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Full Length Research Paper

Investigation of departure time in the journey to work in Tabuk city

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Very little attention has been given on departure choice modelling compared to other travel demand, trip mode choice models. This is especially true in the developing countries. Due to limited research and data availability and state of art and practice in travel choice modelling; local, state and countries transportation agencies do not have an explicit component to accommodate departure time choice in their travel model systems, and as a result simplistic, aggregate-level approaches are often adopted. This research investigate departure time choice and travel time flexibility in the city of Tabuk in the kingdom of Saudi Arabia (KSA). The results show that the female members of the family are more flexible in departure and arrival times, which reflect the fact that female travellers in KSA do not drive and hence have less travel commitments than male travellers. A Probit model has been calibrated and the paper concludes with recommendations of further work in the area of travel behaviour, departure time choices and female travel in Saudi Arabia.

Keyword: Departure time, Journey to work, Probit model, Travel behaviour

INTRODUCTION

Commuter departure time choice analysis has gained importance because it provide better understanding of the behavioural mechanisms behind peak-period road congestion. Better understanding of behavioural mechanisms can provide congestion relief measures that can be better coupled with commuters' decision processes to gain effective policy decision. There are two aspect of behaviour paradigm shift (see Senbil and Kitamura (2004)). First aspect is based on the notion of random utility maximization, and implicitly assumes the network conditions are known to commuters (e.g., Palma et al(1983), Hendrickson and Planck (1984), Mahmassani and Herman (1984) while second one relaxes this assumption considerably and acknowledges the roles of heuristics in human decision, and adopts the concept of bounded rationality proposed by Simon (1955) (e.g., Mahmassani and Chang (1987) ; Mahmassani and Jou (1998); Mahmassani and Liu (1999) Jou and Kitamura(2002)).

Due to limited research and data availability and state of art and practice in travel choice modelling; local, state and countries transportation agencies do not have an explicit component to accommodate departure time choice in their travel model systems. These agencies apply simplistic, aggregate-level, factors to apportion total daily travel demand among each of several time periods (see for example Bhat (1998)).

Transport models are used primarily to predict travel demand forecasts under a number of scenarios. For example when building a new railway line, planners need to have an idea on the predicted demand of the planned service. Moreover, the design and specification of the service will benefit from some modelling on the acceptance of the users and infrastructure capabilities of the transport system.

There is a large number of research work, modelling techniques, investigation and approaches available in each of these three main categories of transport modelling. Research is also still continuing. In this work we adopt a well know and well established model (the binary probit model) to model departure time choice and travel flexibility in Tabuk city in the KSA. The aim of this research therefore is to investigate departure time choices and travel time flexibility in the case of Tabuk city as a case study. Saudi Arabia is a Middle Eastern Islamic country, and female travellers do not have access to driving. There is a five-day working week starting on Saturday, and the normal working hours are 8 a.m. to 2.30 p.m.

In Section 2 the general background and literature review on departure time investigations are presented. Section 3 introduces the case study of Tabuk. The data collection and statistical analysis is presented in Section 4. Further discussions of the findings are presented in Section 5. Modelling is discussed in Section 6. The work is concluded in Section 7.

Departure time investigations and modelling

Ignoring the time-of-day dimension of travel and applying factors that remain unchanged in the modeling process is inadequate for a number of reasons. First, the 1990 Clean Air Act Amendments (CAAAs) require travel demand models to provide accurate estimates of the number of new vehicle trips during different times of the day. One can obtain such accurate estimates only by explicitly modeling the departure time of trips. Second, from a forecasting perspective, the application of static time-of-day factors does not consider the potential shifts in trip departure times due to non-uniform (across time-of-day) changes in network level-of-service between the estimation and forecast periods. This is likely to lead to inaccurate future year highway assignments by time of day. Third, from a policy standpoint, travel demand models have to be able to evaluate a variety of transportation control measures (TCMs) such as peak-period pricing, congestion-pricing, and ride-sharing or transit-use incentives (see Stopher (1993); Weiner and Ducca(1996)). Many of these TCMs will not only have an impact on travel mode, but will also affect departure time choice.

