A NEW APPROACH FOR TRIP GENERATION ESTIMATION FOR USE IN TRAFFIC IMPACT ASSESSMENTS

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ABSTRACT

Findings from an online survey conducted by Queensland University of Technology (QUT) shows that Australia is suffering from a lack of data reflecting trip generation for use in Traffic Impact Assessments (TIAs). Current independent variables for trip generation estimation are not able to create robust outcomes as well. It is also challenging to account for the impact of the new development on public and active transport as well as the effect of trip chaining behaviour in Australian TIA studies. With this background in mind, research is being implemented by QUT to find a new approach developing a combined model of trip generation and mode choice with consideration of trip chaining effects. It is expected that the model will provide transferable outcomes as it is developed based on socio-demographic parameters. Child Care Centres within the Brisbane area have been nominated for model development. At the time, the project is in the data collection phase. Findings from the pilot survey associated with capturing trip chaining and mode choice information reveal that applying questionnaire is able to capture required information in an acceptable level. The result also reveals that several centres within an area should be surveyed in order to provide sufficient data for trip chaining and modal split analysis.

INTRODUCTION

Any new development in an area has the potential to affect the surrounding transportation infrastructure. Most studies for new or expanding developments are concerned with assessing impacts of additional traffic and providing proper accommodations for total site traffic (The Institute of Transportation Engineers 2005). To assess the effect of a development, transport planners and engineers perform a Traffic Impact Assessment (TIA). TIA is defined as the process that assesses the impact of proposed new developments or expansions of existing developments on traffic networks surrounding a site (Vaziri, Aneja et al. 1999). One of the most critical elements of TIA studies is estimating the amount of traffic to be generated by a proposed development, since a small difference in forecasted trip generation may significantly change the resulting travel decisions and financial commitments. This is usually made by using either trip generation rates or trip generation equations (The Institute of Transportation Engineers 2005).

Findings from an online survey recently conducted by Queensland University of Technology (QUT) show that Australia is suffering from a lack of data reflecting trip generation for use in a TIA. It is noteworthy that the most important source related to trip generation in Australia is the New South Wales Roads and Traffic Authority (RTA) Guide to Traffic Generation Developments (The New South Wales Roads and Traffic Authority 2002) as most of the state road authorities such as Queensland (The Queensland Department of Transport and Main Roads 2006) and Western Australia (The Western Australia Department for Planning and Infrastructure 2006) as well as The Australian and New Zealand Road Transport and Traffic Authorities Association (Austroads 2009) have published guidelines for traffic impact assessment preparation which are in some manner based on this database. However, it contains limited land use types and outdated information. The survey has also identified the lack of research associated with trip generation as one of the major reasons for such data shortage.

In addition, trip generation estimation is usually done by using either trip generation rates or trip generation equations (The Institute of Transportation Engineers 2005) which are mainly developed based on specific land use elements such as Gross Floor Area (GFA) of the development as the independent variable. In general, these rates and equations represent a national average, which does not take into account any local characteristics that the site under consideration might have. In fact, local trip generation rates may vary significantly from the national averages. Therefore, using the trip generation rates without adjustment might result in gross over- or under-estimation of the traffic impacts of a proposed land use (The Institute of Transportation Engineers 2008). Thus, applying socio-demographic and built environment parameters, which are more responsive to locational differences, for developing trip generation rates and equations might lead to more accurate and more consistent results.

On the other hand, in the case of small scale studies (e.g. TIA), mode choice analysis is usually ignored by transport engineers because the modal split stage is performed in advance in the trip generation analysis. In fact, as transport professionals are mostly concerned about the impact of new developments on their adjacent road network, they generally apply car trip generation rates for use in evaluation of proposals. Consequently, this means that transport modes are split into just one type: automobile. However, assessing the impacts of the new development on public transport and pedestrian networks can be as significant as car effects.

Furthermore, chaining of trips has direct effects on trip generation. In this respect, Lin (2009) states that mixed land use creates opportunities for increasing numbers of pass-by and multipurpose trips and directly reduces trip generation. A sensitivity test conducted by Koppelman (2009) also showed that a new factory employing 1,000 workers would attract 125 new non-work trips to the surrounding area on an average day as a result of stops on the way to and from work. In terms of trip generation estimation, due to the fact that only the primary trips constitute the additional traffic on the adjacent roadways, it is necessary to isolate the pass-by trips from the total trips in order to obtain the actual number of primary trips generated by the new development (Vaziri, Aneja et al. 1999). However, current trip generation rates and/or equations do not specifically take the trip chaining phenomenon into account for trip generation estimation.

