CVEN90048 Transport System

Project Report

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Introduction

The Metro Tunnel Project, as the largest public transport project in Victoria, is currently under construction and the tunnels are planned to open in 2025. The project will benefit Melbourne's public transport system by increasing the number of trains and providing more spaces in the City Loop to run the trains to and from the suburbs. As a result, the train network will become more efficient and reliable.

A mode choice model is developed to analyse the performance of the transport systems and to evaluate the expected impacts of Melbourne Tunnel. The model is focused on an assigned zone in the Sunbury rail catchment area, and is estimated using Biogeme, based on the given VISTA data from 2012-2016. The best model is found with all significant variables included. Furthermore, the mode shares for all modes before and after the completion of Melbourne tunnel are estimated and compared. The shortcomings and proposed improvement methods for the analysis will be further discussed.

Major work

Firstly, a basic mode choice model consists of car travel time, bike travel time, walk travel time, transit travel time, transit headway is built and has Rho-square value of 0.533. To improve the fitting degree of the model, from h, p, s, t table, 22 attributes which considered to have impact on the mode choice model are selected to be analysed individually.

For numeric attributes, such as Number of stops, they are tested directly. By contrast, dummy variables are used for non-numeric attributes, such as Trip purpose. By running the model time by time, finally 12 attributes improve the goodness of fit of the model and indicate their high relativities to peoples' trip mode choice. However, Study status, Activity status and Household size are filled out due to high P value which means they are insignificant in the model.

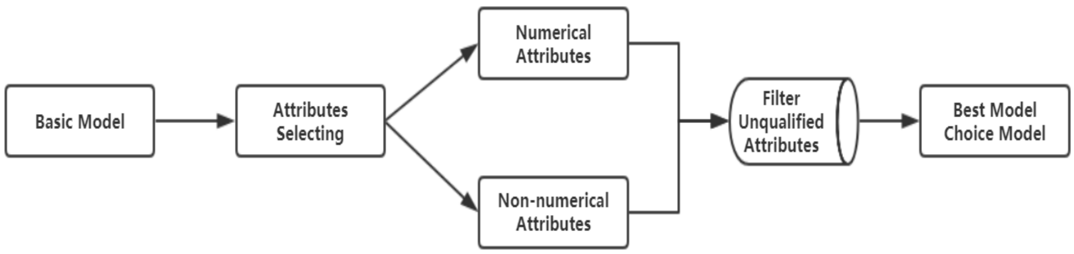

Figure 1. Workflow for finding the best model

Table 1. Tested attributes

Number	***Attributes***	***Impact***	***Comment***
1	Age	NO	
2	Sex	YES	R^2 improved
3	Car licence	YES	R^2 improved
4	Employment status (Anywork)	NO	
5	Study status	YES	Deleted (P-value >=0.05)
6	Activity status	YES	Deleted (P-value >=0.05)
7	Work shift types	NO	
8	Employment types	NO	
9	Number of stops	YES	R^2 improved
10	Sampler's region	NO	
11	Household size	YES	Deleted (P-value >=0.05)
12	Household total bikes	YES	R^2 improved
13	Household total vehicles	YES	R^2 improved
14	Household travel day (day of week)	NO	
15	Travel mouth	NO	
16	Household average age	NO	
17	Trip times	YES	R^2 improved
18	Trip distance	YES	R^2 improved
19	Trip purpose	YES	R^2 improved
20	Waiting time	YES	R^2 improved
21	Personal income	NO	
22	Household income	NO	

The Rho-square value for our final best mode choice model is 0.672, and the p-value of all the variables in the model all significant (i.e. p-value<0.05).