Many of the departure time choice modelling focus on work trip (see Horowitz (1993); Ben-Akiva and Lerman (1985); Swait and Ben-Akiva(1987); Fischer and Nagin (1981), Manski and McFadden (1981) and Train (1980) for work mode choice modeling; Abkowitz (1981); Mannering (1989); Chin (1990); Hendrickson and Plank (1984)), non-work trip like shopping trip or social trip (Bhat 1998, Chu 1995), tour-based model concept (Bowman and Ben-Akiva (2000)) tourism arrival time trip (Cho (2003)). Bhat (1998) proposed the multinomial logit (MNL) model, the nested logit (NL) model with departure time alternatives within each mode specified to share common unobserved random utility attributes for the higher-level mode choice decision and the standard ordered generalized extreme-value (OGEV) formulation (see Small (1987)) for the lower-level departure time choice decision also termed as the MNL ± (OGEV) formulation model for shopping trips.

Cho (2003) proposed ARIMA (autoregressive integrated moving average) and Elman's Model of Artificial Neural Networks (ANN), to predict travel demand (i.e. the number of arrivals) from different countries to Hong Kong and found Neural Networks is best for forecasting visitor arrivals, especially those series without obvious patterns. Bowman and Ben-Akiva (2000) proposed Nested logit models, which has s ability to capture important activity-based demand responses, such as the choice between trip chaining on one tour and conducting two separate tours (an inter-tour trade) or the choice between conducting an activity at home and conducting it on a tour -an on-tour vs at-home trade-. Their model was capable for better for policy sensitive forecasting.

Zhang and Zhang (2010) used Dynamic traffic assignment (DTA) and simultaneous departure time and route (SDR) with choices in transportation networks with bottlenecks, where both link and path capacities are time-dependent. The explicit results showed that an inappropriately added new link could deteriorate the existing network in terms of the increase of individual and system travel costs. DTA-SDR solution is explicitly calculated in the classical Braesss network. Interestingly, Braesss paradox also occurs in dynamic circumstance, and the mechanism is quite different. They found paradoxes which are caused by the self-optimizing behaviour of individual commuters. Specifically, the self-optimizing behaviour includes three types of competitions among commuters, namely competition between different ODs (Akamatsu (2000)), competition between different routes (Braess (1968) Daganzo (1998); Zhang and Zhang [2010]), and competition between different departure times (Arnott et al. (1993); Arnott and Small (1994)). The paradox was caused by a new type of self-optimizing behaviour, was namely the simultaneous departure time and route competitions in Zhang' research.

FUJI and Kitamura (2004) investigated Drivers' Mental Representation of Travel Time and Departure Time Choice in Uncertain Traffic Network Conditions using multinomial logit model. They found that the decisions drivers make, such as choice of route or departure time, constitute typical decision making under uncertainty. They studied drivers' decision making within the framework of expected utility theory. They observed empirical decisional phenomena violating the premise of expected utility theory. Their findings have indicated that decision making is critically affected by the decision frame. It has also been pointed out that the uncertainty of outcome is perceived as an interval of possible resultant values. Results data indicate that commuters differentiated between the 5 alternatives (the risk of being late, the risk of being early for the required arrival time, safe, failed period) if and only if the required arrival time was important for them.

Senbil and Kitamura (2004) used two decision frames in order to access the value and weight functions, two pivotal elements of the Prospect theory. Weight function was associated with a new model coupled as contingency adjustment model (CAM). CAM model has theoretical background on individual updating of perceived likelihood of any arrival time conditioned on a certain departure time. In this regard, the weights were assumed to be realized with respect to a comparison between expected (at the departure time) and realized arrival times. Commuter holds an expected arrival time at a departure time which was established by his commute history, but the same time, every day was taken as another episode of risks and uncertainties: commuter re-evaluated his chances and takes actions, such as listening the radio broadcast carefully when it was raining, or lane changing to make a null probability a possible gain arrival etc. Although our nonlinear regression estimation of the weight function complies with the basic premise of the Prospect theory, it was required to know other structural elements, the effects of observed and unobserved heterogeneity, affecting behavioural responses to the expected probability.

