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Cycle or Not: Usage of Modified Theory of Planned Behaviour to understand the cycling decision among cyclists and non-cyclists

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ABSTRACT

Theory of Planned Behavior (TPB) and its modified versions have frequently been used to understand the determinants of planned behaviour. This research utilized the Modified Theory of Planned Behavior (MTPB) to understand the factors that affect the decision to cycle among cyclists and non-cyclists in Sri Lanka. Using an island-wide questionnaire survey, data related to intention to adopt cycling and four main constructs of TPB namely, individuals' attitudes, perceived behavioral control (PBC), subjective norm (SN) and perception of the environment (EP) were collected. Structural Equation Modelling (SEM) analysis was used to develop MTPB models. For both cyclists and non-cyclists, PBC showed a strong positive effect on the decision to cycle while EP also had an effect. SN did not have a significant influence on the cyclists' and non-cyclists' intentions to cycle. The safety of the cyclists was a key concern for all participants. The study emphasized that the ability to cycle and having a positive perception can lead to more cycling. The presence of proper cycling infrastructure itself may not promote cycling. Motivations through, family and social support may also be effective. A set of interventions focusing on the safety of the cyclist, cycling education, and infrastructure improvements that can inform policymakers and transport professionals are proposed based on the above outcomes.

KEYWORD: *Cycling, Environmental Perception, Micro Mobility Modified Theory of Planned Behaviour, Perceived behavioral control, Structural Equation Modelling (SEM)*

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1 INTRODUCTION

1.1 Research Background

The transport sector's progression towards net zero status requires the sector to maintain an annual emission level decrease of about 3% until 2030 (IEA 2022). The UN report on this has recommended efforts at the personal level as adopting active mobility practices, usage of public transportation or zero-emissions vehicles. For short trips, cycling provides a convenient form of micromobility while having zero emissions and zero operational costs. A global survey to identify the most preferred form of micromobility found that on average 40% of the respondents preferred cycling for daily commuting. Preference for smaller and more environmentally friendly modes for traveling to work has been increasing among workers (Heineke et al. 2021). A previous case study in Mexico indicated that usage of bicycles for utilitarian purpose has led to an approximate 3% reduction in greenhouse emissions (Bussière et al. 2010). This indicates the success of cycling adoption at the individual level. However, cycling has not been popular as a transport mode in Sri Lanka. In this context, it is important to identify the factors that encourage the intention to cycle. In a study to identify the barriers and enablers towards cycling, the authors studied the perceptions of cyclists and non-cyclists (Iwińska et al. 2018). By identifying the perceptional differences between cyclists and non-cyclists, this research intends to identify factors that can influence cycling. In order to account for the range of factors that may influence the decision to cycle, the study employs the widely used theory of planned behaviour.

1.2 LITERATURE REVIEW

1.2.1 Benefits of Cycling

Cycle, frequently known as the common man's vehicle is an environmentally friendly economical transport mode that may also bring a range of health benefits. Since it is faster than walking, cycling has the potential to replace vehicle usage for short to medium trips. It's an easily accessible mode for people with limited financial capabilities. It is considered to be a cheap and entry-level transport mode that is affordable and accessible with minimum training (Mogaji 2022). Other factors favoring cycling include travel time saving in congestion, limited parking requirements and ability to travel door to door without transfers has made cycling popular. The investments in cycle networks could lead to benefits estimated to be at least four to five times the costs (Karanikola et al. 2018).

The daily recommended physical activity levels can be achieved if cycling is used for utilitarian trips done a few days a week (Winters et al. 2017). Healthcare costs can be reduced due to serenity lifestyle benefits related to cycling and results in improved productivity (de Nazelle et al. 2011). In a study conducted in six European cities, the authors found that cycling led to a range of health benefits including avoiding deaths (Rojas-Rueda et al. 2016). Another study, tracked 263,450 people who traveled to work and lived in England, Scotland or Wales for five years to find the health benefits associated with different transport modes

(Murnane 2017). Findings indicated that the risk of cyclists dying from all causes was 41% lower than respondents who used public transport or drove. Their risk of dying from cardiovascular disease was 52% lower, and they had 46% lower levels of developing cardiovascular disease.