With this background in mind, Queensland University of Technology (QUT), Australia, is conducting a research project to create an improved model of traffic generation by Australasian developments for use in evaluation of proposals. The broad aim of this research is to develop a combined model of trip generation and mode choice with the consideration of trip-chaining effects for the most prevalent land use development type subject to trip chaining in terms of TIA. The objective of this paper is to demonstrate findings from this study. The remainder of this paper is organized as follows: the next section delineates the literature review. The research methodology is presented in subsequent section. Afterwards, the required data related to model development for the research, followed by the results associated with the pilot survey conducted are discussed. Ultimately, the final section draws conclusions and the plan for future works.

LITERATURE REVIEW

1. Trip Generation

Trip generation analysis involves estimation of the total number of trips entering or leaving a parcel of land as a function of the socioeconomic, locational, and land use characteristics of the parcel. The function of trip generation analysis is to establish meaningful relationships between land use and trip making activity so that changes in land use can be used to predict subsequent changes in transport demand (Paquette, Ashford et al. 1982).

The explanatory variables set, which has been found in the literature regarding trip generation analysis, ranges from socio-economic and demographic attributes of the household to the built environment characteristics and land-use patterns. In this respect, Khattak (2005) found that the automobile trip generation rate for the neo-traditional neighbourhood is significantly lower than the conventional neighbourhood. Lin (2011) also explained that mixed land use, employment density, walkway quality, leisure facility supply and leisure travel distance encourage generation of leisure trips for children in Taipei. Further, apart from the built environment characteristics and land-use patterns, Pettersson (2010) showed that there is a pronounced decrease in total trips made with increasing age in Manila. Hunt (2010) also indicated that the level of trip generation at a residential development is determined by city size, household size, income levels, and dwelling type.

In terms of model development, prediction of trip making activity is possible by a variety of available methods. The most popular methods have come to be known as: Land Area Trip Rate Analysis, Cross Classification Analysis, and Regression Analysis (Papacostas and Prevedouros 2001). However, many researchers have also examined other techniques to acquire more accurate results. As an example, Washington (2000) introduced an iteratively specified tree-based regression model which can be applied to forecast different transport issues including trip generation. A hierarchical modelling framework for simulating household travel attributes (trip generation and modal split) at the disaggregate level have also been employed by Mohammadian (2011).

In addition to the above models, which intend to predict productions and attractions for large mixed use zones, there are highly specific models for many types of economic activity. These models are usually quite simple in form (only one or two factors) and are especially used in small area studies and in traffic design and traffic impact studies for proposed land development (Banks 2002). In fact, trip generation estimation for use in TIAs is usually done by using either trip generation rates or trip generation equations. Equations are based on regression analysis and represent “best fits” through the data points (The Institute of Transportation Engineers 2005). However, the transferability of rates from one study to another is a topic of importance in metropolitan locations as borrowing rates from one study to be applied to another can be hazardous (Miller, Hoel et al. 2006).

2. Modal Split

Transport mode choice is probably one of the most important classic models in transport planning (Ortuzar S. and Willumsen 2001). The mode choice modelling stage, termed modal split, is primarily to assign person trips to the various alternative modes available (Stopher and Meyburg 1975). The travel modes that are used generally involve walking, cycling, auto (private vehicle) and transit modes (i.e., public transport such as bus, train, and the like) (Khan, Ferreira et al. 2004). In the case of small scale studies (e.g., TIA), however, mode choice analysis is usually ignored by transportation engineers and transport modes are split into just one type: automobile.

Analysing travel mode choice can be regarded as a mapping from the explanatory variables associated with the travel modes and trip decision makers to the mode choice decisions (Zhang and Xe 2008). Many researchers have acknowledged that trip characteristics including travel time (and therefore distance) and travel cost play a key role in modal split choice between auto and transit. In this respect, Khan (2004) suggest that an individual will only consider walking and cycling modes when the travelling distance is significantly small.

