

# UNVEILING THE DRIVERS OF MODAL SWITCH FROM MOTORCYCLES TO PUBLIC TRANSPORT IN SOUTHEAST ASIA

Son-Tung Nguyen <sup>a,b</sup>, Mehdi Moeinaddini<sup>c,\*</sup>, Ismail Saadi<sup>d</sup>, Mario Cools <sup>a,e,f</sup>

<sup>a</sup> *Local Environment & Management Analysis (LEMA), Urban and Environmental Engineering (UEE), University of Liège, Quartier Polytech 1, Allée de la Découverte 9, 4000 Liège, Belgium*

<sup>b</sup> *University of Economics - The University of Danang Viet Nam*

<sup>c</sup> *Centre for Public Health, Queen's University, Belfast, UK*

<sup>d</sup> *MRC Epidemiology Unit - School of Clinical Medicine, University of Cambridge, UK*

<sup>e</sup> *Faculty of Business Economics, Hasselt University, Belgium*

<sup>f</sup> *Department of Informatics, Simulation and Modeling, KU Leuven Campus, Brussels, Belgium*

\* *Corresponding author. E-mail address: mehdi41360@gmail.com (M. Moeinaddini).*

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## ABSTRACT

Most studies on commuter and public transport mode choice rely on theoretical frameworks that draw boundaries between the utility function, social-ecological system, demographic and socioeconomic attributes, and psychological theory. While models predicting the shift towards public transport are commonly applied in developed countries, there is a lack of similar studies that construct these models in developing countries. In addition, in some developing countries, the motorcycle is one of the main private motorised travel modes. Therefore, the modal shift from motorcycles to public transport in Southeast Asia to reduce private mobility is one of the important topics to examine. This paper presents a systematic literature review, utilising a comprehensive search strategy across electronic databases and reputable sources to identify directed acyclic graphs (DAGs), revealing factors influencing the choice and intention to shift to public transport. Data synthesis from selected studies highlights the intrinsic and extrinsic variables influencing public transport use, motorcycle use, and the modal shift to public transport. The study also proposes a theoretical framework for the modal shift in usage from motorcycles to public transport.

## 1. Introduction

Passenger and freight transportation services are of great economic and social importance in upholding the quality of life and consumption standards (Gifford & Steg, 2007). However, transportation services are also criticised for adverse social and environmental concerns (Greene & Wegener, 1997). Indeed, transportation is considered a main contributor to the carbon footprint as most mobility services depend on non-renewable resources (Stradling, 2011). The fast growth of private mobility use in urban areas negatively affects the environment and creates social problems, such as noise pollution and road traffic accidents (Greene & Wegener, 1997; Steg, 2003). The WHO reports nearly 1.35 million deaths yearly due to road traffic accidents (WHO, 2020). Furthermore, increased private mobility reduces the space for other public activities like walking, cycling, and playing (Steg, 2003).

Sustainable public transport is considered a solution to these problems, but it is confronted with a significant barrier: the attractiveness of private motorised mobility (Bhourri, Mayorano, Lotito, Salem, & Lebacque, 2015; Redman, Friman, Gärling, & Hartiga, 2013). Most people prefer private vehicles to participate in various activities instead of public transport or emergent shared mobility services. Compared to other transport alternatives, the private travel mode is generally perceived as more convenient, more comfortable, and as a symbol of or reflecting the person's identity (Steg, 2005). Those without private mobility options are disadvantaged and even socially isolated because the infrastructure of public buildings and workplaces generally suits private mobility users only (Steg, 2003). Thus, developing safe, convenient, and sustainable public transport significantly decreases private motorised commutation and increases public transport use (Bhourri et al., 2015).

A good understanding of the factors influencing travel mode choice is required to achieve a modal shift, the process of transitioning from one mode of transportation to another, towards public transport. Previous studies have used different behavioural frameworks such as utility theory (Domencich & McFadden, 1975), discrete choice models (Eriksson, Friman, Ettema, Fujii, & Gärling, 2010; Satiennam, Jaensirisak, Satiennam, & Detdamrong, 2016), normative decision-making (NDM) (Matthies, Kläckner, & Preißner, 2006), and the theory of planned behaviour (TPB) (Bamberg, Ajzen, & Schmidt, 2003) to understand commuters' decision-making process. However, there has been a lack of conclusive investigation into a model that explores the relationship between objective factors such as gender, age, marriage status, etc., and subjective factors like attitudes, personal norms, perceived behavioural control, etc., for understanding mode choice behaviours.

In addition to the above lack, previous studies have mainly focused on the factors influencing the shift from car use to public transport (e.g., Eriksson et al., 2010; Stanton et al., 2012). The shift from motorcycle use to public transport has not been investigated extensively, even though motorcycles are the main transport mode in many developing countries, especially in Southeast Asia. Previous studies on motorcycle use have mainly focused on traffic safety (Kepaptsoglou, Milioti, Christoforou, & Karlaftis, 2011; Le & Trinh, 2016), economic factors (Burge, Fox, Kouwenhoven, Rohr, & Wigan, 2008; Chang & Wu, 2008; Chen & Lai, 2011; Kepaptsoglou et al., 2011;

Le & Trinh, 2016), and demographic analyses (Abdullah, Rahmat, & Ismail 2007; Le & Trinh, 2016; Satiennam et al., 2016; Sheikh et al., 2006). So, the lack of literature regarding motorcycle utilisation and the modal shift from motorcycle usage to public transport needs to be addressed, particularly in regions such as Southeast Asia, where the transportation situation significantly differs from those in the Western world, with a higher proportion of motorcycle users (United Nations, 2018). For example, of the top 20 countries with the highest number of motorcycles per population of 1000, six are from Southeast Asia: Vietnam, Malaysia, Indonesia, Thailand, Lao, and Cambodia (WHO, 2013).

In the megacities of Southeast Asia, such as Ha Noi in Vietnam, Bangkok in Thailand, and Manila in the Philippines, private vehicles, especially motorcycles, dominate the transportation landscape (Mo, Kwon, & Park, 2014). This shift towards private vehicles is driven by the rapid economic growth in the region and the preference for personal transportation among both local residents and urban migrants (Mo et al., 2014). The increasing popularity of motorcycles can also be attributed to their affordability, lower operating costs, compact size, and manoeuvrability on the roads and in parking spaces (Kepaptsoglou et al., 2011). However, this rise in motorcycle usage is further influenced by the challenges associated with bicycling, walking, and the available local transport modes (Bakker et al., 2018; Mateo-Babiano, 2016). Bicycling and walking face limitations such as a lack of direct and coherent bike lanes, safety concerns when interacting with motorised traffic, infrastructure constraints, conflicts with pedestrians, and a lack of comprehensive policies and planning (Bakker et al., 2018; Mateo-Babiano, 2016). Moreover, local transport modes like Tuk-Tuks in Bangkok and Jeepneys in the Philippines encounter safety issues due to their open-door design (Bakker et al., 2018). Additionally, it is noteworthy that women in Southeast Asia often prefer public transport as it enables them to chain trips while ensuring their safety on the roads (Hidayati, Tan, & Yamu, 2020; Ng & Acker, 2018).

On the other hand, app-based motorcycle ridesharing services (such as Grab) can be a suitable alternative for commuters in Southeast Asian countries. However, these ridesharing services can be categorised as door-to-door travel options that cannot be considered public transport. After all, ridesharing services draw commuters away from public transport, increase vehicle miles travelled, and cause traffic congestion (Franco, Johnston, & McCormick, 2019; Hall, Palsson, & Price, 2018; Henao & Marshall, 2019).

In this study, the authors employ Directed Acyclic Graphs (DAGs), also known as causal graphs, to visually illustrate the established relationships between the factors influencing public transport use, motorcycle use, and the modal shift to public transport identified through a systematic literature review. DAGs provide a robust framework for illustrating the relationships between exposures, covariates, and outcomes, thereby enhancing our ability to comprehend the underlying causal pathways and interdependencies. Following this, the Stage Model of Self-Regulated Behavioral Change (SSBC) is also utilised to develop a comprehensive framework that can reflect multiple decision-making stages and the factors influencing each of these single-stage transitions. By incorporating DAGs and SSBC into the analytical approach, this study aims to develop a robust theoretical framework. The primary objective of this study is to illuminate the factors influencing

the transition from motorcycle to public transport, thereby facilitating a deeper understanding of this complex phenomenon. Through the pursuit of this research, the authors aspire to make a substantial contribution to the existing literature, aiming to address and bridge existing gaps in the understanding of sustainable transportation choices within the region. To achieve this, the authors will investigate the following research questions:

- i. What are the intrinsic and extrinsic factors influencing public transport use, motorcycle use, and the modal shift to public transport in Southeast Asia?
- ii. How do these factors interact to influence the modal shift to public transport?
- iii. What are the implications of these findings for policymakers and planners in Southeast Asia?

## 2. Methodology

### 2.1. ARTICLE SELECTION PROCESS

SCOPUS is the world's largest searchable abstract and citation database of peer-reviewed scientific literature, whereas Science- Direct is the world's leading full-text database for scientific research (Elsevier, 2023). These databases provide comprehensive, high- quality, and trustworthy scientific content and an advanced search that allows complex search queries to be entered (Elsevier, 2023). Therefore, the electronic search was performed on both databases. Moreover, these two databases are the ones available and subscribed to in the first authors' institutions. Search terms included a combination of synonyms of "factors affecting" and either 'public transport' or 'motorcycle.' A detailed overview of all search terms is provided in Appendix A.

