Modelling Travel Demand Management Measurements towards Travel Behaviour with Psycho-Social, Trip Chain Attributes and Quality of Life: A Conceptual Paper

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Abstract-Metropolitan cities are facing massive traffic congestion due to rising population and urbanisation. Traffic congestion and associated problems have become a major worry for transport planners, politicians, and the public as it has negative economic, social, and environmental impact. Accordingly, public transport is encouraged. Initiatives to reduce traffic congestion, air pollution, greenhouse gas emissions, and traffic accident rates have been ineffective. Many megacities in developing countries have low public transportation mode shares despite high investment in public transportation infrastructure. To better manage supply and demand for transport, travel demand management (TDM) strategies must be implemented to manage imbalance of demand and supply. This conceptual paper explores Travel Demand Management Strategies to increase public transportation mode share through psycho-social variables, travel chain attributes, quality of life, and travel behaviour to explore better alternatives to encourage public transportation usage.

Index Terms—travel demand management, travel behaviour, psycho-social attributes, trip chain attributes, quality of life

I. INTRODUCTION

Transportation is a key driver of the development of cities by providing safe, efficient, and reliable transportation for people, goods, and services. When a city experiences rapid population growth, it will exert pressure on existing economic, social, and environmental structure including transportation and mobility [1]. When countries are developing, most of economic activities are focused in urban cities. As the population of urban cities increases rapidly, traffic problems in metropolitan areas such as lack of space and congestion as well as poor air quality increase. Public transportation therefore becomes a necessity to reduce traffic congestion, increase productivity, and reduce carbon emissions. In the west, more people are using public transport. For individuals, public transportation saves money and provides them with choices, freedom, and opportunities [2]. Traffic congestion and associated problems have negative impact on economic, social, and environment development [3]. It is inevitable that rapid economic growth will lead to a simultaneous growth in economic activities. This will further contribute to an increase in urban population and income growth. Car ownership and usage will also increase with more road network infrastructures. The Fundamental Law of Road Congestion states that the travel speed on an expanded road reverts to its previous level before the capacity expansion. In other words, an increase in lane mileage is met by a proportional increase in traffic. This would then create a vicious cycle of more traffic congestion which affects many stakeholders in many ways. Traffic congestion creates serious urban transport problems such as parking difficulties, longer commuting, and difficulties for non-motorised transport, loss of public space, pollution, and accidents [4].

The social, economic, and environmental costs of autodependent cities are already high. Traffic accidents are on the rise with more than 1.2 million lives lost every year and would be the fifth-leading cause of death by 2030 [5]. In the United States, time spent by commuters on the road is equivalent to \$101 billion in lost economic productivity while in Beijing, the costs of congestion and air pollution are estimated between 7% to 15% of GDP [6].

Urban mobility solutions have traditionally focused on the supply side, particularly on expanding roadways. By contrast, Transportation Demand Management focuses on strategies to reduce travel demand, especially from single occupancy vehicles, and make mobility more efficient and sustainable by disincentivising unnecessary driving and stimulating long-term behaviour change [5].

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Transportation Demand Management is the most effective solution to transportation problems [7]. It can provide multiple benefits, including reduced congestion, road and parking facility cost savings, crash cost savings, pollution reduction, and more efficient land use. In addition, factors like travel behaviour, psycho-social, trip chain attributes, and quality of life are important factors to be considered in encouraging greater usage of public transportation in metropolitan cities in developing countries.

Traffic congestion remains a major problem in most cities, especially in developing regions resulting in massive delays, increased fuel wastage, and monetary losses [6]. According to [8], travel delays due to traffic congestion caused drivers to waste more than 3 billion gallons of fuel and kept travellers stuck in their cars for nearly 7 billion extra hours - 42 hours per rush-hour commuter. A report by INRIX in 2014, highlights that people in Europe and the US wasting on average 111 hours annually in traffic congestion. In addition, INRIX together with Centre for Economics and Business Research (CEBR) calculate how much traffic congestion affected individual households and national economies in the United States of America, United Kingdom, France and Germany [8] where in 2013 the expenses from congestion totalled \$200 billion (0.8% of GDP) across the four countries. In 2013 traffic congestion cost Americans \$124 billion in direct and indirect losses, this number will rise to \$186 billion in 2030 [9].

As developing countries are progressing rapidly, traffic congestion has become a new problem [10]. In a report by Peking University's National Development Research Institute [11], 80% of total loss relates to time wasted waiting, 10% to gas and 10% to environmental damage due to traffic congestion. Meanwhile, Dubai's economy was set back by Dh2.9 billion in terms of loss in working hours, time, and fuel in 2013 [12].