Estimation report

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          Number of estimated parameters: 23
                             Sample size: 6106
                   Excluded observations: 0
                     Init log likelihood: -8464.713
                    Final log likelihood: -2776.263
 Likelihood ratio test for the init. model: 11376.9
          Rho-square for the init. model: 0.672
      Rho-square-bar for the init. model: 0.669
            Akaike Information Criterion: 5598.527
          Bayesian Information Criterion: 5753.019
                     Final gradient norm: 1.4061E-03
                              Diagnostic: b'CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH'
                       Database readings: 1275
                              Iterations: 1139
                       Optimization time: 0:00:57.558718
                          Nbr of threads: 8
```

Name	Value	Std err	t-test	p-value	Rob. Std err	Rob. t-test	Rob. p-value
asc_bike	-2.12	0.149	-14.3	0	0.171	-12.4	0
asc_car	1.94	0.116	16.7	0	0.133	14.7	0
asc_transit	-1.96	0.22	-8.92	0	0.23	-8.54	0
asc_walk	2.14	0.106	20.2	0	0.157	13.6	0
beta_PorDsomeone	0.884	0.146	6.07	1.28e-09	0.138	6.4	1.52e-10
beta_accompanysomeone	-0.94	0.238	-3.95	7.76e-05	0.232	-4.06	4.98e-05
beta_buysomething	0.396	0.115	3.43	0.00061	0.111	3.58	0.000342
beta_cumdist	-0.448	0.033	-13.6	0	0.0827	-5.41	6.35e-08
beta_education	1	0.196	5.11	3.2e-07	0.194	5.15	2.63e-07
beta_female	-0.748	0.186	-4.03	5.57e-05	0.195	-3.83	0.000127
beta_fulllicence	-0.998	0.228	-4.37	1.22e-05	0.214	-4.66	3.15e-06
beta_nocarlicence	0.726	0.231	3.14	0.00168	0.232	3.13	0.00177
beta_numstops	0.247	0.0212	11.7	0	0.0194	12.7	0
beta_personalbusiness	0.875	0.134	6.51	7.6e-11	0.125	6.99	2.75e-12
beta_recreational	-1.71	0.124	-13.8	0	0.112	-15.3	0
beta_social	-1.23	0.414	-2.97	0.00294	0.463	-2.66	0.00789
beta_totalbikes	0.356	0.0424	8.38	0	0.0405	8.77	0
beta_totalvehs	0.379	0.0471	8.04	8.88e-16	0.0454	8.35	0
beta_transitheadway	-0.0168	0.00438	-3.84	0.000123	0.00401	-4.19	2.73e-05
beta_traveltime	-0.0168	0.00202	-8.3	0	0.0044	-3.82	0.000135
beta_triptime	-0.0389	0.00269	-14.4	0	0.00624	-6.23	4.8e-10
beta_waitime	-0.33	0.0333	-9.91	0	0.0716	-4.6	4.18e-06
beta_workrelated	0.911	0.18	5.06	4.24e-07	0.185	4.94	7.87e-07

Figure 2. Estimation for the best mode choice model

The utility function of our best mode choice model is as follow:

$$U1(walk) = asc\_walk + \beta_{travel\_time} * walk\_travel\_time + \beta_{cumdist} * cumdist + \beta_{accompanysomeone} * trippurp1 + \beta_{personalbusiness} * trippurp4$$

$$U2(bike) = asc\_bike + \beta_{travel\_time} * bike\_travel\_time + \beta_{totalbikes} * totalbikes + \beta_{social} * trippurp7 + \beta_{female} * female$$

$$U3(transit) = asc\_transit + \beta_{travel\_time} * transit\_travel\_time + \beta_{transitheadway} * transit\_headway + \beta_{numstops} * numstops + \beta_{workrelated} * trippurp8 + \beta_{education} * trippurp3 + \beta_{nocarlicence} * nocarlicence + \beta_{fulllicence} * fulllicence$$

$$U4(car) = asc\_car + \beta_{travel\_time} * car\_travel\_time + \beta_{triptime} * triptime + \beta_{waitime} * waitime + \beta_{totalvehs} * totalvehs + \beta_{buysomething} * trippurp2 + \beta_{PorDsomeone} * trippurp5 + \beta_{recreational} * trippurp6$$

Consequently, applying the best model to estimate mode shares of all trips from Sunbury catchment households and conduct a before/ after analysis for mode share impacts of Melbourne Tunnel on the SLCA households.

Before/after analysis

Quantitative impacts on mode share