A number of studies have also recognized the influence of socioeconomic and demographic characteristics on mode choice. A wide range of variables such as gender, age, household structure (including household size, number of heads in the household, number of students in the household), employment status, number of vehicles per household, weekly working hours, net monthly income, and number of driving licenses can be found as socioeconomic and demographic variables in the literature (Garling 2000; Jang 2003; Golob and Hensher 2006; Khan, Ferreira et al. 2007; Amador, de Dios Ortúzar et al. 2008; Muley, Bunker et al. 2009).

Furthermore, built environment variables have been found to play an important role in mode choice (Mohammadian and Rashidi 2011). In this respect, Tracy et al. (cited in Abou-Zeid and Scott 2011) claim that the built environment is highly correlated to mode choice at the aggregate level of traffic analysis zones and the characteristics of the built environment impact specific modes differently. As one of the most recent attempts, Lin (2011) discovered that intersection density, building density, employment density and walkway quality encouraged a person to use transit systems or non-motorized travel modes for leisure travel.

Finally, the effect of other parameters such as the perceived level of comfort and accessibility of modes (Palma and Rochat 2000) as well as weather (Müller, Haase et al. 2007) on the modal split choice have been examined in the literature. However, all the above mentioned variables are not commonly employed in TIAs.

In terms of model development, traditional travel mode choice analysis is based mainly on disaggregate discrete choice models (Zhang and Xe 2008). These discrete choice models are mostly based on the theory of utility maximisation which visualises the individual as selecting that travelling mode which maximises his or her utility (Khan, Ferreira et al. 2004).

Many recent studies have employed the utility maximisation approach to develop mode choice models (Johnston, Ferreira et al. 2006; Sirikijpanichkul, van Dam et al. 2007; Ye, Gottardi et al. 2007; Amith and Sivaramakrishnan 2008). Regarding theory, the three main models which are used for analysing data based on the utility maximisation approach are logit models, probit models, and multiple regression models (Abou-Zeid and Scott 2011). At present, the issue of which model to choose remains an open question. Multinomial logit models have gained much popularity in travel mode analysis, mainly for their computational tractability (Reggiani and Stefani 1989). However, other methods such as stepwise multiple linear regression model (Ogunjumo and Fagbemi 1991), cross-sectional model (Karthik and Bhargavi 2007), vector machine model (Zhang and Xe 2008), and entropy maximization model (Jörnsten and Lundgren 1989) have also been attempted by researchers to analyse mode choice.

3. Trip Chaining

A pair of trips which begin from a location and return to that location to accomplish a primary activity with none, one, or more intermediate stops of any duration to fulfil a number of secondary activities through travel is titled a tour or a trip-chain. Generally, the term "trip chaining" is defined as stopping at one or more locations during a trip from an origin to a destination (Meyer, Ross et al. 1995). Trip chaining is often seen as a way to reduce the costs of travel, since activities can be more efficiently carried out when linked in sequence (Noland, Schmöcker et al. 2010). Research indicates that about 40 percent of all trips which people make involve stops at more than one location (Ghaly cited in Brooks, Lichtenstein et al. 2008). In the case of a traffic impact assessment for new developments, trips are divided into three different types: primary trips, pass-by trips, and diverted linked trips. Both pass-by and diverted linked trips may be part of a multiple-stop chain of trips (Vaziri, Aneja et al. 1999; Hooper and Institute of Transportation Engineers 2004).

Most studies agree that the forces behind the formation of complex work chains are related to demographic, socioeconomic, and urban form characteristics (Adler and Benakiva 1979; Davis, Dueker et al. 1994; David and April 2000; Golob 2000; Hsu and Hsieh 2004; Arentze and Timmermans 2005; Golob and Hensher 2006; Lee, Hickman et al. 2007; Timmermans, Krygsman et al. 2007; Wu and Ye 2008). **Table 1** shows the most applied variables and compares their effects on trip chaining. However, day-of-week (Noland, Schmöcker et al. 2010), time-of-day (Ye, Gottardi et al. 2007), travel time (Timmermans, Krygsman et al. 2007), level-of-service of travel (Bhat 1997), and work duration (Kuppam and Pendyala 2001) have been found as tested variables in the literature as well.