1.2.2 Barriers for Cycling

A study that was conducted to find out barriers for cycling in England has identified several barriers as need for physical effort, long distances, difficulties for trip chaining, shopping, bad weather, busyness, lack of time, inconvenience and lack of daylight and traffic (Strömberg & Karlsson 2016). Low investment in cycling infrastructure was found to be a barrier for cycling in England and leading to lack of growth in cyclists between 2001 and 2011 (Aldred et al. 2019). The lack of bicycle-only routes was found to be a barrier for cycling (Pucher & Buehler 2007). These highlight the importance of having a separate space for cyclists.

As a part of previous efforts to promote cycling in Sri Lanka, cycle lanes have been introduced. However, barriers for cycling in these lanes were identified as sweating, long travel distances, poor road conditions, lack of facilities and parking for cyclists, and social stigma (Bandara et al. 2016). Another study which focused on same cycle lanes found the existence of bends, the absence of significant buffer width to safeguard cyclists from trespassing vehicles, illegal parking, and overtaking using cycle lanes as factors discouraging cycling (Dahanayaka & Kankanamge 2018).

The barriers for cycling in Sri Lanka have been classified as physical barriers, personal barriers and environmental barriers (Ambuldeniya & Samarasekara 2021). Accordingly, physical barriers included lack of facilities for cyclists, poor road conditions, insufficient buffer width to safeguard cyclists from trespassing vehicles, the existence of bends, absence of safe parking, lack of connectivity in cycle lanes, and parking in the cycle lane. Personal barriers were lack of sufficient fitness, tiredness, the effort needed, difficulty in shopping and picking up children with bicycles, social stigma, poor driver discipline of different transport modes. As environmental barriers, they identified heavy congestion, bad weather and unpredictable precipitation events, and lack of daylight.

1.2.3 Potential of promoting cycling trips in Sri Lanka

Cycling, which has been a popular transportation mode in Sri Lanka, many years back, has recently declined rapidly due to motorization (Dahanayaka & Kankanamge 2018). Sri Lanka has recently been facing many economic challenges which have led to increased transport costs. People could be motivated to use low-cost modes (Samarasekara 2022). According to Sri Lanka Police, the usage of cycling in Sri Lanka has increased during the fuel crisis along with the fatal accident rate of cyclists. Accordingly, these cycle accidents have occurred due to lack of headlights and rear-end lights on bicycles, cyclists wearing dark-colored clothing at night,

non-compliance with road signs and not paying attention to oncoming vehicles while crossing the road (Adaderana 2022). While the economic factors could be motivating more people to cycle, the safety factors may be inhibiting cycling.

People are ready to use bicycles for short distances under improved road conditions. They may further be encouraged to cycle due to economic aspects, the absence of public transport at the doorstep and physical exercise (Salawavidana et al. 2014).

The acceptable distance for cycling for residents of Preveza, Greece was found as 5.08 km (Karanikola et al. 2018). The average length of trips in Colombo Metropolitan area, was 10 km for home-based work trips, 5.7 km for home-based education trips, 5.8 km home-based other trips and 5.9 km for non-home-based trips (Madhuwanthi et al. 2013). Since the home-based education trips, home-based other trips and non-home-based trips had trip length closer to the distance range of (Karanikola et al. 2018), at least part of these trips could be converted into cycle trips. However, inducing such modal shifts should be done properly through interventions identified based on proper research work. Identification of the factors that affect people's intention to cycle or not cycle could reveal information that could be useful in designing cycling interventions.

1.2.4 Typology of cyclists

According to Dill and McNeil (2013), classification of cyclists has been done in the USA for several purposes including identification of the presence of different types, as a requirement of design guidelines and to plan the interventions to cater different typologies. The authors utilized the cyclist classification to understand the characteristics of four types of cyclists in the Portland region. The types were the strong and the fearless; the enthused and confident; the interested but concerned; and no way, no how. The authors used characteristics identified to propose interventions to promote cycling. Another study distinguished cyclist into three types namely who rarely or never cycle; who always or sometimes used bicycles for their transportation need and those who frequently cycle considering its perosnal and societal benefits (Karanikola et al. 2018). Since there is no such classification applicable for Sri Lankan cyclists, profiling cyclists would be useful to plan interventions and designing cycling infrastructure.

