary concerns. No extra fees or charges are figured into costs, such as additional luggage fees, in-flight services, magazines, etc. Costs do include taxes and fees where applicable. Costs are averaged when different options are provided. For example, traveling by bus had four price options that were averaged ($78.00, $93.60, $104.00, $117.00), plus a fee ($2.50) to determine the final cost estimate [3]. For traveling by car, a calculation was run using the distance from Portland, OR to San Francisco, CA (636 mi) [4], the average fuel economy of cars, trucks, and SUVs (22.4 miles per gallon) [5], average price of mid-grade fuel ($3.94) [6], and the cost of a standard room at a top-rated hotel for overnight stay ($113.22) [7] as follows:

$$\left(\frac{Distance}{MPG}\right) * Fuel\ \$ + Hotel = Total\ car\ travel\ cost$$

The total car cost assumes that the traveler is using a car they already own or do not have to pay additional money to use and therefor does not consider the cost of a car rental. The total travel cost for each is listed in the below table:

Mode of Transportation	Cost
Car	$ 225.14
Bus	$ 100.65
Train	$ 84.00
Plane	$ 229.35

This was then broken down into several cost ranges for the model.

- Less than $100
- $100 to $200
- More than $200

2.2 Length of Travel Time

How long a particular mode of transportation takes can be very important for some, while it is not nearly as important for others. This particular criterion is very unique based on the mode of transportation chosen.

Length of travel was based on departure and arrival times from the respective transportation mode websites [1] [2] [3]. When a range of travel times were available, an average was taken. For travel by car the travel time was determined using Google Maps [4] estimated total travel time (9 hours and 44 minutes). This total drive time was split approximately half-way through for an overnight stay in Yreka, CA, where it is assumed that the car is also refueled. Each day also includes one rest stop, at approximately half-way through that days' five hour drive. This gives total travel times as follows:

Mode of Transportation	Travel Time (hours)
Car	36
Bus	18.5
Train	18.5
Plane	4.5

This allowed us to break down travel time for the model.

- 2 to 7 hours
- 7 to 24 hours
- More than 24 hours

2.3 Departure Options

Depending on the particular reason for travel, the number of travel departure times available can also be a deciding factor. This was also very unique depending on the method of transportation chosen.

Departure times were determined using the respective travel mode websites [1] [2] [3]. Based on the available departure times for each mode of transportation the below table was generated:

Mode of Transportation	Number of Departure Times
Car	Unlimited
Bus	4
Train	1
Plane	27

Given the above departure times available the criteria used for the model are as follows.

- 1 available departure time
- 2 to 5 available departure times
- More than 5 available departure times

2.4 Amount of Luggage

The amount of luggage that someone can carry with them without incurring any additional cost can be very important. The amount of luggage someone can carry given a particular mode of transportation is fairly common across the various modes of transportation; however, the type of luggage that can be carried varies. The scope of this paper only considers standard luggage and not odd sized items such as bikes or pets in pet carriers.

The model defines the amount of luggage that can be taken as the maximum amount of luggage that can be taken without any additional fees. The number does not include a personal item, such as a handbag or briefcase as it is assumed that every traveler will at least have this item and these items generally do not incur extra fees. The determinations below were found by researching each transportation mode websites [1] [2] [3] for their luggage policies.

Mode of Transportation	Maximum Amount of Luggage	Notes
Car	Unlimited	Limited by available space
Bus	1	Checked
Train	2	Carry On
Plane	1	Carry On

Given the above table, the model criteria were defined as:

- Less than 2 bags
- Exactly 2 bags
- More than 2 bags

2.5 Number of Stops

The number of stops that are required can be both a positive and negative depending on a given travel situation.

The number of stops required was determined using the respective travel methods website [1] [2] [3]. A stop is defined as a point during the travel journey where a passenger may completely dis-board the mode of transport for a given duration of time. This is often referred to as a layover or transfer. Where multiple layovers were available, an average was taken. For travel by car it was determined that 3 stops would be required as described above, but an unlimited number of stops would be available if needed. The number of stops does not include beginning or ending point, just the stops during travel from each point. The below table was developed to help determine the model criteria:

Mode of Transportation	Number of Stops
Car	3
Bus	10
Train	1
Plane	0 or 1

Using this table the below criteria was determined for the model.

- 0 to 2 stops
- 3 to 5 stops
- More than 5 stops

3.0 Model

The combined selection criteria informed the creation of a Hierarchical Decision Model (HDM).

Criteria	Sub-Criteria	Car	Bus	Train	Plane
Travel Cost	<$100			✓	
	$100-$200		✓		
	>$200	✓			✓
Length of Travel Time	2-7 hours				✓
	7 hours-1 day		✓	✓	
	2 days	✓			
Number of Departure Times	1 departure			✓	
	2-5 departures		✓		
	>5 departures	✓			✓
Amount of Luggage	<2 bags	✓	✓	✓	✓
	2 bags	✓		✓	
	>2 bags	✓			
Number of Stops	0-2 Stops			✓	✓
	3-5 Stops	✓			
	>5 stops		✓		

The HDM was created considering the various criteria to help travelers choose the best mode of transportation depending on their individual requirements.