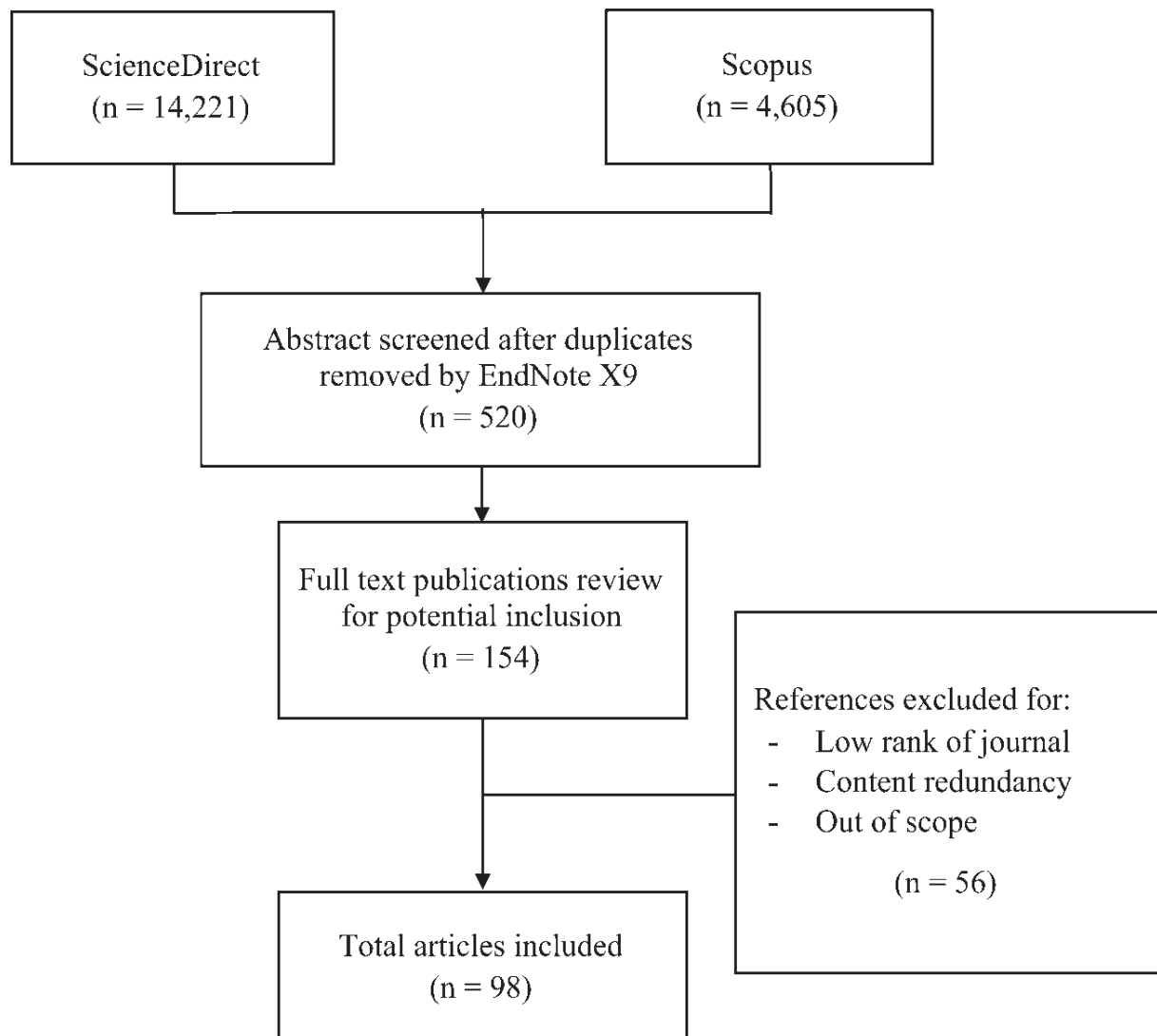
The inclusion criteria were:

- Document type: *reviews, research articles*
- Subject area: *social sciences, engineering, environmental science, decision sciences, psychology*
- Source type: *journal*
- Language of publication: *English*
- Time frame of literature: *from 1990 to 2020*

EndNote X9 software was utilised to conduct the second round of searches based on the articles retrieved during the initial search phase. In this subsequent phase, articles were considered for inclusion if their abstracts contained a combination of predefined search terms related: *Factor, affect/ influence/ important/ contribute/ attribute/ cause, public transport/ motorcycle/ motorcycle/ motor bike/ modal shift*. The final sample was determined by thoroughly examining the full-text articles (Fig. 1). During this review process, certain articles were excluded from consideration as

they fell outside the predefined scope of the study, exhibited content redundancy, or were published in journals with a low ScimagoJR quartile ranking (below the second quartile or Q2). For instance, articles focusing on intercity mode choice, railway systems, shuttle buses, car-following conditions, or commuters' behaviours in mixed traffic conditions were considered beyond the intended scope of this investigation.

**Figure 1.** Flow chart of the article selection process.



## 2.2.DIRECTED ACYCLIC GRAPHS

The power of Directed Acyclic Graphs (DAGs), commonly referred to as causal graphs, lies in the fact that they serve as a crucial tool for developing a robust framework to elucidate and evaluate causal relationships among exposures, covariates, and outcomes, as derived from the systematic review findings (Table 1). DAGs are firmly grounded in a well-established framework that employs a systematic methodology to illustrate the appropriate nodes (variables) for manipulation, allowing researchers to investigate and understand causal relationships (Pearl, Glymour, & Jewell, 2016). By

carefully specifying the causal pathways and dependencies among variables, DAGs facilitate identifying and adjusting confounding factors, thereby reducing bias and enabling more accurate inference of causal effects. In line with these principles, the present study extensively uses the DAGitty platform (Textor, van der Zander, Gilthorpe, Liskiewicz, & Ellison, 2016) to construct causal graphs based on the systematic review results. This approach enhances the study's robustness in identifying causal relationships and provides valuable insights into the examined phenomena.

**Table 1.** Factors influencing motorcycle and public transport mode choice.

Factors			PT	Motorcycle	Modal shift towards PT	Sources and study areas
Psychological characteristics	Attitude	Instrumental	x	x	x	Beirao & Sarsfield Cabral, 2007 - (Porto - Portugal); Chen & Chao, 2011 - (Kaohsiung - Taiwan); Chen & Chen, 2011 - (Taiwan); Johansson et al., 2006 - (Stockholm & Uppsala - Sweden); Kitamura et al., 1997 - (San Francisco - the US); Le & Trinh, 2016 - (HCM - Vietnam); Murray et al., 2010 - (Auckland, Wellington, & Christchurch - New Zealand); Parkany et al., 2004 - (Massachusetts - the US); Steg, 2003 - (the Netherlands); Steg, 2005 - (Groningen & Rotterdam - the Netherlands); Steg & van Brussel, 2009 - (the Netherlands); Van & Fujii, 2011 - (Tokyo - Japan, Bangkok - Thailand, Tianjun - China, Bandung - Indonesia, HCM - Vietnam, Manila - the Philippines); Van et al., 2014 - (Tokyo - Japan, Bangkok - Thailand, Tianjun - China, Bandung - Indonesia, HCM - Vietnam, Manila - the Philippines); Wong et al., 2010 - (Taiwan); Zailani et al., 2016 - (Kuala Lumpur - Malaysia)
		Symbolic Social orderliness				
	Habits	x	x	x		
	Personal norms	x	x	x		
	Social norms	Injunctive norms	x	x	x	
	Descriptive norms					
	Perceived behavioural control	x	x	x		
Mode characteristics	Travel time	x	x	x	Andreassen, 1995 - (Oslo - Norway); Beirao & Sarsfield Cabral, 2007 - (Porto - Portugal); Hensher, Stopher, and Phillip 2003 - (Australia); Javid, 2017 - (Lahore - Pakistan); Redman et al., 2013 - (systematic review paper); Rietveld, 2005 - (conceptual analysis paper); Satiennam et al., 2016 - (Khon Kaen - Thailand)	
	Travel cost	x	x	x		
	Service reliability	x		x		
	Frequency	x				
	Station facilities	x				
	Seat availability	x				
	Number of transfers	x				
	Independence		x			
	Convenience		x	x		
	Flexibility		x	x		
Travel distance		x				
Built environment	Residential density	x	x	x	Abdullah et al., 2007 - (Kuala Lumpur - Malaysia); Chang & Wu, 2008 - (Taipei - Taiwan); Ewing & Cervero, 2010 - (systematic review paper); Kepaptsoglou et al., 2011 - (Athens - Greece); Lucas et al., 2016 - (the United Kingdom); Satiennam et al., 2016 - (Khon Kaen - Thailand); Zhang et al., 2012 - (the US)	
	PT accessibility	x				
	Walking facilities	x				
	Mixed land use	x		x		
	Parking spaces		x			
	Traffic safety		x			
	Weather		x			
Demographic and socio-economic characteristics	Age	x	x		Abdullah et al., 2007 - (Kuala Lumpur - Malaysia); Chang & Lai, 2015 - (Taiwan); Hsu et al., 2003 - (Taiwan, Malaysia & Vietnam); Kepaptsoglou et al., 2011 - (Athens - Greece); Tran et al., 2014 - (Hanoi - Vietnam); Santos et al., 2013 - (112 medium-size European cities); Satiennam et al., 2016 - (Khon Kaen - Thailand); Sheikh et al., 2006 - (Selangor - Malaysia); Steg, 2005 - (Groningen & Rotterdam - the Netherlands); Van et al., 2014; Vu, 2015 - (Hanoi - Vietnam)	
	Gender	x	x			
	Households	x	x			
	Marital status	x	x			
	Education		x			
	Vehicle ownership	x	x			
	Household income	x	x			

### 3. Results

The total number of articles considered for review after the second round equals 98. The included articles combine theoretical and empirical studies conducted to understand how commuters choose their travel mode under different scenarios and contexts. Pioneering studies in this field have explained commuter mode choice by using discrete choice modelling (DCM) based on aggregate data during the 1960s (Barff, Mackay, & Olshavsky, 1982). However, an important limitation of the aggregate approach is that it could not capture the specificities of different subgroups of the population (Domencich & McFadden, 1975).

Since disaggregated data can give a better understanding of commuters' behaviour, its use has become common in mode choice modelling, and many public transport agencies adopted it during the 1980s (Ratrouf, Gazder, & Al-Madani, 2014). In addition, these studies explain commuter mode choice by primarily focusing on the objective elements using utility theory and assuming that people make trade-offs between travel costs and travel time (McFadden, 1986). Their major focus is primarily on the economic variable, and they ignore the socio-cognitive factors in understanding commuters' needs and interests (Ramos, Daamen, & Hoogendoorn, 2014).