For this reason, they used linear and probit regressions that control for heterogeneity but only refer to over- and under- weighting of probabilities. The weight function yielded results that were significant for trip attributes but not for most of the commuter attributes. The value function was devised by using two decision frames, the first one was symmetric about the preferred arrival time for gains and losses, and the second one is not symmetric. The estimation of the value function by the binary Probit model yielded approximately similar results for both of the decision frames. In both of the decision frames, it was significantly true that commuters are responsive to the time deviations from reference points in their decision frames. The arrival points in the gain region were not equal in values and the choice of the departure time is strongly conditioned on the possible arrival times.

Case study: City of Tabuk in Saudi Arabia

Tabuk is one of the provincial capital situated in north-western Saudi Arabia, which has induced enormous intra- and inter-city transportation demand due its rapid economic growth and due to recent oil and gas based growth economy in recent years. Travel condition in Tabuk city of Saudi Arabia are influenced by the Islamic culture and norms and the high income due to cheapest oil prices (Al-Atawi and Saleh, (2013)). These led to huge investments in infrastructures and urban developments, including but not limited to public transportation services. IN order to aim to achieving a sustainable transport system, it is of crucial importance to acquire information and understanding of travellers' behaviour, preferences, attitudes and choices. In the context of mode choices and captivity to modes, Al-Atawi and Saleh, (2014), showed that the private cars, private drivers and car sharing are the most used modes of transport in Tabuk city. They also show that policy-relevant variables such as travel cost or time, travel mode attributes in do not affect choice of modes of travel.

Data collection and current travel patterns in Tabuk

The data used in this study was collected using a questionnaire. In total 1226 surveys were distributed throughout the city of Tabuk, overall 516 completed surveys forms were returned which is an overall response rate of 42.0 % for the study as a whole in month of September 2012. Questionnaires were distributed in different sectors in order to cover broad spectrum of characteristics of different workplaces in Tabuk city. This includes, health services (hospitals, health care centres, military's hospitals), educational services (schools and universities), military services, security, private, Tabuk Municipality and the water Authority.

The questionnaire comprised of five separate sections. The first section of the questionnaire analysed the current travel patterns of the respondents in which they were asked to identify the mode of transportation which they use to reach their place of work along with some characteristics of this mode which were specific to them such as the travel time, travel cost and the needs which these modes most satisfy for the user. In the second section of the questionnaire the respondents were asked to provide their attitudes and preferences on alternate modes of transport in relation to comfort, reliability cost travel time etc. This was aimed at determining how willing individuals would be to change their mode of transportation and what it is that would instigate the decision to change.

The questionnaire gathered information on preferences and attitudes related to the times which individuals travelled to their place of work in the third section. In addition, preferences and attitudes to their travel patterns were also investigated. The fourth and final sections of the questionnaire collected information of respondents' preferences and attitudes to a number of traffic and travel transport policies and socio economic and household structure of respondents.

From the collected data it was seen that the mode of transportation most commonly used on a regular basis to reach the workplace within Tabuk was to drive a private vehicle which was indicated by 55.7% (287) of the respondents to the survey. This was followed by the participation in informal car share schemes which were used by 17% (88) of respondents. 46 (8.9 %) of the respondents indicated that they regularly utilised the services of a contracted driver in order to reach their place of work. This level of usage was followed by the use of a private driver or chauffeur which 42 (8.16 %) of the respondents indicated that they employed. Cycling was the mode of transportation which was used by 6.4 % (33) of the respondents on a regular basis; this was followed in prevalence by walking which was undertaken by 25 (4.85 %) of the respondents. The use of private buses was indicated by 18 (3.5 %) of the respondents as the means by which they reach their place of work most often. The options for utilising a taxi service and other modes of transport were both indicated by 10 (1.94 %) respondents as their most commonly used mode of transportation. Unfortunately within the other option none of these individuals specified the mode which they used therefore further investigation of these modes is not possible.