Figure 2 shows the estimation of the total trips for different travel mode before and after completing the Melbourne tunnel. By analysing the result, we summarize the following changes:

After the tunnel is completed, the trips that choosing from these three modes: walking, bicycle, and car are decrease. To be specific, the number of trips that choose to walk is reduced from 397 to 345, while the trips for bicycles are reduced from 3718 to 3223. The most significant decline in the number of trips is for car mode, there are about 1134 trips no longer choose cars (from 28794 to 27660). However, the number of trips for transit shows the opposite change, there will be more trips to choose public transport, increased from 21217 to 22898.

In summary, the above statistics show that public transportation has become more attractive after completing the Melbourne tunnel.

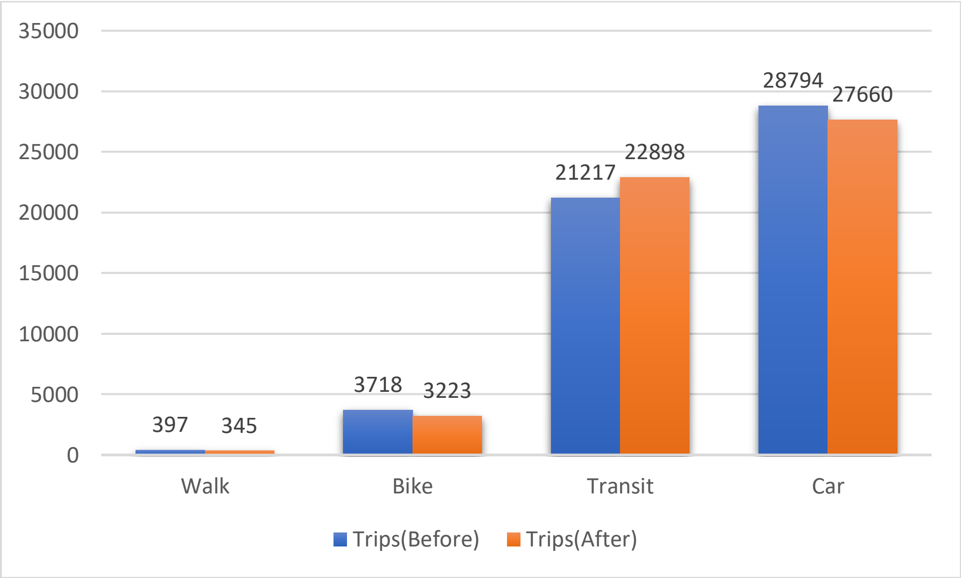

Figure 3. Total trips for different mode (before/after)

The following figure captured the emissions and space consumption of different modes of transport, which can used to quantitatively evaluate the impact on sustainability and efficiency.

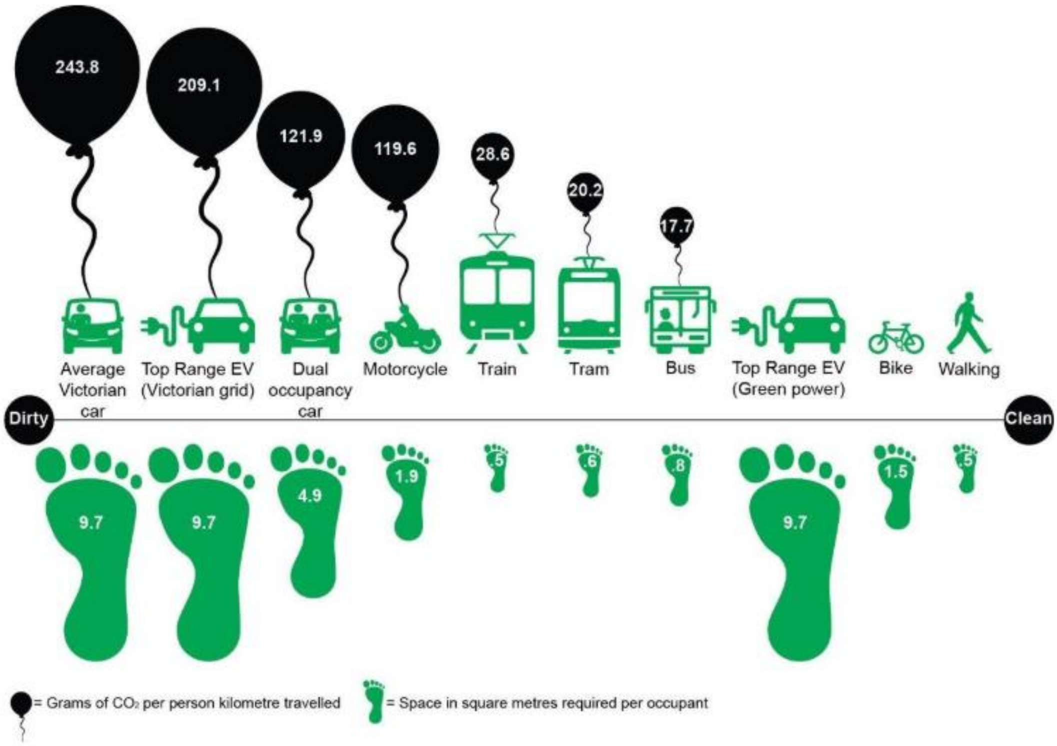

Figure 4. The emissions and space consumption of different transport modes

For transport sustainability, we take the average emissions of the average of the per capita CO2 emissions of the three types of public transportation(train, tram, and bus) as the per capita CO2 emissions of transit mode, the average emissions of the average of the per capita CO2 emissions of the three types of car (Average Victorian car, Dual occupancy car, and Motorcycle) as the per capita CO2 emissions of car mode. Combined with the previous data, we can calculate that after the completion of the Melbourne tunnel, it can reduce about *146,181* grams of CO2 (*per person kilometre travelled*).

For transport efficiency, space-saving is an important indicator that reflects transport efficiency. Similarly, we still consider the average of train, tram, and bus as the data of transit mode, and the average of average Victorian car, dual occupancy car, and motorcycle as the data of car mode. Combined with the previous data, we can calculate that it can save about *5,172* square meters of spaces after the completion of the Melbourne tunnel.

Qualitative impacts on transport sustainability

For an urban transport system to be sustainable, one of the most important criteria is per capita carbon emissions. According to the climate council factsheet, transport is the third largest source of Greenhouse gas (GHG) emission in Australia with the highest growth rate. Among transport emissions produced in Australia, cars are accounted for about half of them. With the construction of Melbourne Metro Tunnel, an alternative viable public transport mode is provided to the public. With this new convenient and cheap transport mode which can be easily accessed, a significant portion of the public will be encouraged to change their travel preference from cars to metro. As the percentage of cars users among all transport modes is reduced, the amount of GHG emission can also be reduced.

Qualitative impacts on transport efficiency

Travel efficiency

With the construction of Melbourne metro tunnel, travel time and travel speed can be effectively improved. Since metro system is independent of above-ground roadway systems, it can be classified as uninterrupted traffic flow that is not delayed or interfered by external factors. By diverting a part of travellers from cars to metro, the pressure on existing roadway system can be reduced and network performance can be improved as well as traffic congestion.

Service efficiency