1.2.5 Usage of Modified Theory of Planned Behaviour (MTPB) to promote cycling in Sri Lanka

Researchers have traditionally used different models to predict human behavior to account for the effect of series of factors. Ajzen (1985) proposed the Theory of Planned Behaviour (TPB) which explains how the intention for a certain behavior can be predicted based on a range of psychological factors (Ajzen 1985). According to this theory and its subsequent modifications, intention to engage in a certain behaviour is influenced by four factors, which are attitude (AT), Subjective Norm (SN), Perceived Behavioral Control (PBC), and Environmental perceptions (EP) (Ajzen 1991).

Modified Theory of Planned Behaviour (MTPB) can thus be used to understand the determinants of cycling in relation to afore mentioned AT, SN, PBC and EP.

Moving beyond individual factors, Acheampong attempted to understand how a set of such factors can influence the intention to cycle (Acheampong 2017). For this purpose, he used the Modified Theory of Planned Behaviour (MTPB) which explains how the perception of a range of determinants towards cycling is taken into account in deciding to cycle. A similar attempt was made in another study focusing on bicycle commuting (Heinen et al. 2010). When a person decides to cycle, his decision is based on how he perceives the four TPB constructs and the determinant parameters of each TPB construct. Thus, with proper statistical analysis techniques, TPB can be used to understand the cycling decision comprehensively.

As shown in Figure 1 studies suggest that the intention to cycle may be affected by different factors that could be represented through the aforementioned four constructs of MTPB, which are Attitude (AT), Subjective Norm (SN), Perceived Behavioral Control (PBC), and Environmental Perceptions (EP). Thus, this study aims to identify the determinants of cycling behaviour in Sri Lanka using above mentioned four MTPB constructs. How each of the four construct is specifically related to cycling behaviour in Sri Lanka is explained below.

Attitudes refer to the personal values held within people in relation to the outcome of the behaviour (Sutton et al. 2003). With respect to cycling, attitudes represent a positive or negative evaluation of the adopting cycling which is related to perceiving cycling as a healthy convenient, enjoyable, comfortable, fast and safe transportation mode, which provides exercise, while reducing environment pollution. Individuals' intention to adopt cycling is stronger when the attitude towards cycling behaviour is positive, and it would lead to stronger intentions towards cycling.

Society or significant people can influence the individuals' behaviour as denoted by SN. Society's belief of cycling as a poor transportation mode and less prestigious mode, social or family acceptance may influence the intention to cycle.

An individual's perception of the ease or difficulty of adopting cycling behavior is explained by PBC which includes the individual's ability to cycle and the availability of time and cost for cycling. Previous studies have focused on aspects such as little training required for ability, confidence about ability, fits with lifestyle under PBC.

Multiple natural and built environment attributes can affect cycling (Heinen et al. 2010; Titze et al. 2008). These factors include weather conditions, landscape differences, the presence or absence of infrastructure that support cycling and other environmental factors that affect cycling. Environmental perception refers to these factors that may affect cycling.

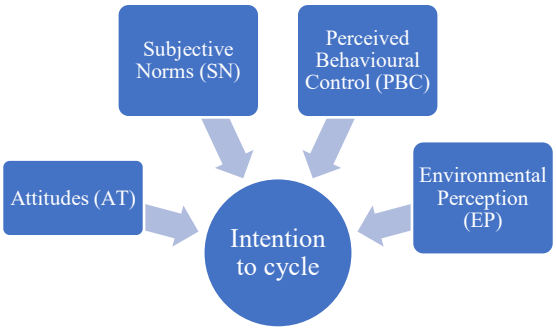

Figure 1. Effect of MTPB constructs on cycling behavior

1.3 Research Aim and Objectives

This research aims to investigate how the decision to cycle varies between cyclists and non-cyclists using MTPB. The first objective is to identify how the four underlying constructs and their constituent variables would influence the decision to cycle among the two groups. The second objective is to propose a set of interventions to promote cycling based on the findings of first objective.