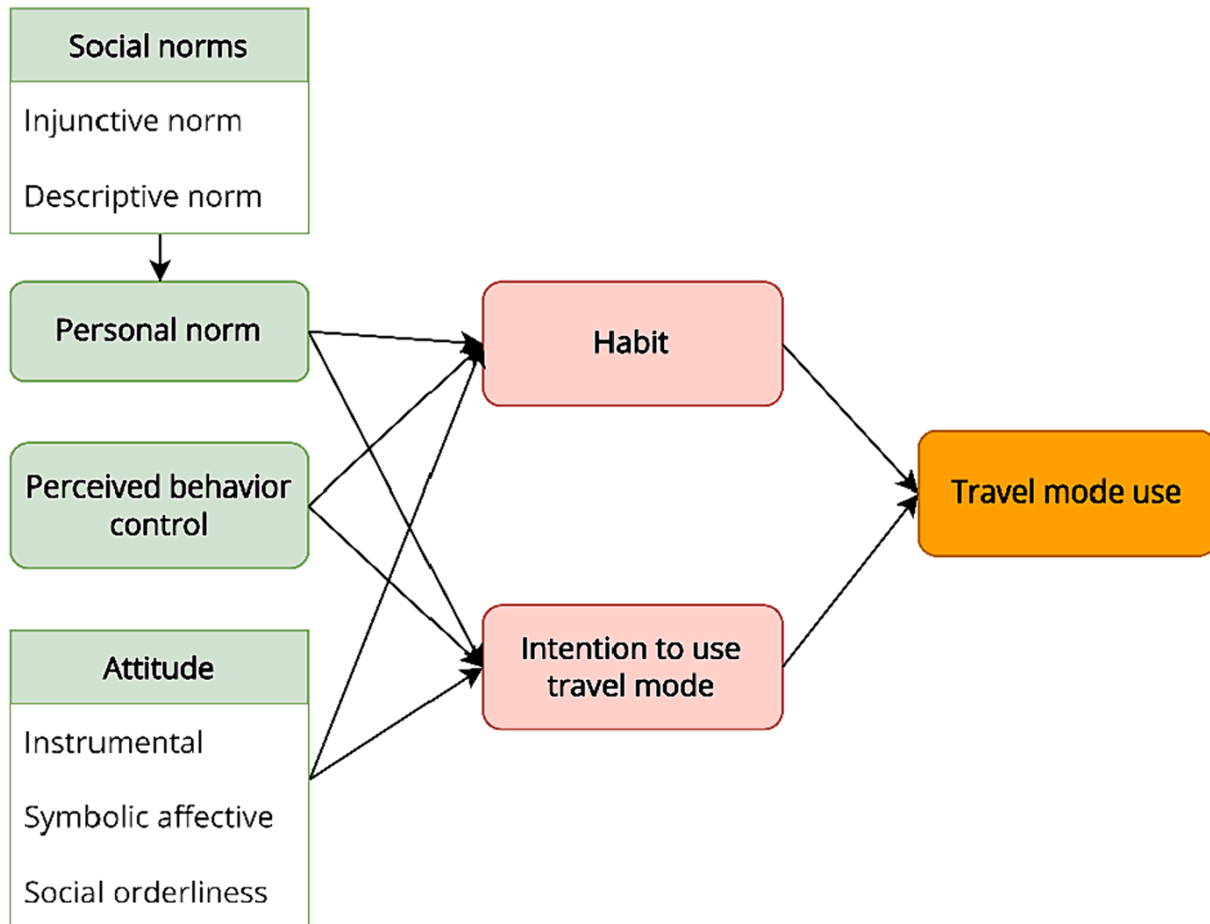
In later studies, researchers have focused more on the influence of psychological factors such as attitudes, intention, subjective norm, perceived behavioural control, etc. (Acker, Wee, & Witlox, 2010; Beirão & Sarsfield Cabral, 2007; Le & Trinh, 2016; Steg, 2005; Van & Fujii, 2011). These studies have shed light on significant relationships between psychological factors and commuter behaviour, providing a deeper understanding of the factors influencing residential location preferences (Beirão & Sarsfield Cabral, 2007; Le & Trinh, 2016; Schwanen & Mokhtarian, 2005). These psychological factors are measured using the theory of planned behaviour (TPB). However, the TPB has faced criticism for its limited scope, focusing solely on four explanatory concepts and failing to consider all volitional behaviours, including some factors such as the influence of social norms, habitual behaviour, and external factors (Sniehotta, Pesseau, & Araújo-Soares, 2014). Furthermore, concerns have been raised about the TPB's ability to explain sufficient variability in behaviour, as well as its mediation assumptions conflicting with evidence (Sniehotta et al., 2014). It is argued that the TPB may not fully encompass the influence of social norms, habitual behaviour, and external constraints (Sniehotta et al., 2014). Consequently, researchers have turned to extended versions of the theory, signalling the need for change and expansion (Sniehotta et al., 2014). Additionally, other behaviour theories have also been applied, such as the theory of interpersonal behaviour (Kang, Jayaraman, Soh, & Wong, 2019) and the stages of change theory (Bamberg, 2013), which provide complementary insights into the complexities of mode choice and modal shift.

The papers retained after the selection process allow identifying the factors influencing public transport mode choice, motorcycle mode choice and the modal shift to public transport (Table 1). The specific study areas are also outlined in Table 1, while the objectives and respondents of selected studies are shown in Appendix B (studies highlighted in red indicate that these studies are conducted in the context of Southeast Asia). In what follows, this paper highlights the factors that



affect all three aspects (public transport mode choice, motorcycle mode choice, and modal shift to public transport) and proposes a theoretical framework to explain the modal shift from motorcycle to public transport.

**Figure 2.** Influence of psychological factors (extended from the TPB (Ajzen, 1991)).



### 3.1. PSYCHOLOGICAL FACTORS OF BEHAVIOURAL INTENTION TOWARD TRAVEL MODE USE

Psychological factors are intrinsic motivation factors that represent the inner state that affects individuals' travel mode choices and include the behavioural intention to use a specific travel mode, which results from the mental function that immediately yields antecedents to mode choice behaviour. Intention is one of the best indicators for predicting and studying human behaviour, especially if the behaviour is difficult to observe (Ajzen, 1991; Armitage & Conner, 2001; Fishbein & Ajzen, 2009; Sheeran, 2002; Yurtkoru, Kuşcu, & Doğanay, 2014; Webb & Sheeran, 2006). The theory of planned behaviour (TPB), commonly employed to examine behavioural intention, posits that understanding intrinsic motivational factors enables the prediction of individual behaviour (Ajzen, 1991). TPB identifies three determinants of behavioural intention: attitudes, subjective norms, and perceived behavioural control (PBC). Notwithstanding the previously mentioned limitation, TPB has been widely adopted as a framework in studies exploring human decision-making processes in the context of travel behaviour. Over the years, this theory has been expanded by incorporating



additional variables to enhance its predictive capacity regarding travel choice behaviour. Fig. 2 illustrates the interrelationships among these factors.

### 3.1.1. ATTITUDE

Many studies have examined the influences of attitude toward travel behaviour (Beirão & Sarsfield Cabral, 2007; Chen & Chao, 2011; Chen & Chen, 2011; Kitamura, Mokhtarian, & Laidet, 1997; Steg & van Brussel, 2009; Steg, 2005; Van & Fujii, 2011). Attitude is measured by assessing the service quality, such as flexibility, saving time, cost sensitivity, or the intention to use alternative transportation modes (Beirão & Sarsfield Cabral, 2007; Parkany, Gallagher, & Viveiros, 2004). Previous studies generally admitted that attitudes toward mode choice are formulated from *instrumental, symbolic, and affective motives* (Steg, 2003, 2005). *Instrumental attitudes* are driven by practical considerations such as cost, time, and convenience, while *symbolic attitudes* are associated with the expressive meanings attributed to different modes of transport (Steg, 2005). *Affective attitudes*, on the other hand, are linked to individuals' emotional experiences and well-being (Steg, 2005). Subsequent studies have identified a strong relationship between symbolic and affective factors without a clear distinction between them (Steg, 2005; Van & Fujii, 2011).

Indeed, mode characteristics such as flexibility and comfort affect the attitude toward an individual's mode choice (Johansson, Heldt, & Johansson, 2006). In Canada, a study found that public transport services' reliability and convenience were more effective on passenger attitudes toward public transport than comfort (Habib, Tian, & Zaman, 2011). Based on public transport prejudice scores in New Zealand, Murray, Walton, and Thomas (2010) investigated the influencing factors of attitudes towards public transport. They found that public transport's service quality and social norm can influence attitudes towards public transport. These attitudes were also affected by demographic and socio-economic features such as age, gender, household income, etc. (Murray et al., 2010; Van & Fujii, 2011). Moreover, Beirão and Sarsfield Cabral (2007) found that potential users' intentions can be improved by enhancing public transport's image and service level.

In Vietnam, despite the improvement in the public transport system in terms of onboard services and bus fleet, the percentage of student and employee users is still limited. Thus, students and employees do not have a positive attitude towards bus service, whereas motor vehicles remain their highest travel priority (Le & Trinh, 2016). Indeed, motorcyclists have a positive attitude towards motorcycle use as they enjoy speeding (Chen & Chen, 2011), while this travel mode's flexibility also allows them to beat the traffic (Steg & van Brussel, 2009). Van and Fujii (2011) conducted a study in six Asian countries and found a new factor called *social orderliness* as a dimension of commuters' attitudes toward travel mode. *Social orderliness attitude* was related to safety, quietness, environmental friendliness, altruism, etc. (Van & Fujii, 2011). This factor reflected that the traffic condition of some developing countries in this area was more chaotic than orderly (Van & Fujii, 2011). This situation occurred due to non-compliance with traffic regulations and low awareness of commuters, such as aggressive driving, illegal U-turns, weaving between lanes, etc (Van & Fujii, 2011).

### 3.1.2. HABITS

Several studies consider mode choice as habitual and automatic behaviour (Verplanken et al., 1994, 1998). Klöckner and Matthies (2011) found that the stability of cognitive psychological factors (attitude, personal norms, and perceived behaviour control) in the same travel condition/script is necessary to form habitual behaviour. However, these cognitive psychological factors do not directly translate into habitual behaviour (Klöckner & Matthies, 2011). The processes of persistence and initiation, as described by Ronis, Yates, and Kirscht (1989), shed light on the transition from reasoned decision-making to automatic habit. Initially, individuals make conscious decisions based on behavioural intentions, following the principles of the Theory of Planned Behavior (TPB) (Ajzen, 1991). However, with repeated performance, the behaviour becomes ingrained as a habit, and decision-makers rely heavily on past experiences without actively considering alternative options (Betsch, Fiedler, & Brinkmann, 1998). This interplay between cognitive factors from TPB and the development of habitual behaviour is particularly evident in mode choice (Chen & Chao, 2011; Verplanken & Aarts, 2011; Verplanken, Henk, van Knippenberg, & Moonen, 1998). Commuters, for instance, tend to habitually select a specific mode of transportation unless a significant event disrupts their habitual pattern, prompting them to re-evaluate their choice (Chen, Gärling, & Kitamura, 2004). Thus, understanding how cognitive factors interact with the formation and persistence of habits provides a comprehensive perspective on the dynamics of mode choice behaviour (Verplanken & Aarts, 2011; Verplanken et al., 1998).