Table 1: The most influential variables on trip chaining and their effects

Characteristics	Main Variables	Effects
Demographic	• Household Structure	– The number of household heads and their working status have effect in generating trip-chains – Larger households tend to make less complex tours – The presence of young children increases tour complexity
	• Age	– Young commuters are less likely to pursue complex non-work tours – Trip-chaining peaks at ages between 45 and 54 – Older people tend to make less stops during the work commute
	• Gender	– Females undertake more complex trip-chains – Males pursue simpler work trip patterns
	• Marital Status	– Married women are more likely to make stops
Socioeconomic	• Income	– Higher income households have more complex tours
	• Employment	– Part time employment is positively associated with stop numbers – College and high school students tend to make additional trips on the way to the workplace – Retired persons are inclined to make non-work trips in the AM peak
	• Car Ownership	– Using the car is associated with more complexity
Urban Form	• Population Density • Residential/Retail/Employment Density • Distance to Transit • Street connectivity	– Metropolitan area residents are more likely to form complex trip-chains – Density of opportunities increases trip chaining propensity – Neighbourhood/regional accessibility decreases tour complexity

Further, the most prevalent approach to model trip chaining in the literature follows the Random Utility Maximization (RUM) framework rooted in the economic theory of consumer choice (Lee and McNally 2006). In practice, the most commonly used discrete choice model is the multinomial logit model (Adler and Benakiva 1979; Davis, Dueker et al. 1994; Bhat 1997; Timmermans, Krygsman et al. 2007) and the nested logit model (Theo and Michel 1998; David and April 2000; Lawton, Frank et al. 2008). It is commonly used in practice because it can be estimated conveniently without using any approximation methods (Huang and Wang 2008). In addition, other types of RUM framework applications such as simultaneous doubly-censored Tobit models (Lee, Hickman et al. 2007), the bivariate ordered probit model (Wu and Ye 2008), and ordered probit model (Noland, Schmöcker et al. 2010) can be found in the literature. Other approaches such as regression analysis (Hildebrand 2003; Lee and McNally 2006), time-space prisms (Kondo and Nishii 1992), and structural equations modelling system (Kuppam and Pendyala 2001; Jang 2003) have also been examined in the literature to achieve better insight into trip chaining behaviour and individuals' travel patterns.

4. Trip Generation, Modal Split, and Trip Chaining Interactions

The review of the current literature of trip generation, mode choice, and trip chaining behaviour has revealed that chaining of trips has direct effects on both trip generation and mode choice (**Figure 1**).

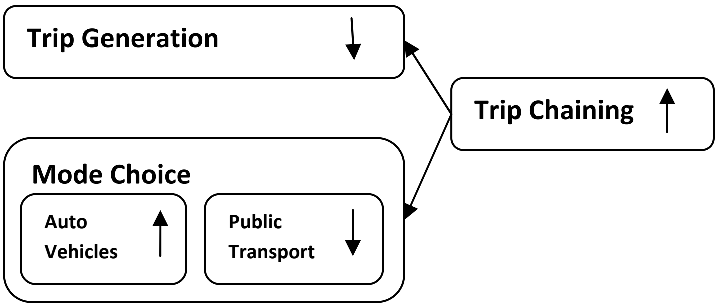

Figure 1: The overall effect of trip chaining on trip generation and mode choice

In general, mixed land uses reduce travel by eliminating or shortening vehicle trips by capturing travellers at new, more convenient destinations (Cervero and Duncan 2006). Retail-oriented developments such as shopping centres, discount stores, restaurants, banks, service stations, and convenience markets attract a portion of their trips from traffic passing the site on the way from an origin to an ultimate destination. These retail trips may not add new traffic to the adjacent street system (Hooper and Institute of Transportation Engineers 2004). Consequently, due to the fact that only the primary trips constitute the additional traffic on the adjacent roadways, it is necessary to isolate the pass-by trips from the total trips to obtain the actual number of primary trips generated by the new development (Vaziri, Aneja et al. 1999). In fact, trip generation estimation for use in TIA should be adjusted under the trip chaining phenomenon.

In terms of mode choice, Huang (2008) suggests that trip chaining activity is a significant factor encouraging travellers to use private vehicles. Commonly, if a tour entails more stops, the probability of choosing auto are increased (Cynthia, Hongmian et al. 2008). On the other hand, as individuals move from a simple tour to an increasingly more complex tour, the likelihood of using public transport decreases with the increasing number of links in the chain (Noland, Schmöcker et al. 2010). Thus, the complexity of a tour has a negative influence on the choice of using mass transit and a positive impact on the probability of choosing auto.