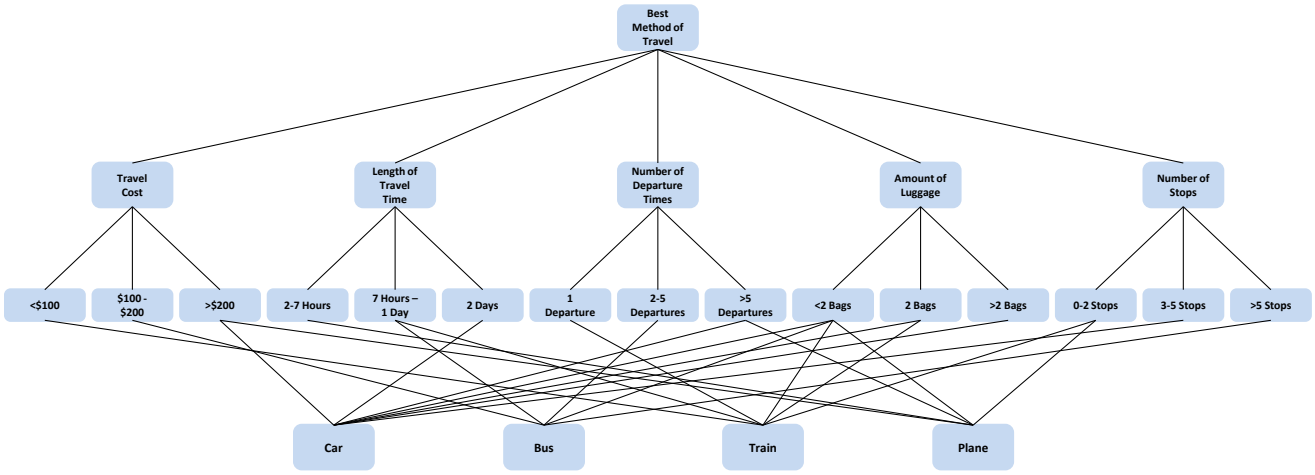

Figure 1: Hierarchical Decision Model

The HDM has four levels;

- First section identifies best method of travel as the goal of the model
- Second section identifies the basic criteria considered for the model
- Third section identifies the sub-criteria for each basic criteria considered for the model
- Fourth section identifies the various methods available for transportation

The basic criteria Travel Cost, Length of Travel Time, Number of Departure Times, Amount of Luggage and Number of Stops were used to select the importance of one criterion over another.

4.0 Scenarios

To demonstrate the framework of the model, three different traveler scenarios were considered.

4.1 A Businessman traveling for business from Portland, OR to San Francisco, CA

A businessman travelling for business would always prefer the shortest mode of transport. Also, for a businessman convenience or the number of departures available would be the top consideration as compared to cost required for the travel.

A businessman with all his constraints would need a mode of transport that is convenient as well as allow him to reach the destination in the shortest time.

4.2 A Mom with some medical condition travelling from Portland, OR to San Francisco, CA

A mom who has a medical condition and is travelling from Portland, OR to San Francisco, CA would definitely prefer a mode of transportation that would allow her to make frequent stops during her travel. For her, luggage and number of departures would not matter that much as compared to the number of stops available considering her medical condition. Also she would be considering cost as one of her top decision criteria.

The mom with all her consideration would need a mode of transport that would be cost efficient and will give her flexibility to take stops during travel.

4.3 A Student moving permanently from Portland, OR to San Francisco, CA

A student travelling from Portland, OR to San Francisco, CA is assumed to have a limited budget. Being a student, he won't have a time constraint. Also for the student, cost would be the top consideration as compared to convenience of travel or number of departures available. As the student is moving permanently from Portland to San Francisco, he would have more than three bags.

The student with all his constraints would need a mode of transport that would allow him to take more than 3 bags while keeping the cost low.

To demonstrate the application of the HDM model; The Businessman, The Mom and The Student are considered to be the experts. These experts, depending on the requirements of the scenarios, weight the various available options for travel against each other from Portland, OR to San Francisco, CA in a pairwise comparison.

5.0 Results

The three traveler scenarios showed different selections for the best method of travel for each individual.