2 MATERIALS AND METHODS

This research was carried out by following a method similar to research which analyzed the intention to cycle in Ghana using MTPB (Acheampong 2017). The indicator variables to represent the four constructs of MTPB were initially identified through a literature review. This set was then reinforced with further variables identified through an exploratory qualitative study, ensuring a comprehensive representation of the psychological factors affecting the Sri Lankan cyclists' behaviour. Data for 'cycling intention' which was the dependent variable was collected using three indicator statements (intend to cycle, willing to make changes to daily routine to incorporate cycling and motivated to try cycling). Data from indicator variables for each of the four MTPB constructs were collected using a MTPB-based questionnaire. For each of the variables participants rated their level of agreement using a 5 - point Likert scale varying from 'Strongly Disagree (1)' to 'Strongly Agree (5)'. Questionnaire surveys were distributed in public spaces in 9 districts (one district for each province) that were selected to represent whole Sri Lanka. The participants in these public spaces were selected randomly and invited to participate in the survey. The survey gathered and analyzed data from 516 cyclists and 349 non-cyclists separately. Those who have cycled at least once in the last 6 months were considered cyclists. If such a participant requested, an online questionnaire was shared instead of a hard copy.

3 RESULTS AND DISCUSSION

The sociodemographic characteristics of the sample, purpose and average distance for the purposes are given in Table 1. Table 2 details the average ratings for individual variables and the results of independent sample t-tests for the differences in mean values of the variable between cyclists and non-cyclists.

3.1 Specification of SEM

The intention to cycle was modeled using the variables representing the MTPB constructs. Two separate models were developed for cyclists and non-cyclists. Due to the complexity of the behavioral decision of cycling, Structural Equation Modelling (SEM) was used to model

the decision to cycle instead of regression-based models. SEM can model and test complex phenomena, to understand the validity and reliability of the observed model parameter estimates (Schumacker & Lomax 2022). For this purpose, Confirmatory Factor Analysis (CFA) was conducted first to specify the measurement model after which the structural model was specified. The specified model was interpreted based on goodness-of-fit indices of SEM analysis to clarify the hypothesized relationships among the four MTPB constructs, and variable fit the data.

Table 1. Demographic and other data of participants

		Cyclists	**Non-Cyclists**
	Number	516	349
Gender (%)	Male	79	47
	Female	21	53
Average Age		32	35
Highest Educational Level (%)	Below O/L	17	11
	GCE O/L	22	17
	GCE A/L	25	21
	Diplomate	7	12
	Undergraduate	19	18
	Graduate	9	17
	Post Graduate Qualifications	0	3
Average household monthly income level (%)	Below 50,000	59	49
	50,000 - 100,000	29	33
	100,000 - 250,000	9	12
	250,000 - 500,000	1	4
	Above 500,000		1
Purpose of cycling (%)	Recreation/ Exercise	45	
	Getting to and from school/ university	28	
	Getting to and from work	24	
	Getting to and from shopping	65	
	Getting to or from the public transport stop	20	
	Other	6	
Average Distance per trip in one direction (km)	Work/ Trade trip	7.0	
	School/ University trip	3.7	
	Recreational trip	3.8	
	Shopping trip	2.3	
	Trip to get in to/after leaving public transport	2.5	
	Running for errands	5.1	

Table 2. Mean values of variables and results for the significant differences of mean between cyclists and non-cyclists