METHODOLOGY

Based on the literature review, a simple comparison amongst most accepted modelling techniques for each of trip generation, mode choice, and trip chaining studies shows that the (multiple) regression analysis is the most suitable model structure which can be applied for all of these topics. Consequently, multiple-regression equations will be used for developing the mathematical model construction for this study. The proposed equation for predicting trip generation for a specific land use type can be shown as follows:

$$TG = \sum_{i=1}^{n} c_i \, IV_i + \varepsilon \qquad (1)$$

Where:

TG	Trip Generation Rate per unit (e.g. 100m^2 for buildings, per child for schools)
IV_i	The Independent Variable i
c_i	Coefficient related to the IV_i
n	Number of Independent Variables (i.e. socio-economic, demographic, and urban form variables)
ε	Error Term

With respect to modal split, mode of transport will be divided into three categories: motorised (private), motorised (public), and non-motorised. As a result, three regression equations will be developed for each land use type. Coefficients and the error term for each equation will also be calculated by applying matrix formulation as shown below:

$$\mathbf{TG} = \mathbf{C} \times \mathbf{IV} + \boldsymbol{\varepsilon} \qquad (2)$$

Where:

$\mathbf{TG}$	A column vector of traffic count results related to m surveyed existing proxy developments
$\mathbf{C}$	A column vector of coefficients
$\mathbf{IV}$	A $(n \times m)$ matrix of independent variables including socio-economic, demographic, and urban form variables associated with the areas within which the n surveyed existing proxy developments are located
$\boldsymbol{\varepsilon}$	The error term
n	Number of Independent Variables
m	Number of surveyed existing proxy developments

In addition, findings from the online survey recently conducted by the Queensland University of Technology (QUT) shows that the most prevalent land use subject to trip chaining in terms of TIA is Child Care Centre/Kindergarten followed by Primary School, Supermarket, and Service/Petrol Station respectively. Accordingly, Long Day Care land uses have been selected for model development as this land use type is able to demonstrate the effects of trip chaining phenomenon on the trip generation thoroughly.

In terms of independent variables, weighted average age, gender ratio, and weighted average household size associated with the areas within which the surveyed existing proxy Long Day Care Centres are located have been employed as demographic variables while average household income, employment ratio, and average car ownership related to the mentioned areas have been used as the socioeconomic variables. Further, population, land use density, and average distance to transit in the area of the surveyed existing proxy developments have also been applied as urban form factors. On the other hand, the dependent variable is the trip generation rate of the surveyed existing Child Care Centres divided by travel mode with the consideration of trip chaining during the morning peak period.

DATA

In this research, two general types of information are needed for model calibration: trip generation, mode choice and trip chaining data related to the existing proxy Child Care Centres and information associated with socioeconomic, demographic and urban form related variables.

In terms of independent variables for use in the model development phase, a database containing socioeconomic, demographic and urban form related information for all Brisbane's suburbs was developed as the study intends to generate a combined trip generation and mode choice model with the consideration of trip chaining effects for the the Brisbane area, Australia. Information from 2006 Census Data was employed to form socioeconomic and demographic related variables. According to the literature review, it was decided to use age, gender, and household size as socioeconomic variables while income, employment status, and car ownership were defined as demographic variables.

As direct application of the socioeconomic and demographic information (e.g. age, gender, income and the like) from 2006 Census Data for use in the model development phase is not appropriate, a specific indicator for each of the proposed independent variables was created. In this regard, gender ratio (i.e. number of men divided by number of women within a suburb) was used as an indicator to depict gender differences among suburbs while residents' weighted average of age and weighted average of household size within each suburb were developed as a sign of age and household size. In addition, average household income and average car ownership were determined for each suburb based on the 2006 Census Data for use as socioeconomic variables. The employed population (both full time and part time) to unemployed population ratio within each suburb was also calculated to indicate employment rate.