### 3.1.3. SOCIAL AND PERSONAL NORMS

Social norms are considered collective representations of accepted group behaviour and individual awareness of group behaviour (Lapinski & Rimal, 2005). They can be seen as cultural products, such as values, customs, and traditions, that display individuals' basic

knowledge about what others do and think they should do. Social norms can be divided into two subgroups: *descriptive norms* and *injunctive norms*. *Descriptive norms* are significant indicators of public transport use (Heath & Gifford, 2002; Olsson, Huck, & Friman, 2018). *Descriptive norms* define that an individual's intention to perform a specific behaviour is significantly influenced by others who engage in that behaviour (Heath & Gifford, 2002). Meanwhile, *injunctive norms* relate to perceived group approval of a particular behaviour and support an individual in deciding whether a behaviour ought to be implemented (Borsari & Carey, 2003). Note that the intention to perform a specific behaviour is affected by these subgroups of social norms indirectly through personal norm, which refers to a personal belief that acting in a certain way is true or false (Olsson et al., 2018). Personal norms are also referred to as consequences' perceptions related to specific behaviours. Hence, both personal and social norms are related to using a particular transportation mode, especially the intention to use public transport (Bamberg, Hunecke, & Blobaum, 2007).

### 3.1.4. PERCEIVED BEHAVIOURAL CONTROL

Perceived behavioural control (PBC) refers to an individual's perception of their ability to perform a specific behaviour, encompassing factors such as skills, resources, and situational constraints

(Ajzen, 1991). PBC has been extensively examined in the context of travel intention and behaviour, yielding diverse findings across different studies (Bamberg et al., 2003; Chen & Chao, 2011; Chen & Lai, 2011; Haustein & Hunecke, 2007; Heath & Gifford, 2002). For instance, research conducted in Taiwan revealed that PBC significantly influenced the intention to shift to public transport for motorcyclists, but not for car users (Chen & Chao, 2011). Another research in Taiwan highlighted PBC as the most influential factor in predicting the intention to use motorcycles (Chen & Lai, 2011). Furthermore, on a broader scale encompassing environment-friendly transportation options (walking, bicycling, and public transportation), PBC also yielded a significant direct impact (Haustein & Hunecke, 2007).

### 3.2. FACTORS INFLUENCING PUBLIC TRANSPORT MODE CHOICE

Many factors affect public transport use, including costs, physical accessibility, attitudes, etc., which relate to the capacity and motivation of public transport use (Abdullah et al., 2007; Andreassen, 1995; Beirão & Sarsfield Cabral, 2007; Chen & Chao, 2011; Kitamura et al., 1997; Parkany et al., 2004; Satiennam et al., 2016; Steg, 2005). Public transport, which includes busses, metros, bus rapid transit (BRT), etc., is an alternative to private vehicles and has many advantages such as high capacity, cost-effectiveness, not being affected by traffic congestion, etc. (Profillidis & Botzoris, 2018). Public transport plays a key role in ensuring access to activities and services in urban and crowded areas and contributes to mitigating environmental and social problems by decreasing private mobility trips and carbon footprint (Dirgahayani, 2013; Stanton et al., 2012).

Factors influencing public transport mode choice can be broadly divided into *mode characteristics* (Andreassen, 1995; Beirao & Sarsfield Cabral, 2007; Hensher, Stopher, & Bullock, 2003), *demographic and socio-economic characteristics* (Abdullah et al., 2007; Satiennam et al., 2016; Sheikh et al., 2006), *psychological characteristics* (Beirão & Sarsfield Cabral, 2007; Kitamura et al., 1997; Murray et al., 2010; Parkany et al., 2004; Steg, 2005), and *built environment* (Abdullah et al., 2007; Ewing & Cervero, 2010; Jenelius, 2012; Lucas, Mattioli, Verlinghieri, & Guzman, 2016; Wang & Lin, 2013; Zhang et al., 2012). Since psychological characteristics are previously discussed, this section only focuses on the remaining ones.

#### 3.2.1. MODE CHARACTERISTICS

Transport mode characteristics are the extrinsic motivation factors (e.g., public transport service quality and accessibility) that affect individuals' travel mode choices. Early studies on public transport mode choice focused on measuring the public transport system's service quality and availability. Results indicated that travel time, travel cost, service reliability, frequency, seat availability, station facilities, and various other mode characteristics mentioned in Table 1 are highly ranked attributes for service quality (Andreassen, 1995; Redman et al., 2013; Rietveld, 2005). For most work-related and school-related journeys, travel time and cost are the most influencing factors (Beirão & Sarsfield Cabral, 2007). Indeed, commuters want to feel in control when travelling, which means short waiting times and a fast journey (Beirão & Sarsfield Cabral, 2007). In

addition, lower fares would increase commuters' perceptions of public transport quality, thus affecting their satisfaction with this mode choice (Andreassen, 1995; Hensher et al., 2003).

Service reliability and frequency are other important public transport quality attributes. Previous studies showed that most public transport commuters experience poor service during peak hours, whereas service reliability is more important for commuters at this time of day (Beirao & Sarsfield Cabral, 2007; Redman et al., 2013; Rietveld, 2005). Furthermore, commuters do not want to change vehicles during their journeys; this leads to a preference for frequent direct public transport services (Beirao & Sarsfield Cabral, 2007). Indeed, the most important policies encouraging public transport use are reducing travel time from home to public transport stations and low fares (Satiennam et al., 2016).

### 3.2.2. DEMOGRAPHIC AND SOCIO-ECONOMIC CHARACTERISTICS

Previous studies have indicated demographic and socio-economic characteristics significantly influence commuters' behaviour (Abdullah et al., 2007; Satiennam et al., 2016; Sheikh et al., 2006). Demographic variables such as age, gender, and household size were found to be good explanatory variables in understanding commuters' behaviour (Sheikh et al., 2006). Indeed, in the same service quality, older people were more willing to use public transport (Abdullah et al., 2007).

Earlier studies had found a strong preference for private vehicle dependency among adults (aged 18 and above) (Chang & Wu, 2008). Also, most households with younger members were more mobile and had a higher expenditure on private and public transportation (Santos, Maoh, Potoglou, & von Brunn, 2013). Public transport is not a convenient mode of transport for households with younger members, as it typically entails walking to and from a station and waiting on top of the actual journey, which entails several stops and sometimes a detour relative to the destination (Santos et al., 2013).

In countries such as Malaysia and Vietnam, apart from extrinsic motivation factors (such as travel time, travel cost, age, and gender), vehicle ownership and household income are also significant factors that influence individuals' mode choice (Abdullah et al., 2007; Le & Trinh, 2016). Indeed, in developing countries, an increase in household income makes private mobility, especially motorcycle, a more affordable means of transport, and young commuters perceive this travel mode as a status symbol, creating a high private mobility share (Chang & Lai, 2015; Satiennam et al., 2016; Steg, 2005). Gender is also an influencing factor in mode choice behaviour. Male commuters prefer private mobility as they seem to place a high premium on symbolic aspects compared to their female counterparts (Satiennam et al., 2016; Sheikh et al., 2006; Steg, 2005).

### 3.2.3. BUILT ENVIRONMENT

In recent years, built environmental factors are increasingly seen as influencing travel mode choice. Four built environment components are seen as driving forces for public transport mode choice: (1) high residential density, (2) compact cities with mixed land use, (3) good access to public transit, and (4) good walking facilities (Ewing & Cervero, 2010; Wang & Lin, 2013). Higher residential density is shown to be responsible for reducing private vehicle use and encouraging

public transport use (Zhang et al., 2012). In terms of mixed land use, the closer the housing, employment, and social facilities, the less likely commuters would choose a motorised mode of transportation (Ewing & Cervero, 2010). When considering transit accessibility, the inconvenience of walking to bus stops or subway stations leads to more private vehicle use (Abdullah et al., 2007; Jenelius, 2012; Lucas et al., 2016). Finally, improved walking facilities towards public transport stations could increase public transport ridership (Lucas et al., 2016).

### **3.3. FACTORS INFLUENCING MOTORCYCLE MODE CHOICE**

A motorcycle is a two-or three-wheeled motor vehicle. Its design can be different to suit different purposes: long-distance travel, cruises, sports including racing, and off-road riding (Cossalter, 2006). The motorcycle is considered utilitarian in developing countries due to its lower purchase and operation costs. Southeast Asia has a considerable share of the global two-wheeler market (MotoCycles Data Team, 2020).

Factors influencing motorcycle mode choice can be broadly divided into *mode characteristics* (Beirão & Sarsfield Cabral, 2007; Le & Trinh, 2016; Sheikh et al., 2006), *psychological characteristics* (Beirão & Sarsfield Cabral, 2007; Kitamura et al., 1997; Le & Trinh, 2016; Van & Fujii, 2011; Van, Choocharukul, & Fujii, 2014), *built environment characteristics* (Chang & Wu, 2008; Kepaptsoglou et al., 2011), and *demographic and socio-economic characteristics* (Abdullah et al., 2007; Hsu, Sadullah, & Nguyen, 2003; Le & Trinh, 2016; Satiennam et al., 2016; Sheikh et al., 2006). Because psychological characteristics have already been discussed, this section focuses solely on the remaining ones.

#### **3.3.1. MODE CHARACTERISTICS**

Motorcycling is an interesting travel mode as it reduces travel time during traffic congestion and has low acquisition and maintenance costs (Sheikh et al., 2006). Travel time instead of travel cost is the most significant attribute of motorcycle mode choice, reflecting the convenience of motorcyclists for commuting over travel distances that are not very long (Beirão & Sarsfield Cabral, 2007). Travel time is the total time on the street, including the in-vehicle travel time, waiting time due to traffic congestion, time for waiting at the gas station, and time to find a parking spot (Le & Trinh, 2016). Indeed, when considering the total travel time, the motorcycle is considered the fastest mode, while the bus is the slowest for all distances (Tran, Zang, & Fujiwara, 2014; Vu, 2015). Therefore, if the travel time of using a motorcycle increases, the probability of choosing this travel decreases (Le & Trinh, 2016). In addition, the amount of time to wait depends on traffic conditions and the road user's perception (Hess, Brown, & Shoup, 2005).