In relation to the least utilised or never option it was seen that cycling was the mode identified by the majority of respondents as not being utilised with 284 (55.15 %) responses in this area. This was followed by walking to work which was never undertaken by 278 (54 %) of the respondents. Driving was the mode which resulted in the lowest response rate within this category with only 75 (14.6 %) of respondents indicating that they never drove to their place of work.

When asked to identify the factors which affected the choice of mode it was seen over all of the mode options available that comfort was the most common factor which influenced the individuals choice.

This was indicated by a total of 262 (50.87 %) of the individuals as being a determining factor in their decision making process. The next most influential factor was that of privacy which was indicated by 231 (44.9 %) of the respondents and was followed by cost effectiveness of the mode which was indicated by 209 (40.58 %). The fact that such a large proportion of respondents indicated cheapness as being a determining factor leads us to believe that they are not fully aware of all of the factors of each mode they take as in most instances the use of bicycles and walking are much cheaper than that of the private car however this desire to utilised the cheapest mode is not reflected in the actual mode choices as the private vehicles is by far the most commonly used mode.

Environmental considerations was the factor which had the least influence on the mode choice of the survey group with only 66 (12.8 %) of the respondents indicating that it influenced their mode choice. Reliability was also a factor which was not deemed important by many individuals with 80 (15.5 %) responses in the category. 37 (7.18 %) individuals did indicate that other factors affected their mode choice however these once more were not expanded upon.

When asked to identify the duration of their journey from their home to their place of work it was seen that the overall average journey time was 20.63 minutes. When a more detailed analysis of the data is completed we see that those which participated in formal car share schemes had the shortest average journey time of 15 minutes. This was followed by those whom took part in informal car shares with 16.56 minutes. On average drivers journey times stood at 21.29 minutes which was slightly above the average journey time. Those which had the highest journey time were those whom hired taxies to reach their destination and it was seen that their average journey time was 80 minutes. This journey duration differs greatly from the average journey time and therefore it was deemed prudent to determine an overall average journey time when these users are excluded. When this takes place the average journey time is seen to be reduced to 20.24 minutes. Only a small adjustment in the figures takes places as only two individuals indicated that they utilised taxis in this sector. The use of buses are seen to have the next highest average journey time at 26.67 minutes and is in turn followed by walking at 23.89 minutes.

In relation to the cost of commuter journeys initially respondents whom used private vehicles were asked to identify the cost of refilling their vehicles and how often they refilled them. From this data it was seen that the average cost of refuelling a vehicle varied from 320.55 to 287.78 SR per month depending on the level of usage and extremes of expenditure taken into account.

Following on from this, individuals whom employed private drivers and utilised taxies for their commute were asked to provide data on their expenses. From this data it was seen that users of taxis on average paid 360.25 SR per month while those whom employed private drivers spent on average 457.69 SR per month.

Respondents were required to provide a detailed account of their perception of the relative importance of certain attributes in relation to their most frequently used mode of transportation to their place of work. A total of 455 individuals provided a response in this category with a total of 353 (79.33%) of these individuals rating safety as being very important. The lower ratings of important, moderately important, only slightly and not at all each gained the support of 80 (18%), 16 (3.6%), 3 (0.67%) and 3 respondents each. The second most important factor for respondents was that of travel time with a total of 355 (73.3%) of the 457 respondents whom provided data in this section indicating it as a very important factor. A total of 308 (67.1%) respondents indicated that comfort was very important for them.