Thus, developing a model to address this issue is critical for the cities to plan ahead to tackle the problem at the early stage of the demand side. To achieve higher public transportation usage, transportation or travel demand (TDM) strategies must be implemented to control the imbalance of demand and supply. Travel demand management measures can be used to encourage car users to set car use reduction goals when experiencing impairments in travel options [13]. Some of the TDM strategies like removing subsidy on fuel prices, controlling car ownership, and usage and intelligent road user pricing scheme must be executed. According to UITP European Union Committee Green Paper on Urban Transport, in order for the local policy to be successful, it must address three pillar of sustainable transport [1]:

- Land use planning and addressing the environmental impact of urban sprawl;
- Restricting private car usage in urban areas; and
- Developing high quality public transport.

This paper proposes a framework to address two questions; "What are the factors that influence travel behaviour in implementing TDM?" and "Which factor is most significant in travel behaviour?"

Since TDM measures should be effective in reducing travel demand, detailed knowledge of the behavioural adaptations (e.g., reduced car use, increased use of alternative travel modes) made in response to different measures is needed for a successful implementation of transport policy measures. The behavioural effects of TDM measures have been examined in a range of different studies [14]. Many factors that can influence travel behaviour towards TDM, however, factors like quality of life, trip chain attributes, and psycho-social attributes are not focused on in-depth in predicting travel behaviour. This conceptual paper explores these possibilities.

II. LITERATURE REVIEW

A. Travel Demand Management

Transportation Demand Management (TDM) is a strategy to reduce demand for single occupancy vehicle (SOV) use on the regional transportation network [15]. It is also known as travel demand management, traffic demand management and mobility management [2]. Reference [16] defined TDM as maximising travel choice whereby managing demand is about providing travellers, regardless of whether they drive alone, with travel choices, such as work location, route, time of travel and mode. In short, TDM provides travellers with effective choices to improve travel reliability. It is also a general term for various strategies that increase transportation system efficiency. It prioritises travel based on the value and costs of each trip, giving higher value trips and lower cost modes priority over low value, higher cost travel when doing so increase the overall system efficiency [7]. TDM is used in policies, programmes, services and products to influence whether, why, when, where, and how people travel [9].

An important reason to implement TDM is to balance between demand and supply of traffic where transport used to be supplied to accommodate travel demand must be managed to use the available transport supply efficiently [10], [17]-[19].

The five major Asian cities of Hong Kong, Tokyo, Seoul, Shanghai, and Singapore have shown that TDM strategies encourage motorists to change their mode of transport, travel route, and time of travel [1]. They provide excellence public transport infrastructure but also put some restriction especially on private car ownership so that public transportation would be used to the maximum.

Table I shows how TDM can be measured.

According to [20], TDM can be assessed at few levels such as awareness, attitudes, participation, satisfaction, utilisation, and impact. It can also be implemented by focusing on four major areas: physical, legal, economics, and information [18].

B. Psycho-Social Attributes

Psycho-social attributes play an important role in determining travel behaviour in public transport in metropolitan cities. In addition, various psycho-social factors appear to play a part in determining people's travel behaviours and how they perceive their travel

choice [21].

Author	Measures
Steg and Vlek (1997)	Push Strategies: Taxation of cars and fuel Closure of city centres for car traffic Road pricing Parking control Decreasing speed limits Avoiding major new road infrastructure Teleworking Land use planning encouraging shorter travel distances Pull Strategies: Traffic management reallocating space between modes and vehicles Park and ride schemes Improved public transport Improved infrastructure for walking and biking Public information campaigns about negative effect of driving Social modelling where prominent public figure use alternative travel modes
Cambridgeshire Country Council 2003	Prohibiting car traffic in city centre
Foo (1997, 2000) Goh (2002)	Road pricing (Singapore)
Department of Transport Western Australia (1999, 2001)	Individualised Marketing
Garling et al. 2002	Road pricing Parking fees Increased service level of public transport Improved walk paths Improved bike paths
Tananoriboon, 1994	Increasing vehicle occupancy Peak period diversion Route diversion to less congested networks Reduction of overall demand in the system

TABLE I. TDM MEASURES

A smaller number of studies examined the influence of various psycho-social attributes on travel behaviour. Reference [22] studied the perceived psycho-social benefits of car use and ownership as well as the significance of the car as providing protection, autonomy, and prestige compared with public transport where the respondents were car owners and non-car owners. The results found that there were some psycho-social benefits to car users. Car users felt that they gained protection, autonomy, and prestige from their car and car ownership gave them 'street-cred'. Their car provided them with protection from 'undesirable' people, provided autonomy, convenience and greater access to a greater range of destinations than public transport. Socially desirable attributes such as competence, skill, and 'masculinity' were also perceived to be derived from car ownership.

Reference [23] found similar psycho-social perceptions amongst students attending five universities in Hong Kong. The findings are interesting in that car ownership was extremely low amongst the participants, less than 1% owned a car at the time of the study with the overall Hong Kong population having car ownership levels of 49 cars per 1000 population in 1999. Forty percent of participants felt that public transport was plentiful and low-cost in Hong Kong and suppressed their demand for a car. Few participants felt that they would own a car within the next ten years. However, latent demand was high particularly.