In Vietnam, motorcycling is one of the most well-fit travel modes due to urban planning and economic development in current conditions. Indeed, motorcycles having characteristics such as independence, flexibility, convenience, and inexpensiveness, can help commuters save travel time.

### 3.3.2. DEMOGRAPHIC AND SOCIO-ECONOMIC CHARACTERISTICS

The motorcycle is a popular road transportation mode in some developing countries due to its advantages in cost and flexibility, making it relatively attractive to large population groups (Hsu et al., 2003). Several studies have demonstrated that women prefer owning fewer private vehicles, such as motorcycles, as they perceive the public transportation system to offer superior service. (Abdullah et al., 2007; Le & Trinh, 2016; Satiennam et al., 2016; Sheikh et al., 2006). Also, a study in Vietnam found that commuters, who are single or do not have children, are more likely to commute by public transport. However, if there are children, the parent is more likely to use a motorcycle (Le & Trinh, 2016). Indeed, if the households include children, the number of daily trips increases as the children must go to school and take extra classes outside the regular school hours.

In developing countries, apart from the classic factors (travel time, travel cost, and travel distance), age, gender, household motorcycle ownership, and income are also major demographic and socio-economic factors that affect motorcycle use (Satiennam et al., 2016). Indeed, commuters with higher household motorcycle ownership are more likely to use motorcycles (Satiennam et al., 2016). Also, along with the increasing household income, the role of transportation costs decreases rapidly, while comfort and safety become more important. Thus, low-income households prefer public transport or bicycles for cost savings. Middle-income choose the motorcycle for time-saving and convenience, whereas high-income households prefer a car for comfort and safety (Satiennam et al., 2016; Vu, 2015).

Education also influences motorcycle use (Hsu et al., 2003). A study in Taiwan, Malaysia, and Vietnam found that commuters with low education levels would rather use motorcycles. However, this study is based on 2001 data and may not apply well in the current situation. This result could be explained as the commuters with higher education levels would have better incomes. Thus, these commuters would choose more comfortable and safer travel modes. One study in Ho Chi Minh City found that despite the motorcycle being a top priority in daily transport mode for students and employees, they still expressed their awareness of the negative aspects of motorcycles on the environment and community (Le & Trinh, 2016). These commuters also expressed their willingness to shift to bus use if public transportation infrastructure and quality are upgraded (Le & Trinh, 2016).

### 3.3.3. BUILT ENVIRONMENT

Commuters living in suburbs and areas of lower residential density have low motorcycle ownership due to better traffic conditions, higher income, and longer travel distances (Kepaptsoglou et al., 2011). Conversely, in areas with high residential density, poor traffic conditions, limited parking spaces, and coverage by public transportation is lower. Therefore, commuters depend more on private modes, resulting in higher motorcycle ownership and use (Kepaptsoglou et al., 2011). However, some factors, such as comfort, traffic safety, and weather conditions, can discourage motorcycle ownership and use.



### **3.4. FACTORS INFLUENCING MODAL SHIFT TOWARD PUBLIC TRANSPORT**

A modal shift can occur when a transport mode can achieve a competitive advantage in travel compared to another transport mode (Stanton et al., 2012). The competitive advantage can exist in many different forms, such as time, cost, capacity, flexibility, and reliability (Vedagiri & Arasan, 2009). Several studies have examined the modal shift to public transport in Asian countries with a high proportion of motorcycle use (e.g., Javid, 2017; Vedagiri & Arasan, 2009). Most of these studies focus on the mode choice utility function (Abdullah et al., 2007; Javid, 2017; Satiennam et al., 2016; Vedagiri & Arasan, 2009). For example, a study in India that analysed the possibility of a modal shift from an auto rickshaw (a three-wheeled motor vehicle) to a bus revealed that convenience most strongly influenced shift intention (Vedagiri & Arasan, 2009). Besides, perceived difficulty using public transport also negatively impacts modal shift (Eriksson et al., 2010).

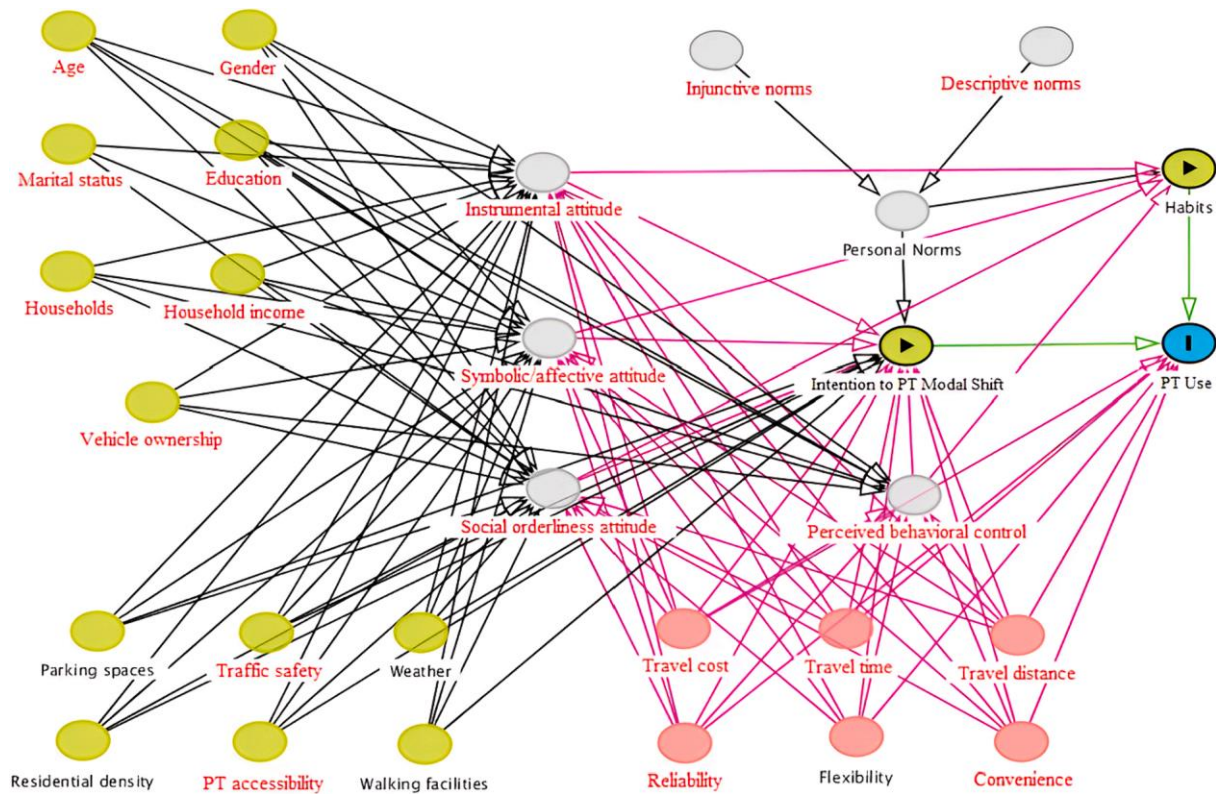
In Pakistan, a study examining the effect of auto-oriented and transit-oriented development on the intention to shift to public transport indicated that convenient, reliable, time-saving, and comfortable transport services are significant factors in defining commuters' intentions toward public transport (Javid, 2017). The result showed that to encourage the shift to public transport, transit-oriented attitudes need to be developed and promoted among commuters who use private modes, especially motorcyclists (Javid, 2017).

In Thailand, a study on the modal shift from private vehicles to BRT found that BRT could significantly attract private vehicle users, especially motorcyclists, due to better service (Satiennam et al., 2016). This study also found that travel costs significantly affected motorcyclists' choices (Satiennam et al., 2016). Therefore, increasing the costs related to private mobility use would increase the likelihood of switching to public transport use (Satiennam et al., 2016).

A study in Malaysia indicated that mitigating travel time/walking distance to public transport stations with subsidised fares is likely to encourage public transport use (Abdullah et al., 2007). Depending on the nature of travelling passengers and their circumstances, that is, demographic and socio-economic characteristics and trip purpose, the relative importance of each factor varies (Khaki, Afandizadeh, & Moayedfar, 2009). In some Southeast Asian countries (Cambodia, Malaysia, Thailand, and Vietnam), motorcyclists are highly restricted from using their specific travel mode because of poor public transport service. Moreover, status considerations are particularly important for high-income families in these countries (Emberger, Pfaffenbichler, Jaensirisak, & Timms, 2008). Therefore, most private vehicle users still prefer their own private vehicles (Satiennam et al., 2016). So, to change commuters' behaviour and overcome the existing constraints, an individual will need the motivation and the ability to change their behaviour in favour of public transport use (Stanton et al., 2012).



**Figure 3.** A DAG illustrating the hypothesised causal pathway toward public transport use. 🟦 Outcome, 🟡 ancestor of outcome, 🟢 exposure, 🟠 ancestor of exposure, 🟤 ancestor of exposure and outcome, 🟥 unobserved (latent), 🟩 causal path, 🟪 biasing path, 🟫 directed edge.



### 3.5. A DIRECTED ACYCLIC GRAPH (DAG) TO DESCRIBE THE CAUSAL STRUCTURE

In this section, a directed acyclic graph (DAG) is developed to clarify the cause-and-effect pathway in promoting the shift toward public transport use and support statistical modelling strategies (Fig. 3). A DAG is a special subset of graphical causal models representing statistical dependencies (edges) on a set of variables (nodes) with direct causal relationships (Pearl et al., 2016). In most cases, nodes can represent different types of variables, such as a measurable parameter, a latent variable, or a hypothesis, rather than just observable variables. Thus, the DAG in this section is hypothetically developed based on the results from Table 1, which show common intrinsic and extrinsic variables influencing public transport use, motorcycle use, and the modal shift to public transport. The results in this section will summarise the proximal and distal variables suggested to affect public transport mode use causally and the variables considered as proxies for causal factors or risk indications (non-causal) for public transport mode use.