In defining urban form variables, the residential density to non-residential density ratio related to each suburb was selected for use in the model as one of the urban form variables. It is noteworthy that residential density in this research refers to the actual density (not proposed density) of dwelling units (i.e. trip generators) within an area while non-residential density is related to the actual density of other land uses (i.e. trip attractors) in that area. The preparation of this data is ongoing as residential and non-residential density data has not been gathered yet. In addition, the average distance to transit in each suburb has been defined as another independent variable associated with urban form. Employing the geographic coordinate data of bus stops, train stations and City Cat (river linear fast ferry) stations throughout Brisbane area in combination with Brisbane's cadastral and road network maps in ArcGIS software, the distance from each lot within Brisbane area to the nearest public transport stop/station was calculated. Eventually, the average of the calculated distances for each suburb was applied as the average distance to transit variable.

Actual trip generation data as well as mode choice and trip chaining information for existing proxy and shadow proxy Long Day Care Centres must also be collected. This type of data will be utilised as dependent variables in the model development phase. In respect to minimum sample size for model development, James (2001) suggests that the ratio of observations to independent variables should not fall below five in multiple regression analysis. This means at least 5 samples per each independent variable should be applied in order to create an appropriate multiple regression model. As a result, at least 40 Long day Care centres should be surveyed for this research as the number of independent variables based on the above discussion is 8. However, such amount of data collection does not fall into the research's constraints.

In order to reduce the required sample size, it was decided to develop the proposed model for each variable category (i.e. socioeconomic, demographic and urban form) separately, as the number of variables for each category is not more than three. A further model based on specific indices for each category will also be developed. Consequently, the number of Long Day Care Centres samples will be decreased to 15. Eventually, with the consideration of 5 more samples as shadow proxies for model evaluation, the total number of required Long Day Care Centres for the survey will reach 20.

In terms of data associated with trip generation, traffic counts at all the study sites' driveways and non-car mode access points for the morning peak period is the preferred method. However, counting motor vehicles will be challenging in some cases as some of the Child Care Centres do not have specialised parking spaces and the customers park their vehicles on the road side of the Child Care Centre's adjacent street. Counting such trip ends will be more difficult when the customers park their vehicle far from the centre and arrive to the centre by foot. As a result, these trips will combine with other trips conducted by public transport and walking and consequently will not be recognisable. For this reason, with the assumption that each family is arriving at the centre with one travel mode, counting the number of families at the centre's access point during morning peak period will be recognised as the trip generation associated with the centre. The results of the mode choice survey will then be employed to divide the trip generation data into different mode shares.

The most challenging part of data collection might be associated with gathering information related to mode share and trip chaining. Effectively, capturing data linked to mode choice and trip chaining should be conducted through a customer interview or questionnaire. In terms of a Child Care Centre, employing a questionnaire may provide more accurate information as the number of children and employees in each Child Care Centre is fixed. Therefore, this method might be able to collect modal split and trip chaining data with the highest response rate by sending out a simple questionnaire to all study sites' parents and employees. To do so, a questionnaire with five simple questions has been designed. The questions ask the respondents about their usual arrival time and usual mode of transport (including private motor vehicle, public transport, walking and cycling) to reach the centre as well as their usual destination after leaving the centre and the number of persons accompanying him/her during the journey to the Child Care Centre. The questionnaire, then, will be distributed to all parents and employees within the selected study sites. A number of specific items of information related to the Child Care Centres such as number of students, number of staff and gross floor area of the centre (excluding open spaces) will also be collected. It is note-worthy that an ethical clearance has already been obtained for this survey.

Eventually, data collection must be conducted on a typical working weekday during good weather conditions to capture the high end of typical weekday traffic in the middle of school term. It is important to avoid survey data collection during school holidays in order to achieve accurate trip generation data for model development. In this respect, a pilot survey has also been conducted to identify any unexpected problems and issues during the survey procedure.

PILOT SURVEY

The pilot survey was conducted during February 2012 to identify any possible problems and issues which might occur during the survey data collection as well as to evaluate the survey results' consistency. A child care centre within the Brisbane area for conducting the pilot survey was selected through a discussion with the centre's director and signing a statement of consent form.

As a first step, the general information related to the centre was collected. The centre takes care of 86 children with 15 staff including the Director. However, the centre's Director was not able to provide any information related to the centre's gross floor area except that the centre has 7 rooms. This lack of such data in the centre is a consequence of most of the child care centres throughout Australia being corporate chain centres. They are generally administered by the headquarters of the organisation which is responsible for administrative purposes. For this reason, collecting information about the size of centres needs to correspond with the centre's headquarters. Thus, the researchers decided to select all of the required centres for conducting the survey only from one corporate chain centre (i.e. study sites will be selected, for instance, among Goodstart Early Learning Child Care Centres).