A range of psycho-social variables have been identified as playing some part in influencing travel

behaviour, many of which appear to be dominant in carowning younger males. Those papers which identified these psycho-social variables tended to use subjective and qualitative measures and discussed the following [21]:

- Feelings of power
- Feelings of achieving 'street-cred'
- Safety
- Protection from socially undesirable groups
- Feelings of prestige within peer group
- Identification with selected peer group
- Feelings of greater autonomy
- Perceptions of greater skill and competence through car ownership
- Perceptions of greater masculinity amongst male car owners – interestingly no mention of greater femininity amongst female car owners and users
- Non-car owners/users deemed to be 'eccentric' and hence undesirable

C. Trip Chain Attributes

The effectiveness of TDM measures would encourage public to decide on their trip chain choices [24]. Their decision will be based on:

- Purpose of trip
- Destination
- Travel modes
- Travel times
- Routes to be taken
- Costs that incurred, and

• Departure time

Intuitively, transportation researchers assume that knowing more about travellers' attitudes will help illustrate how travellers make transportation behavioural choices related to trip choice (whether to even make the trip or not), route choice, mode choice, and departure time choice. So attitudinal data is collected, generally through a paper survey, and models are provided showing the effect of attitudinal information on at least one behavioural choice [25].

Travel choice and mode are more often than not influenced by travel time and cost [26]. The costs perceived by users have monetary or out-of-pocket costs and the value of time spent travelling [27].

D. Quality of Life

Quality of Life (QoL) is perceived to be a reflection of how well individual needs and values are fulfilled in various fields of life [28]. QoL can be assessed from either individual or society level which further divided into objective and subjective indicators [28]. Studies on QoL have listed 24 indicators of QoL which are comfort, status, recognition, material, beauty, aesthetic beauty, security, money, partner and family, health, social justice, leisure time, change variation, freedom, privacy, environmental quality, self-respect, social relations, spirituality, religion, education, safety, nature, biodiversity, challenge, excitement, and work [28]. More often than not, quality of life is associated with environmental concern and has recently been emphasised in travel behaviour studies [19], [29], [30].

E. Travel Behaviour

Travel behaviour can be explored from the perspective of attitude and perception. It can also explain by social expectations about behaviour such as norms, values, beliefs, attitudes, and lifestyle [31]. TDM measures or strategies are determined by the effects of travel behaviour on travel choice, travel mode etc.

Attitude

Attitude can be defined as positive or negative evaluations or beliefs held about something that in turn may affect one's behaviour; attitudes are typically broken down into cognitive, affective, and behaviour components [32]. A traveller's attitude is an important aspect in travel behaviour research [25], [33]. According to attitude theory, attitude refers to evaluation of a behaviour, which disposes a person to behave in a certain way towards it [25]. Attitude is conceptualised as positive or negative evaluations or beliefs of something that affects one's behaviour and can be broken down into cognitive, affective, and behaviour components [32].

Social psychologists described attitudes as an element in decision-making process [25] whereas transportation researchers described attitudes as part of the decision process [34]. Additionally, attitude along with intentions have significant impact in understanding travel behavioural choices [35]. In case of choosing public transportation, attitude was found to be a more significant indicator than demographics and travel needs [25], [36], [37]. A traveller's attitude is an important aspect in travel behaviour research [25]. According to attitude theory, attitude refers to evaluation of a behaviour, which disposes a person to behave in a certain way towards it [25]. Attitude is conceptualised as positive or negative evaluations or beliefs of something that affects one's behaviour and can be broken down into cognitive, affective, and behaviour components [32].

Perception

Perception is very important to encourage and determine behaviour [38]. The perception which is a prosocial emotion would result in obligation to do good according to social reference group standard which eventually become their personal norm [39]. For this study, perceived value will be explored to assess customers' perception towards TDM measures. Perceived value can be summarised as a trade-off between perceived benefits and perceived costs [40], [41]. More specifically, perceived value comes from a trade-off between perceived benefits and perceived costs [24]. Previous studies suggested that perceived value may be a better predictor of repurchase intentions than either satisfaction or quality [42]. Perceived value has been identified as an antecedent to satisfaction and behavioural intentions [42]. In the context of public transport, [40], [43] established and tested the perceived value model, which they applied to identify factors affecting passengers' repurchase intentions to- ward public transit services. Their results revealed that passengers' behavioural intentions are significantly affected by perceived value, which is determined by perceived benefits and perceived costs.

III. DISCUSSION AND CONCLUSION

Travel demand management is a strategy to address traffic congestion in metropolitan cities [44]. TDM focuses on balancing the supply and demand of transportation. Public and private investments on public transportation have helped cities to develop public transport infrastructure. Vibrant economic growth would result in many economic activities normally centred in business centres. This would result in traffic congestion which would affect drivers' quality of life. However, encouraging people to use public transport has been a great challenge where car ownership has become a priority. Thus, for more public transport ridership, TDM must be deployed efficiently.

In encouraging changes in travel behaviour to use more public transport and reduce single-occupant vehicle (SOV), factors like quality of life, psycho-social, and trip chain attributes need to be addressed accordingly.

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