Fig. 3 shows that there must be a public transport mode shift intention for actual public transport use in all circumstances. A cause- and-effect pathway is hypothesised to account for the total causal effect of public transport mode shift intention on public transport mode use. Factors highlighted in red represent the most crucial variables affecting motorcyclists in Southeast Asia

and their shift intention to public transport use. These variables are drawn from the empirical studies that had the context of Southeast Asia (Appendix B).

If the DAG is recognised as true, it implies that the total causal effect of public transport mode shift intention on public transport use can be unbiasedly estimated by adjusting the attitudes toward public transport mode shift intention (instrumental, symbolic/affective, and social orderliness attitude), personal norms (injunctive norms and descriptive norms), or perceived behaviour control. These factors are suggested to affect public transport mode shift intention exposure afterwards. Following public transport mode shift intention, public transport use is also determined by mode characteristics (travel time, travel cost, travel distance, etc.) and habit, which mutually influence motorcyclists' mode choice.

Furthermore, motorcyclists' attitudes and PBC toward public transport mode shift intention are determined by motorcyclists' demographic and socio-economic characteristics and the built environment. These extrinsic variables would negatively or positively change accordingly to the study context. For example, previous studies in Southeast Asian countries found that as motorcyclists' income increased, the instrumental and symbolic/affective attitudes toward public transport use decreased because this mode choice decreased their social status (Satiennam et al., 2016; Sheikh et al., 2006) and found that women have a stronger attitude toward public transport as this mode can facilitate their trip while ensuring their safety (Hidayati et al., 2020; Ng & Acker, 2018). In addition, public transport with good station accessibility would also encourage an increase in the attitudes toward public transport mode shift intention and the ability to use this mode choice in the near future (Ng & Acker, 2018).

It is important to acknowledge that the DAG provides a sufficiently minimal set of adjustments; for instance, the variables' minimum set needed to exclude bias. For further study in this field, these variables can be imported to a multivariate statistical model to minimise the bias when estimating the total causal effects of intention to public transport modal shift on public transport use.

Using causal diagram theory as an underlying framework for synthesising this evidence allowed the authors to infer potential cause-and-effect relationships between variables related to public transport mode use. The causal diagram theory principles can be applied to the DAG for presenting the research design as well as the strategies of statistical modelling in public transport mode use study. Moreover, this DAG can be used as a reference, and other researchers can propose more variables to the set of adjustments.

As this DAG has been built on the existing knowledge with reasonable cause-and-effect structures, it is expected to change as new evidence becomes available. This presents the reality of making cause-and-effect reasoning in a growing evidence base. In its current form, the DAG is a feasible working model for mode-choice behaviour learning. Future research can adopt the DAG to perform their modelling strategy and update it with their evidence and hypotheses. Furthermore, the DAG can also pave the way for future studies at a design stage by displaying the variables that are important to measure. A critical note is that cause-and-effect reasoning obtained from DAG is based on the supposition that the diagram is valid. The DAG is referred to the evidence interpretation by the authors so that different relationships can be implied with the same

evidence. In comparison with the conventional statistical modelling method, approaches using DAG can take advantage of the enhanced transparency about causal suppositions and highlight possible sources of bias that remain.

## **4. Discussion and comprehensive theoretical framework for modal shift from motorcycle to public transport use in Southeast Asia**

To change commuters' behaviour, an individual will need motivation as well as the ability to change. Therefore, the factors influencing travel mode choice and their evaluation models have to be considered comprehensively. However, most of the current evaluation criteria have the following major drawbacks.

First, most of the studies are conducted in developed countries which have better infrastructure networks and are dominated by car use. To investigate commuter mode choices, these studies have used several different behavioural frameworks such as discrete choice models (Eriksson et al., 2010; Satiennam et al., 2016), utility theory (Domencich & McFadden, 1975), normative decision-making (NDM) (Matthies et al., 2006), and the theory of planned behaviour (TPB) (Ajzen, 1991; Bamberg et al., 2003). These studies have identified several specific extrinsic motivations (travel time, travel cost, built environment, etc.) and psychological constructs (attitudes, personal norms, perceived behavioural control, etc.) related to travel mode choice.

However, the effects of psychological factors on travel behaviour are only considered in the NDM and TPB models, while the utility theory only investigates the impact of extrinsic values. Hence, the problem is that most of these frameworks draw boundaries between various levels such as utility function, social-ecological system, demographic and socio-economic, and psychology. Furthermore, these frameworks list characteristics like gender, age, ethnicity, attitude, travel cost, etc., but rarely mention the interactions between the psychological and the extrinsic variables.

Secondly, motorcycling is often ignored in transport planning. It is only studied generally from the safety perspective and is rarely considered on equal terms with respect to other travel modes (Burge et al., 2008). In Asian megacities in general and Southeast Asia in particular, the urban traffic situation worsens due to rapid economic growth, faster urbanisation, and higher density. As a result, there is a continuous increase in travel demands (Morichi, 2009). As these megacities do not have adequate road infrastructure and standard public transport services, they fail to meet the growing travel demands. Therefore, the ownership and usage of motorcycles have developed at a rapid pace, and they currently dominate the urban traffic in many Southeast Asian megacities. For example, in Hanoi and Jakarta, the rate of motorcycle ownership is 600-700 motorcycles per 1000 people (Vu, 2015).

Southeast Asian countries are dominated by motorcycles with less powerful engines. In 2019, the segment with engines under 125 cc had a 79.2 per cent market share in Indonesia, Thailand, and

Vietnam (Frost & Sullivan, 2020). Another reason for the high percentage of motorcycles in Southeast Asian countries is that land-use patterns for public facilities are scattered, and motorcycles fit well in this pattern due to their high flexibility (Vu, 2015). However, the domination of motorcycles has led to severe traffic accidents and reduced the use of public transport. Even with these persistent problems related to motorcycle use, the studies in this field are still deficient.

Finally, the changing process of commuters' behaviour toward pro-environmental travel modes, as it is considered complicated (Keller, Eisen, & Hanss, 2019), has received little focus from scholars or been investigated widely with typical behavioural change models, especially in the case of modal shift from motorcycle to public transport. Two main models focus on behavioural change: the transtheoretical model (TTM) (Prochaska & DiClemente, 2005) and the state model of self-regulated behavioural change (SSBC) (Bamberg, 2013). TTM is an integrative theory that examines an individual's willingness to act for new healthy behaviours and then proposes strategies or processes of change to guide personal behaviours (Prochaska & DiClemente, 2005). Drawing on the foundation of TTM, the SSBC behavioural change model introduces a specialised behavioural change model designed specifically for personal travel planning. This theoretical framework has garnered widespread application in numerous studies, offering invaluable insights into behavioural transformations within diverse contexts, ranging from health-related behaviours to fostering environmental sustainability and influencing transportation decisions (Ahmed, Adnan, Janssens, & Wets, 2020; Keller et al., 2019; Olsson et al., 2018; Weibel, Ohnmacht, Schaffner, & Kossmann, 2018).

Also noteworthy is the difference in public transport symbolism between the global south and the global north (Ashmore, Pojani, Thoreau, Christie, & Tylera, 2019). Cities located in the global south (cities in China or India) have a high power differential (PDI), while cities in the global north (the United Kingdom or Sweden) have a low PDI. Commuters with a high PDI are less likely to use public transport because they can be socially misclassified by bus riding.

The major drawbacks of the current evaluation criteria mentioned above can be summarised as follows:

- A model that can study both the extrinsic and intrinsic motivations that influence public transport and motorcycle mode choice is still missing.
- There are few studies that try to understand the factors that influence motorcycle use in Southeast Asian countries. Furthermore, in the case of European countries, they only consider motorcycles as a minor mode of travelling. The focus on motorcycle use in Southeast Asia is underlined by the significantly different living conditions and land-use patterns with a higher proportion of motorcycle riders (United Nations, 2019).
- There is a lack of studies on the modal shift from motorcycle to public transport (especially in Southeast Asian countries).
- The mode utility characteristics are mostly investigated separately from attitude and intention toward the modal shift. This implies a lack of research on the relationship between these factors.

- Very few studies on modal shift use behavioural change to study the changing process of commuters' behaviour toward proenvironmental travel mode, especially for the modal shift from motorcycle to public transport.

Due to the above gaps in this field, there is a need to propose a comprehensive theoretical framework for the modal shift from motorcycle to public transport use, especially in Southeast Asian countries such as Vietnam. Considering behavioural change, the stage model of self-regulated behavioural change (SSBC) can be used to investigate the modal shift to public transport. Bamberg (2013) proposed this stage model to explain behavioural change as a complex process with many different influencing factors. SSBC is a comprehensive framework that can reflect multiple decision-making stages as well as the factors influencing each of those single-stage transitions. The SSBC models behavioural change as a series of four stages: *pre-decision*, *pre-action*, *action*, and *post-action*. Each stage is distinguished by distinct tasks and intentions that indicate progression to the next stage.

The proposed theoretical framework based on SSBC is extracted from the above DAG (Fig. 3) and illustrated in Fig. 4. The four stages of this proposed SSBC can be explicated as follows: In the first stage, *pre-decision*, the current behaviour (using private travel mode, especially motorcycle) must be perceived as doubtful, and a state of self-awareness arises, leading to an intention of reducing this behaviour and finding an alternative behaviour (goal intention). Personal norms are assumed to influence this type of intention.

In the next stage, *pre-action*, an individual chooses an alternative behaviour (public transport use) to reduce the current behaviour. The intention to perform this newly chosen behaviour is referred to as behavioural intention and is influenced by variables from the Theory of Planned Behavior (TPB). These TPB variables include perceived behavioral control, injunctive and descriptive norms, and different types of attitudes, such as instrumental, symbolic/affective, and social orderliness attitudes.