Among the two different functionalities of transit, metro tunnel system can be classified as mass transit. It has a high ridership with a reasonable revenue. As a result, a relatively high cost recovery rate can be obtained. Apart from this, the obtained revenue can be used to fill in the deficit produced by social transit modes with poor ridership and poor cost recovery.

Conclusion

Key findings from the mode choice model

The mode choice utility functions for walk, bike, transit and car consist different attributes with corresponding coefficients. The sign and value of the coefficients for each attribute would affect the value of utility functions as well as the probability of choosing the alternatives.

If the sign is positive, the attribute would increase the probability of choosing the mode. For example, for mode choice of car, the coefficient for ‘Pick-up or Drop-off Someone’ (beta_PorDsomeone) is 0.884, which increases the probability of choosing car. In reality, if someone is going to pick up or drop another person, it is likely that he/she will drive a car. Also, the coefficients for ‘education’, ‘number of stops’, ‘work related’ and ‘no car licence’ are positive, these attributes would increase the probability of choosing mode of ‘transit’.

In contrast, a negative coefficient will negatively impact the probability of the mode choice. For mode choice of transit, the coefficient for ‘full licence’ is -0.998, which means this attribute will inversely impact the probability of choosing the mode of transit. It is also true in reality. If someone has full licence, he/she could prefer driving rather than taking public transport. Also, ‘total distance for trip’ and ‘accompany someone’ have negative coefficients, so that the probability of choosing mode choice of walk will be decreased.

For some of the attributes, the magnitude of the coefficients would directly affect the mode choice probability. For example, for 'total vehicles' attribute, if number of vehicles increase, the probability of driving would increase as well. On the other hand, both 'wait time' and 'trip time' would negatively impact the mode choice probability. An increase in these attributes will result in a decrease in the probability of choosing car.

Shortcoming of the analysis

One of the shortcomings is that the incomprehensive input variables. The model is mainly based on the data from the VISTA tables. However, some other factors might have an impact on the mode choice model such as region population and weather. Also, some data within the dataset VISTA is missing for some of the trip ID and household ID.

Moreover, current analysis is a lack of behavioural considerations. Although multiple efforts have been put in the model, high accuracy has not been achieved due to the nature of behavioural analysis which is hardly estimated by a computer program.

Last but not least, the small sample size of the model is another shortcoming. Our sample size for modelling is around 6100, which might result in low accuracy of the model.

Potential ways to improve the analysis

Firstly, consider more variables that may impact the model and enlarge the sample size. Many other factors such as environment and culture mentioned above influence the behaviours of the model.

Secondly, the use of TripGo API or Google API can get more mode attributes such as the cost of parking and environmental footprint efficiently.

Besides, use the nested-logit model structure for modelling instead of logit model, which will be more accurate.

Finally, increase the input sample size will help to improve the analysis. The larger the sample size, will lead to more accurate results.