The same attributes were examined as in the previous section with respondents being asked to rate them on a scale of very good, good, fair, poor and very poor. From this summary of the collected data we can see that reliability achieved a slightly higher rating when compared to any of the other attributes examine achieving responses in the very good category by 274 individuals and 124 in the good category. The second highest rating was achieved by comfort which achieved 219 and 127 in each of these categories respectively. When the data with regards the fair rating is examined we see that environmental friendliness gains the higher rating with 119 responses followed by flexibility and convenience with 72 and 71 responses each. In relation to the lower achieving attributes we see that the majority of responses in the poor and very poor categories were achieved by the travel cost category with 32 responses in these categories. Drivers accounted for a total of 14 of these respondents. This indicates that a certain amount of drivers do recognise that their mode of transportation is not the most cost effective however they still choose this mode.

One of the main factors which will influence the mode which is chosen by a commuter is whether or not they have additional commitments on their journey to their place of work. In this section the respondents who drove to work were asked to identify any possible commitments which they may have. It was seen that 123 (33.43 %) indicated that they had additional commitments while a further 243(66.57 %) said they did not. 76 (67.26 %) of these individuals indicated that they were required to transport their children or other family members to their place of education during their commute. This was followed by the need to carry out shopping which was indicated by 10 (8.85 %) of the respondents.

DISCUSSIONS OF THE FINDINGS: DEPARTURE TIME AND TRAVEL CHOICE FLEXIBILITY

This section the questionnaire attempts to identify the possibility of respondents altering their travel patterns and if so by what degree this could be done. In instances where there is an inability to change these patterns the respondent is asked to identify the reasons as to why no alterations can be made.

In total 175 (37.8 %) of the respondents indicated that their working day began before 07:00, while a further 207 (44.71 %) commenced their work between the hours of 07:00 and 08:00. A further 45 (9.72 %) indicated that they commenced working between 08:01 and 09:00. This shows that working departure time is distributed between 07.00 to 8.00 clock.

Following on from this, individuals were asked if they would be capable of finishing work after their usual time. A total of 221 (52.2 %) respondents indicating that they would be able to alter their finishing time while a further 153 (36.2 %) indicated that they would not be able to make any alterations. 49 (11.6 %) respondents indicated they did not know if they could change their finishing times. It was seen that an alteration of 60 minutes was the most popular option being selected by a total of 95 (42 %) individuals. This was followed by 120 minutes which was selected by 43 (19 %) respondents as being a possible alteration in their finishing time.

153 (35.25 %) of the respondents indicated that they finished their working day before 14:00 with a further 133 (30.65 %) ending their working day between 14:00 and 14:30. 97 (21.89 %) individuals indicated that they finished between 14:31 and 15:00. 3 respondents finished work between 15:30 and 16:00, with the 16:01 and 16:30 time frame once more seeing an increase in activity with 27 respondents departing their place of work. Between the hours of 16:30 and 18:00 a total of 17 further respondents finished with 6 respondents indicating that they finished after 18:00. Finish time of work is ranging before 14.00 15.00 clock.

Respondents were then asked to identify whether or not they felt that they were able to commence their working day earlier or later than they currently did. When the respondents were asked by how much earlier or later they could starting paradoxically a larger number of responses were seen than those who indicated that they could alter their work times. In total 249 (56.2 %) responders indicated that they would be able to start earlier while a total of a 194 (43.8 %) responses were seen in the area of being able to start later. This shows that largely people in Tabuk are flexible to start before their actual start time and also finish their work before usual time of working hours.

Within the group whom indicated that they were able to begin their work earlier it was seen that the modal response was a 30 minute alteration in the start time being indicated by a total of 72 (28.9 %) respondents followed by the ability to start 60 minutes as was indicated by 55 (22 %) individuals. This is significant finding. However the flexibility of departure time is linked with several factor such as valuable mode , cost , safety, traffic rule. Many factors were used to understand the relation between departure choice and its flexibility. The modelling analysis is discussed below.