In the context of Southeast Asia, perceived behavioural control is influenced by several factors, including the availability, accessibility, affordability, and convenience of public transportation (Zailani, Iranmanesh, Masron, & Chan, 2016). When individuals perceive public transportation as convenient, reliable, and accessible, they are more inclined to have higher perceived behavioural control and are more willing to transition from private travel modes to using public transportation (Zailani et al., 2016). Moreover, societal attitudes towards public transportation play a significant role in shaping injunctive norms, wherein if public transport usage is socially accepted or encouraged in the region, it positively impacts individuals' decisions to adopt this behaviour (Le & Trinh, 2016). Descriptive norms, which involve observing how prevalent public transportation usage is among others in the area, also contribute to the acceptance and adoption of public transport use (Le & Trinh, 2016). Different types of attitudes further influence the receptiveness to adopt public transport use, such as instrumental attitudes driven by the perception of practical benefits like cost savings and reduced traffic congestion (Van & Fujii, 2011). Symbolic/affective attitudes, on the other hand, arise from positive emotional associations with public transport use, such as feelings of comfort, relaxation, or enjoyment during travel (Van & Fujii, 2011). Additionally,



social orderliness attitudes are linked to individuals' perceptions of public transport, contributing to a cleaner environment and reducing traffic-related issues in Southeast Asia, thereby promoting positive attitudes towards this behaviour (Van & Fujii, 2011). These TPB variables are also influenced by various extrinsic factors, such as demographic and socio-economic, built environment, mode characteristics, among others, which collectively shape individuals' beliefs, attitudes, and intentions towards adopting public transport as their preferred travel mode.

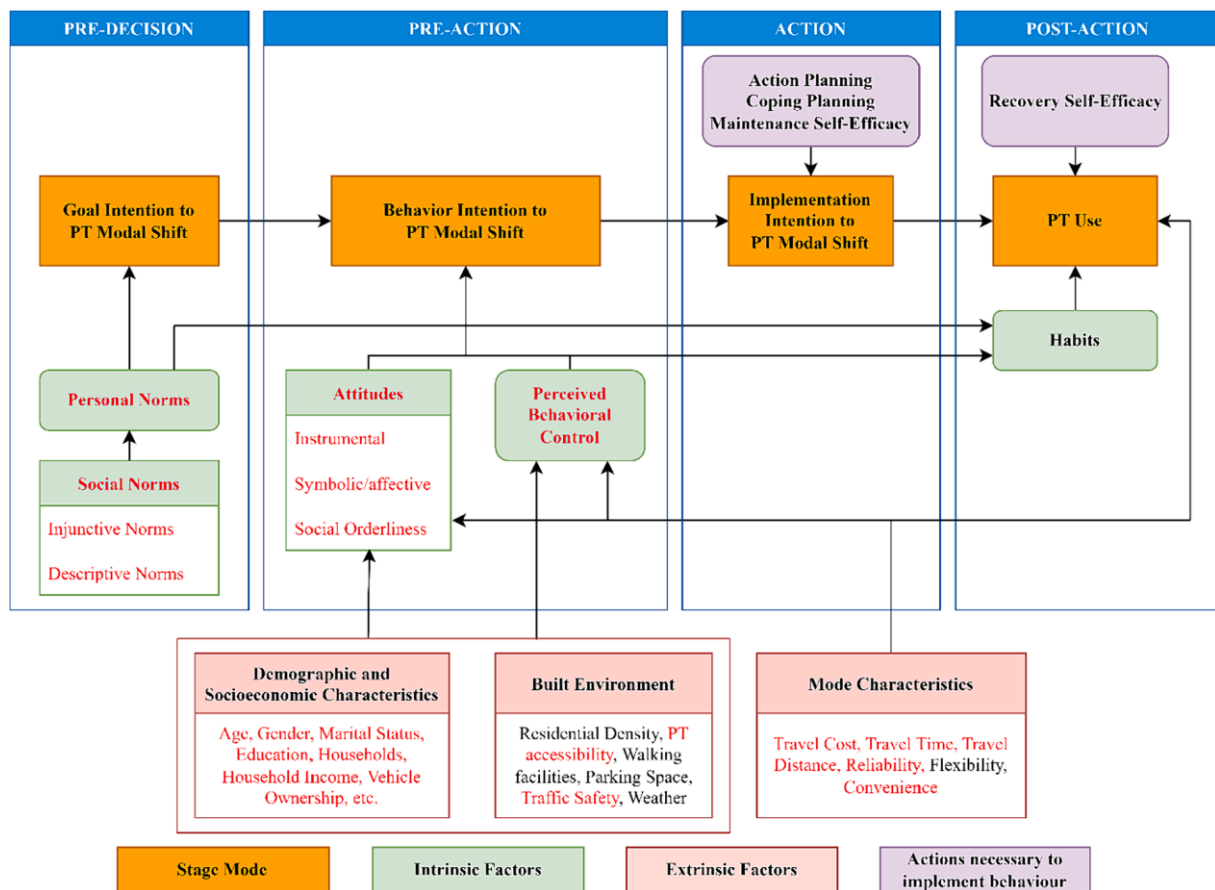
The new behaviour (public transport use) must then be implemented in everyday life during the *action* stage. This new behaviour is determined by the strength of an individual's implementation intention, which is influenced by planning abilities and self-efficacy maintenance. Action planning entails the development of a specific plan detailing how the individual will transition to their new behaviour (Bamberg, 2013). This encompasses setting goals, identifying steps, and creating a timeline. On the other hand, coping planning refers to the individual's ability to envision potential obstacles that may impede the performance of the intended behaviour (in this context, the shift to public transportation) and subsequently devising one or more plans to cope effectively with these challenges (Bamberg, 2013). Meanwhile, maintaining self-efficacy refers to the individual's belief in their capacity to successfully carry out the intended behaviour, even when facing obstacles (Bamberg, 2013). During the *action* stage, both action and coping planning help individuals anticipate and overcome potential obstacles, while self-efficacy enhances their confidence and determination to carry out the intended behaviour successfully. Together, these factors contribute to a more effective and successful self-regulated behavioural change process.

Finally, the new behaviour must be habitually maintained without permanent relapse (recovery self-efficacy) during the *post-action* stage. This stage heavily relies on the concept of recovery self-efficacy. Recovery self-efficacy is the belief an individual holds in their ability to rebound or recuperate in the face of setbacks or relapses after adopting the new behaviour (public transport use). This factor signifies the individual's confidence in their capacity to get back on track if they slip back into the old behaviour or encounter difficulties in sustaining the new behaviour. Recovery self-efficacy plays a significant role in both the post-action stage and the establishment of the new behaviour as a habit. It profoundly influences how individuals deal with setbacks, relapses, or challenges that might arise after implementing the new behaviour, significantly impacting their ability to maintain the desired behaviour change in the long term. As the new behaviour becomes habitual, it becomes more resistant to changes in motivation or external factors. Even in the face of temporary setbacks or challenges, individuals are more likely to revert to habitual behaviour. If the new behaviour has become a strong habit, individuals with high recovery self-efficacy are more likely to bounce back from setbacks and swiftly return to the habitual behaviour of using public transport, ensuring the sustainability of the behaviour change.

From the proposed SSBC, future studies can design and develop the stage intervention modules to experimentally test the causal relationship between the variables and intentions in each stage in promoting public transport use among motorcyclists of Southeast Asia. Noted that, Intrinsic and extrinsic variables highlighted in red are the most important factors that influence motorcyclists' intention to shift toward public transport use in the context of Southeast Asian countries.

As mentioned, the DAG and proposed SSBC in this study are hypothetically developed based on a systematic review (Table 1) that shows common intrinsic and extrinsic variables influencing public transport use, motorcycle use, and the modal shift to public transport. The main aim of this study is to propose a theoretical framework for a modal shift from motorcycle use to public transport use in the context of Southeast Asia. But the findings also reveal the overall common intrinsic and extrinsic variables that could influence the shift intention to public transport in the general context. Therefore, the findings of this study can also be used and applied by researchers, policymakers, and planners in Southeast Asia and other regions that want to develop a modal shift from motorcycle use to public transport use.

**Figure 4.** Proposed theoretical framework for public transport modal shift in Southeast Asian countries (adopted from the SSBC (Bamberg, 2013)).



## 5. Conclusions

This comprehensive study systematically reviewed the factors influencing public transport use, motorcycle use, and the modal shift to public transport, specifically focusing on Southeast Asia. Intrinsic and extrinsic variables that play a pivotal role in shaping motorcyclists' intentions to transition towards public transport have been identified. The findings of this investigation illuminate the complex interplay of sociocultural conditions and constructs unique to Southeast



Asian countries, underscoring the region's distinctive dynamics in the context of transportation choices. A theoretical framework, supported by DAGs and SSBC, has been provided to elucidate the causal pathways driving the modal shift from motorcycles to public transport. This framework offers a fresh perspective and paves the way for robust statistical modelling techniques.

Furthermore, it is essential to acknowledge the limitations of this study's framework and explore avenues for potential enhancements. While DAGs have been employed to illustrate established relationships derived from systematic review findings, the accuracy of DAGs relies on the precise specification of causal relationships. This can pose challenges in complex real-world scenarios and lead to residual confounding. However, despite these limitations, DAGs remain a valuable tool, offering profound insights into the interplay of variables and causal effects. Their systematic and transparent nature encourages application across diverse fields, facilitating the replication and extension of findings in various contexts. To further enrich the scope of research, several considerations are proposed. Firstly, broadening the review to include studies in languages other than English would enhance the comprehensiveness of the analysis. However, acknowledging the challenges in locating such articles, reputable international databases like SCOPUS and ScienceDirect often have limited coverage of non-English literature and scholarly documents beyond journal articles. Secondly, future studies can utilise the proposed theoretical framework to collect data from multiple Southeast Asian countries. This approach would not only enable the assessment of the generalizability of findings across the region but also uncover critical local factors influencing the shift from motorcycles to public transport. Moreover, it is important to acknowledge the temporal dynamics of modal choice in

Southeast Asian countries. Therefore, it is recommended that a longitudinal study design is adopted for future investigations. This approach would allow for tracking changes in modal choice over time, providing valuable insights into the evolution of transportation preferences within the region. Additionally, future studies should prioritise providing a comprehensive and explicit delineation of geographic constraints, especially when examining Southeast Asian countries. This emphasis is crucial due to the region's vulnerability to various external factors, such as economic fluctuations, political changes, and environmental events. Acknowledging these external influences is essential, as they can significantly impact the shift from motorcycles to public transport. By adopting this approach, researchers clarify the specific areas under investigation and contribute to a nuanced understanding of the generalizability of conclusions drawn in future studies, acknowledging potential variations across diverse regions. These suggestions aim to enhance the robustness and applicability of the framework while acknowledging its limitations and paving the way for further advancements in the field.