		Mean		Comparison of means
	Indicator variable	Cyclist (Number of participants = 516)	Non-Cyclists (Number of participants = 349)	Significance level (2- tailed)
A1	Cycling is a healthy way to travel	4.58	4.43	0
A2	Cycling is a good way to get exercise	4.52	4.48	0.42
A3	Cycling is an enjoyable activity	4.19	4.01	0.01
A4	Cycling is a convenient transportation mode	3.69	3.36	0
A5	Cycling is a comfortable transportation mode	3.44	3.06	0
A6	I can travel fast by using cycling as my travel mode	3.31	2.65	0
A7	Cycling is a safe activity with lower risk of accidents	3.72	3.21	0
A8	Cycling does not contribute to environmental pollution	4.51	4.46	0.29
SN1	My family members encourage me to cycling	3.48	2.93	0
SN2	My colleagues/ friends are cycling	3.59	2.94	0
SN3	Other people will think I am poor if I cycle	2.48	2.52	0.72
SN4	Using a cycle for transportation is prestigious in my community	3.02	2.92	0.21
PBC1	Little training is required to control a bicycle	3.9	3.83	0.29
PBC2	I feel confident in my cycling abilities	4.3	3.57	0
PBC3	Cycling fits well with my lifestyle	4.02	3.13	0
PBC4	I have enough time to travel by bicycle	3.66	2.67	0
PBC5	I have initial investment to get a bicycle	3.19	3.2	0.91
PBC6	My transportation cost is low if I travel by bicycle	4.27	3.81	0
EP1	There is no dedicated space for cyclists in the road	3.78	3.74	0.61
EP2	There is no connectivity for the cycles to continuously travel along selected roads	3.75	3.7	0.44
EP3	There are no safe and secure facilities to store my bicycle in my destination/ office	3.63	3.55	0.35
EP4	There are road intersection facilities which provide safe for cyclists	3	2.69	0
EP5	There are streetlights at night in my area	3.1	2.99	0.2
EP6	There is heavy traffic on routes I bike	3.49	3.31	0.01
EP7	There are fast-moving motorized vehicles on the road	3.87	3.73	0.02
EP8	There is shading against sunshine and bad weather when cycling	3.45	3.22	0

3.1.1 Specification of Measurement Model: Confirmatory Factor Analysis

Figures 2 and 3 show the path diagrams resulting from the SEM which also illustrates the confirmatory factor analysis (CFA) estimates. As per the model identification indices, the CFA model was identified and the hypothesized direction of effects among the variables was supported by the data. Since the data was normally distributed the Maximum likelihood estimation method was used over other estimation methods to estimate the parameters of identified CFA. The contribution of each observed variable to the respective MTPB construct evaluated using the squared multiple correlation (SMC) estimates of the confirmatory factor analysis (CFA) which have been scaled between 0 and 1. A value is closer to 1 indicates a good measure of the underlying latent variable. These SMC results are shown on the top left of the rectangles containing indicator variable in Figures 2 and 3. Statistically significant ($p<0.01$) squared multiple correlation (SMC) values were observed for all measurement model indicators other than EP4 and EP5 for cyclists and A8 for non-cyclists.

3.1.2 Specification of the Structural Model

The Structural model was developed to describe the effect of the MTPB constructs on cycling intention as detailed in Figures 2 and 3.

The parameters that were estimated using maximum likelihood (ML) method shown using path co-efficient on arrows depict the influence of MTPB constructs on intention to cycle are indicated in path diagrams and Table 3.

3.2 Profiling cyclists and non-cyclists

The demographic variables depicted certain trends for cyclists. Accordingly, 79% male cyclists represented lesser number of females cycle. Further, 47% males in non-cyclist group closely resembled of general gender composition of Sri Lanka. The income and education profiles of participants reveal that in comparison to cyclists, non-cyclists were more educated and had higher income although the differences were not very high. The main trip purposes of cyclist was shopping and recreational / exercise. Only a few people used cycling for traveling to work/education or to access public transport. People prefer to cycle for recreational purposes more than transport purposes (Iwińska et al. 2018). The average one-way cycling length for work/trade trips was 7.0 km. The average length of trips in Colombo Metropolitan area, for trips except for home-based work trips, ranged between 5.7 km to 5.9 km (Madhuwanthi et al. 2013) which was closer to the 5.08 km acceptable cycling distance found for Preveza, Greece (Karanikola et al., 2018). This study indicates that Sri Lankan cyclists are not cycling long enough to substitute the average trip lengths of Colombo Metropolitan region. This calls for more efforts to encourage cyclists to cycle longer lengths.

Table 2 details the similarities and differences of the two groups related to indicator variables. Both groups agreed that cycling is a non-polluting good way to exercise. For the other indicator variables for representing AT, cyclists

believed that cycling was safe, fast, healthy, enjoyable, convenient, comfortable and convenient strongly in comparison to the non-cyclists.