Subsequently, sufficient questionnaires were distributed to all centre's staff and customers (i.e. parents of children). Parents with more than one child in the centre received only one questionnaire. 10 more questionnaires were also provided for contingencies. Notably, all of the questionnaires were distributed on the same day. Completed and unused forms were, then, collected seven days later. Counting the filled forms, the response rate was 8.61% (8 returned questionnaires out of 98 distributed). Therefore, the results are not statistically significant to be considered for modal split and trip chaining.

A simple review of the filled questionnaires shows that more than half of the trips to the Child Care Centre (5 trips) have been performed by private vehicles followed by 2 trips by foot and only one trip by public transport. In addition, only 3 out of 8 respondents indicate that the trip to the Child Care Centre was the only reason for them to leave their home. Home and work was also mentioned (four responses for each) as the next destination after leaving the centre. In terms of identifying the centre's morning peak period, 5 families arrived at the centre between 8 and 9 am while two families were at the centre between 7 and 8 am and one at 10 am. Finally, the results of the survey show that the majority of the trips coming into the Child Care Centre consist of a group of 3 persons (5 responses).

Overall, the results from the pilot survey shows that this method (i.e. applying the questionnaire) is able to capture information related to trip chaining and modal split at an acceptable level as all of the respondents provided clear and concise responses to the questions to give the data to use for trip chaining and modal split analysis. However, the quantity of the responses was not statically significant. This means that not only the selected centre for trip generation data collection but also other Child Care Centres within the suburb should be surveyed in terms of data related to trip chaining and mode choice.

SUMMARY

This paper attempts to demonstrate findings from the research which aims at developing a new approach for estimating trip generation and mode choice simultaneously with the consideration of trip-chaining effects for use in TIAs. A comprehensive literature review has been performed to identify the best model structure and independent variables for model development. Data collection of independent variables as well as a pilot survey related to mode share and trip chaining information has also been conducted.

Based on the literature review, (multiple) regression analysis is the most suitable model structure which can be applied for each of trip generation, mode choice, and trip chaining studies. The socioeconomic, demographic, and urban form characteristics were also found to be influential in all of the trip generation, mode choice, and trip chaining stages. As a result, weighted average age, gender ratio, and weighted average household size (as the representative of demographic variables), average household income, employment ratio, and average car ownership (as the socioeconomic delegate) and population, density, and average distance to transit (as the explanation of urban form factor) have been selected as independent variables for model development.

In terms of data collection, socioeconomic and demographic variables can be simply derived from census data. Employing the geographic coordinate data of public transport stops/stations in combination with cadastral and road network maps in ArcGIS software can be used to calculate the average distance to transit variable. However, providing density information is challenging as city councils' databases may have proposed density information instead of updated actual density data related to each type of land use within an area and consequently, providing such data will be time consuming and costly.

In addition, findings from the pilot survey reveals that applying a questionnaire is able to capture information related to trip chaining and modal split in an acceptable level. However, the response rate in this method is not high enough for drawing conclusions related to trip chaining and modal split characteristics based on the results from just one survey.

Overall, the project is at the data collection stage at present. Completing data collection including trip chaining and modal split information as well as counting the number of families at the centre's access point to capture data related to trip generation will be the next step in this study. Density information for Brisbane area will also be collected through Brisbane City Council. The proposed model (i.e. multiple regression models), then, will be developed and calibrated by applying the information which has been collated in the previous stage. The trip generation rate and equation based on the US Institute of Transportation Engineers methodology will also be calculated. The latter analysis will allow the researchers to compare the results from the proposed model with the prevalent trip generation rates and evaluate whether the new approach provides an improved performance for trip generation estimation.

In conclusion, it is expected that findings from this research will assist transport professionals to better assess the transport impacts of new development proposals. The research is significant in that it will provide a suitable tool to examine socio-demographic and urban form variables' sensitivity and will help decision makers to develop new policies based on the results of the sensitivity tests. It is also expected that the model provides transferable outcomes as the model is developed based on socio-demographic parameters while the function of land use types are consistent among cities and countries.

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