The research findings are important for policymakers and urban planners operating in Southeast Asia. These stakeholders can utilise the suggested framework to explore the potential correlations between intrinsic and extrinsic factors impacting the intentions of motorcyclists and their shift towards public transportation. Furthermore, the implications of the SSBC framework for statistical modelling are significant and broaden the scope of this study, contributing to a deeper understanding of motorcycling behaviour in Southeast Asia. The SSBC framework and the DAG

form the basis for a range of statistical modelling techniques, including path analysis, structural equation modelling (SEM), and Bayesian network models. These techniques enable researchers to conduct more comprehensive analyses, considering mediating and moderating effects and estimating the strength of relationships within the context of travel mode choice behaviour. By integrating the proposed framework with these statistical modelling approaches, future research can statically test the possible relationships within the proposed framework presented in this study. The outcomes of forthcoming empirical studies utilising the proposed framework promise to offer invaluable insights for policymakers and planners in formulating effective strategies to promote public transport use in Southeast Asia. In brief, this study not only broadens the understanding of motorcycling behaviour in Southeast Asia compared to prior research but also introduces an innovative framework that integrates the SSBC framework with DAG. Moreover, it contributes to the evolving discourse on transportation preferences in Southeast Asia, offering a nuanced understanding of the factors shaping modal choices. The hope is that this research will serve as a catalyst for further exploration in this field, ultimately leading to more sustainable and efficient transportation systems in the region.

#### **CRedit authorship contribution statement**

Son-Tung Nguyen: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Software, Visualization, Writing - original draft, Writing - review & editing. Mehdi Moeinaddini: Conceptualization, Formal analysis, Methodology, Software, Writing - original draft, Writing - review & editing. Ismail Saadi: Formal analysis, Methodology, Writing - original draft, Writing - review & editing. Mario Cools: Conceptualization, Formal analysis, Funding acquisition, Methodology, Project administration, Resources, Supervision, Writing - original draft, Writing - review & editing.

#### **Declaration of competing interest**

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

#### **Data availability**

No data was used for the research described in the article.

## Appendix A

Electronic Search Terms	
ScienceDirect	Scopus
“factors affecting” “public transport”	factor* affect* “public transport*”
“factors influencing” “public transport”	factor* influence* “public transport*”
“important factors” “public transport”	important* factor* “public transport*”
“factors contributing” “public transport”	factor* contribute* “public transport*”
“factors attributing” “public transport”	factor* attribute* “public transport*”
“factors causing” “public transport”	factor* cause* “public transport*”
“factors affecting” “motorcycle”	factor* affect* motorcycle*
“factors influencing” “motorcycle”	factor* influence* motorcycle*
“important factors” “motorcycle”	important* factor* motorcycle*
“factors contributing” “motorcycle”	factor* contribute* motorcycle*
“factors attributing” “motorcycle”	factor* attribute* motorcycle*
“factors causing” “motorcycle”	factor* cause* motorcycle*
“factors affecting” “motorbike”	factor* affect* motorbike*
“factors influencing” “motorbike”	factor* influence* motorbike*
“important factors” “motorbike”	important* factor* motorbike*
“factors contributing” “motorbike”	factor* contribute* motorbike*
“factors attributing” “motorbike”	factor* attribute* motorbike*
“factors causing” “motorbike”	factor* cause* motorbike*
“factors affecting” “motor bike”	factor* affect* “motor bike*”
“factors influencing” “motor bike”	factor* influence* “motor bik*”
“important factors” “motor bike”	important* factor* “motor bike*”
“factors contributing” “motor bike”	factor* contribute* “motor bike*”
“factors attributing” “motor bike”	factor* attribute* “motor bike*”
“factors causing” “motor bike”	factor* cause* “motor bike*”
“factors affecting” “modal shift”	factor* affect* “modal shift*”
“factors influencing” “modal shift”	factor* influence* “modal shift*”
“important factors” “modal shift”	important* factor* “modal shift*”
“factors contributing” “modal shift”	factor* contribute* “modal shift*”
“factors attributing” “modal shift”	factor* contribute* “modal shift*”
“factors causing” “modal shift”	factor* cause* “modal shift*”

## Appendix B

### The Summary of Studies' Objectives and Respondents

#### Mode characteristics

Sources	Study's respondents	Study's objectives
Andreassen, 1995	American public transport users	Increasing public transport use
Beirão & Sarsfield Cabral, 2007	Portuguese car users, public transport users	Reducing car use and increasing public transport use
Hensher, Stopher, and Phillip, 2003	Australian public transport users	Increasing public transport use
Hess et al., 2005	American student public transport users	Increasing public transport use
Javid, 2017	Pakistani car users, motorcyclists	Reducing car, motorcycle use and increasing public transport use
Kepaptsoglou et al., 2011	Greek motorcyclists	Finding factors affecting motorcycle ownership and use
Le & Trinh, 2016	Vietnamese motorcyclists	Reducing motorcycle use and increasing public transport use
Redman et al., 2013	Systematic review	Reducing car use and increasing public transport use
Rietveld, 2005	Systematic review	Supply-oriented measures vs demand-oriented measures in public transport
Satiennam et al., 2016	Thai car users and motorcyclists	Modal shift toward public transport
Sheikh et al., 2006	Malaysian motorcyclists	Reducing motorcycle use and increasing public transport use

#### Built-environment & Pro-environment

Chang & Wu, 2008	Taiwanese motorcyclists	Exploring motorcyclist dependence
Ewing & Cervero, 2010	Systematic review	Summarising empirical results on associations between the built environment and travel demand.
Kepaptsoglou et al., 2011	Greek motorcyclists	Finding factors affecting motorcycle ownership and use
Lucas et al., 2016	General British commuters	Reducing transport poverty
Satiennam et al., 2016	Thai car users and motorcyclists	Modal shift toward public transport
Zhang et al., 2012	General American commuters	Reducing vehicle miles travelled

#### Demographic and socio-economic characteristics

Abdullah et al., 2007	Malaysian car users and public transport users	Modal shift from car to public transport
Chang & Lai, 2015	Taiwanese Motorcyclists	Understanding factors affecting motorcycle use
Hsu et al., 2003	Secondary data about	Motorcycle traffic safety situation in Taiwan, Malaysia, and Vietnam
Kepaptsoglou et al., 2011	Greek motorcyclists	Finding factors affecting motorcycle ownership and use
Santos et al., 2013	Car users, motorcyclists, bicyclists, pedestrians and public transport users among 112 medium-sized cities in Europe	Exploring significant factors causing an increase or decrease in the share of certain travel mode
Satiennam et al., 2016	Thai car users and motorcyclists	Modal shift toward public transport
Sheikh et al., 2006	Malaysian motorcyclists	Reducing motorcycle use and increasing public transport use
Steg, 2005	Dutch car users	Understanding attitude factors affecting car use
Tran et al., 2014	General Vietnamese commuters	Reducing short-distance access by motorcycle to the mass transit system
Van et al., 2014	General commuters in Japan, Thailand, China, Vietnam, Indonesia, and the Philippines	Investigated the affecting of psychological factors in explaining several mode choices such as public transport, car, and other modes

Vu, 2015 Vietnamese Car users, motorcyclists, bicyclists, and public transport users Modal shift toward public transport

### Psychological characteristics

#### Attitude

Beirão & Sarsfield Cabral, 2007	Portuguese car users, public transport users	Reducing car use and increasing public transport use
Chen & Chao, 2011	Taiwanese Motorcyclists and car users	Modal shift toward public transport
Chen & Chen, 2011	Taiwanese Motorcyclists	Understanding characteristics of speeding behaviours
Johansson et al., 2006	Swedish commuters	Reducing car use and increasing public transport use
Kitamura et al., 1997	American car users, pedestrians, and public transport users	Examining the effects of attitudinal characteristics on travel behaviour
Le & Trinh, 2016	Vietnamese motorcyclists	Reducing motorcycle use and increasing public transport use
Murray et al., 2010	New Zealander car users	Understanding attitudes towards public transport use
Parkany et al., 2004	Western Massachusetts commuters	Exploring attitude toward travel mode
Steg, 2003	General Dutch commuters	Reducing car use and increasing public transport use
Steg, 2005	Dutch car users	Understanding attitude factors affecting car use
Steg & van Brussel, 2009	Young Dutch moped riders	Understanding attitude towards speeding
Van & Fujii, 2011	General commuters in Japan, Thailand, China, Vietnam, Indonesia, and the Philippines	Exploring attitudes toward car and public transport use
Van et al., 2014	General commuters in Japan, Thailand, China, Vietnam, Indonesia, and the Philippines	Investigated the affecting of psychological factors in explaining several mode choices such as public transport, car, and other modes
Wong, Chung, & Huan, 2010	Young Taiwanese motorcyclists	Understanding characteristics of risk-taking behaviours
Zailani et al., 2016	Malaysian car users and public transport users	Understanding intention for various travel purposes

#### Habits

Chang & Lai, 2015	Taiwanese Motorcyclists	Understanding factors affecting motorcycle use
Chen et al., 2004	Staff members working at the UC Davis	Is the activity rescheduling behaviour reasoned or habitual?
Johansson et al., 2006	Swedish commuters	Reducing car use and increasing public transport use
Vu, 2015	Vietnamese car users, motorcyclists, bicyclists, and public transport users	Modal shift toward public transport

#### Personal norms

Bamberg et al., 2007	German car users	Reducing car use and increasing public transport use
Eriksson, Garvill, & Nordlund, 2006	Swedish car users	Reducing private car use
Hoffmann, Abraham, White, Ball, & Skippon, 2017	Systematic review	Reducing car use and increasing public transport use
Olsson et al., 2018	Swedish car users	Reducing car use and increasing public transport use

### **Social norms**

Heath & Gifford, 2002	Canadian student bus user	Increasing public transport use
Le & Trinh, 2016	Vietnamese motorcyclists	Reducing motorcycle use and increasing public transport use
Olsson et al., 2018	Swedish car users	Reducing car use and increasing public transport use
Steg, 2005	Dutch car users	Understanding attitude factors affecting car use

### **Perceived behavioural control**

Bamberg et al., 2003	German students	Examining Theory of Planned Behaviour - TPB in choosing travel mode
Chen & Chao, 2011	Taiwanese Motorcyclists and car users	Modal shift toward public transport
Chen & Lai, 2011	Taiwanese car user, motorcyclist, public transport user.	Modal shift from motorcycle use toward public transport and car
Haustein & Hunecke, 2007	German car users	Reducing car use
Heath & Gifford, 2002	Canadian student bus user	Increasing public transport use
Zailani et al., 2016	Malaysian car users and public transport users	Understanding intention for various travel purposes

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