Modelling analysis

The study estimates probit model to explore the effects of various characteristics on times of travel. In this research, the respondent was asked to report on preferences and attitudes related to the times which individuals travelled during to their place of work. In addition, preferences and attitudes to their travel patterns were also investigated. A binary Probit model has been estimated for the choice of departure time flexibility using data from Tabuk city. The dependent variable represents the choice flexibility of choosing departure time such as 1 is flexible and 0 otherwise. It is should be noted here that interestingly, in these models, most of the usual variables that have been reported in the literature to affect departure time flexibility (i.e. travel time, travel costs, waiting time, etc.) have not shown statistical significance and therefore have not been included.

The formulation of the probit model begins by specifying a function that determines travellers' choice of the mode of travel. In this case, the utility function is written as (see also Train (2003), Hensher et al. (2005) and Bhat (1997)) as shown in Equation 1:

$$U_{in} = \beta_n^{'} X_{in} + \varepsilon_{in} \text{ ----------------------------(1)}$$

where U_{in} is the propensity function that determines the probability of discrete adoption level n for individual traveller i; X_{in} is a vector of observed variables such as rider attributes, system characteristics, β_n is a vector of parameters associated with X_{in}; and ε_{in} is error term. In this model, it is assumed that *the error term* is normally distributed.

Number of models were tried but probit models was selected as it was found significant.

The list of the parameters is given in Table 1 and estimation results for the probit logit models are reported in Table 2. As for the rule for the variables selected to estimate the models, the trial-and-error method, commonly used in building models, was applied and the variables with insignificant p values were excluded.

From the results presented in Table 2 it shows that female do not hold driving licence , the coefficient is positive P Value is 0.0007 which shows that female has no choice for self-drive. The cost factor has been considered in terms for filling petrol. This is coming negative that shows that it has a negative impact on departure time flexibility. Time of finish of work between 05 hr and 06 hr is showing to have significant impact on departure time flexibility. The coefficient shows a higher value along with the P value of 0.0052. Finish of work time is also found quite significant. This factor has been hardly explored in any literature. One of the major factors amongst all other factors was safety of a particular transport mode. Departure time flexibility only will be accepted if the mode is perceived to be safe. In this case the coefficient for safety was 4.01 with the highest with p value 0.0005

From the results presented in Table 2 above it appears that all the variables included (mentioned in Table 1) in the model are statistically significant at a 95% level and with the expected signs of the coefficients. The results also show that the female member of the family is more flexible in departure and arrival times. This might be because female members do not drive in Saudi Arabia and therefore, they do not have commitments of shopping, picking up or dropping other members of the family. In fact, this also reflects the commitment of the male members of any typical Saudi family to meeting the travel needs of the female members of the family. The alternative would be hiring a private driver who would drive the female members as well as younger members of the family to their various destinations. In terms of the criteria associated with the flexibility in departing earlier or later, safety shows statistical significance. In otherworld's, the travellers are willing to travel earlier or later to guarantee a safer mode of travel ($P < 0.0005$ in all cases) and always has a positive sign.

CONCLUSIONS

Departure time choice modelling is lacking behind in comparison with other travel choices. This research is investigating departure time and travel time flexibility in the city of Tabuk in KSA, where female travellers do not have access to car driving. A binary Probit model has been calibrated. The results show that show that the female members of the family are more flexible in terms of departure and arrival times choices. This might be because female members of the family in KSA do not have access to driving private cars and it is only the male members of the family do drive. One of the implications of this is that the male members of the family take all responsibilities related to any activities which need travelling such as shopping, dropping children or picking up other members of the family. Private cars' driving. On the other hand, female members of the family do not get this type of commitments. In terms of the criteria associated with the flexibility in departing earlier or later, safety shows statistical significance. In other words, the travellers are willing to travel earlier or later to guarantee a safer mode of travel ($P < 0.000$ in all cases) and always has a positive sign.

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