Best Method of Travel	Car	Bus	Train	Plane	Inconsistency
Businessman Expert	0.16	0.14	0.16	0.55	0
Mom Expert	0.3	0.35	0.2	0.16	0
Student Expert	0.39	0.19	0.31	0.11	0
Mean	**0.28**	**0.23**	**0.22**	**0.27**	
Minimum	**0.16**	**0.14**	**0.16**	**0.11**	
Maximum	**0.39**	**0.35**	**0.31**	**0.55**	
Std. Deviation	**0.09**	**0.09**	**0.06**	**0.2**	
Disagreement					**0.11**

5.1 Businessman Expert

Traveling by plane is the best method for the Businessman Expert with a value of 0.55. This result is expected because the Businessman Expert placed the most emphasis on having a short length of travel time and frequent number of departures criteria. Having minimal stops during the travel journey was also highly important since his time was limited. No other methods of travel are recommended for the Businessman Expert.

5.2 Mom Expert

The Mom Expert results favored bus at 0.35; however car was close behind at 0.30 for the best method of travel. This result makes sense because she chose the number of stops criteria as the most important due to her health concerns. Her selection also favored a greater number of departures which suggests the car method, but with a lower cost and shorter total travel time preferred, the best method for her is the bus. We feel that a car is still a reasonable option for the Mom Expert given that she has access to a reliable car and is able and willing to drive herself. This option would then give her the most flexibility and freedom to make decisions and travel adjustments based on medical needs.

5.3 Student Expert

The Student Expert travel scenario shows that car is the best method at 0.39 followed by train at 0.31. Travel cost is the most important criteria for the student, with the amount of luggage as the next most important criteria. Having more than two pieces of luggage without additional fees was highly rated in the sub-criteria along with multiple departure options which suggest the car method of travel is the best. However, the Student Expert also highly valued having a low cost, which favors taking the train. If the student has access to a reliable car then this is the best method of travel. Taking the train is a viable second option, especially considering that the student could reduce the number of bags or pay the extra luggage fee and still have lower total costs than driving a car.

The overall average best method of travel for all three scenarios combined is to drive a car from Portland, OR to San Francisco, CA at 0.28. However traveling by plane is the next best method of travel at 0.27, with bus and train showing similar results at 0.23 and 0.22 respectively. The average results show that it does not make sense to choose a method of travel in comparison to other traveler selections. Each situation and person is highly unique, and their selections should not be averaged with other scenarios that are irrelevant to their decisions. The high discrepancy value of 0.11 proves this to be true. Because of this, we recommend viewing overall results for either scenarios that are similar or for an individual with a variety of scenarios.

6.0 Model Application

The project helped us learn the decision process which is an important aspect of the HDM model. We developed a model to help determine the best method of travel from Portland, OR to San Francisco, CA. We determined the key criteria and then defined the significance of the attributes used in the model. We tested the model using some very specific cases as defined above and achieved an outcome that was to be expected proving the validity of the model. Using the model is as simple as performing weighted pairwise comparisons against the various criteria to determine the best mode of transportation given your needs.

A decision maker can apply this model or a similar model to determine the best method of travel for their unique scenario. This model is flexible and can be easily adjusted to accommodate for different travel criteria and sub-criteria. In this way a decision maker can feel more confident with their travel mode selection as the model will help them with their determination. It is also easy to compare different traveler selections which can be helpful if travel companions are unable to agree on a travel mode before using the model.

7.0 Limitations and Future Research

This HDM was limited with the scope to serve as an example of how a decision maker could use this selection method to make travel decisions. The model only considers one city-to-city travel scenario; however it could be expanded to include multiple cities within one model or could be adjusted to consider a different set of cities. The model should also be expanded to consider travel companions as this would alter many of the travel decisions and criteria. For example, the cost of traveling by car would not change with an additional

adult traveler assuming that they shared a hotel room during the overnight stay, but the cost of tickets for all other modes would increase. Many travelers require round-trip options, and this model is limited in this respect.

Additional models could be developed for each mode of transportation to help an individual chose which sub category of travel works best for them (ex: Private charter flight vs. commercial flying, sight-seeing while driving vs. driving straight through). Also, averages had to be used when calculating the costs of travel for each method. This lack of variables has the potential of causing a particular travel option to be more attractive when it should be due to several factors that cannot be included in the model such as fuel economy, time of year, and weather conditions. These things can drastically alter what method a person may choose. These are things that could also be included in a secondary model once a primary mode of transportation has been chosen however.

8.0 Conclusion

In this paper, we addressed a problem of evaluating the best method to travel from Portland, OR to San Francisco, CA. A set of travel criteria and sub-criteria were determined that represent decisions that travelers face when determining a transportation method. A hierarchal decision model was developed to evaluate which method of travel is best for an individual based on a very specific set of requirements. These examples were used a means to test our model to determine if the hypothesized outcome was correct. By performing pairwise comparisons on each scenario we were able to verify that the model is accurate and, within the parameters of the chosen criteria, is a valid option for deciding which method of travel an individual should use. There is room to expand the model, but the focus of this model was looking at the bigger picture of travel from one destination to another.

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