Results indicate that non-cyclists' have concerns related to the safety of cycling. In a study done in Turkey safety and security was found to be main barriers leading to dissatisfaction (Cebeci et al. 2022). Cyclists' judgements of quality of service is determined by perception parameters like safety (Barrero & Rodriguez-Valencia 2022). Expansion of cycling infrastructure in Boston has led to increase of cycle safety as well as cycling usage (Pedroso et al. 2016). Fear of injury as the strongest deterrent against cycling (Iwińska et al. 2018).

By referring to several previous research work and concepts of design guidelines, Dahanayaka and Kankanamge emphasized that the safety of non-motorized users including bicyclists is a responsibility of other vehicle users (Dahanayaka and Kankanamge, 2018). Further authors highlighted the importance of mutual responsibility and discipline of vehicle riders towards cyclists. In order to address the safety concerns of non-cyclists, education programs intended to increase the awareness of cyclists' safety could be conducted to drivers of other vehicles.

Cyclists had more friends and colleagues who cycle, and their family members encouraged them to cycle. They were more confident about cycling and had more time to cycle. They strongly believed cycling as a lower transport. Cyclists in Warsaw, Poland also had supportive friends and family members in comparison to non-cyclists (Iwińska et al. 2018). A study which investigated cycling in Lagos has also highlighted that family members would discourage cycling for safety reasons (Mogaji 2022).

Table 3. Maximum likelihood parameter estimates

	Cyclists		**Non-Cyclists**	
	S	p-value	S	p-value
SN	0.04	0.46	0.03	0.72
AT	0.30	0	0.11	0.10
PBC	0.11	0.03	0.20	0.00
EP	0.29	0.01	0.46	0.00

S- Standardized regression coefficient

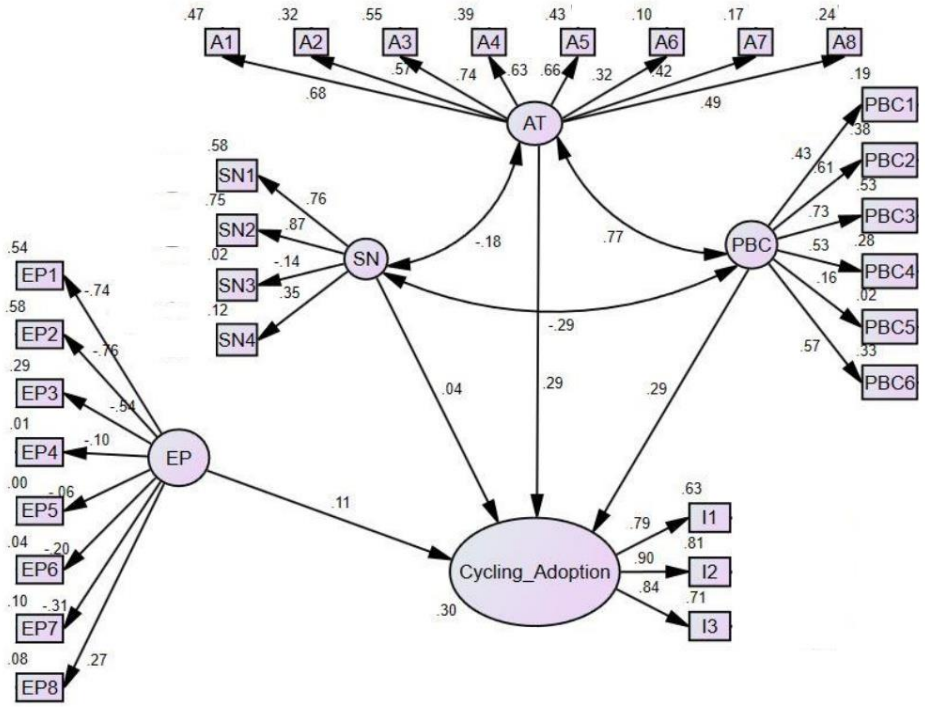

Figure 2. Cyclists Path diagram of the identified SEM showing the effect of latent constructs and observed variables AT, PBC, SN and EP on intention to adopt cycling. Model Identification Indices ($\chi 2 = 1362.35$, df = 362, $p < 0.01$; RMSEA = 0.073; Non-normed fit index (NFI) = 0.74; Comparative fit index (CFI) = 0.80)

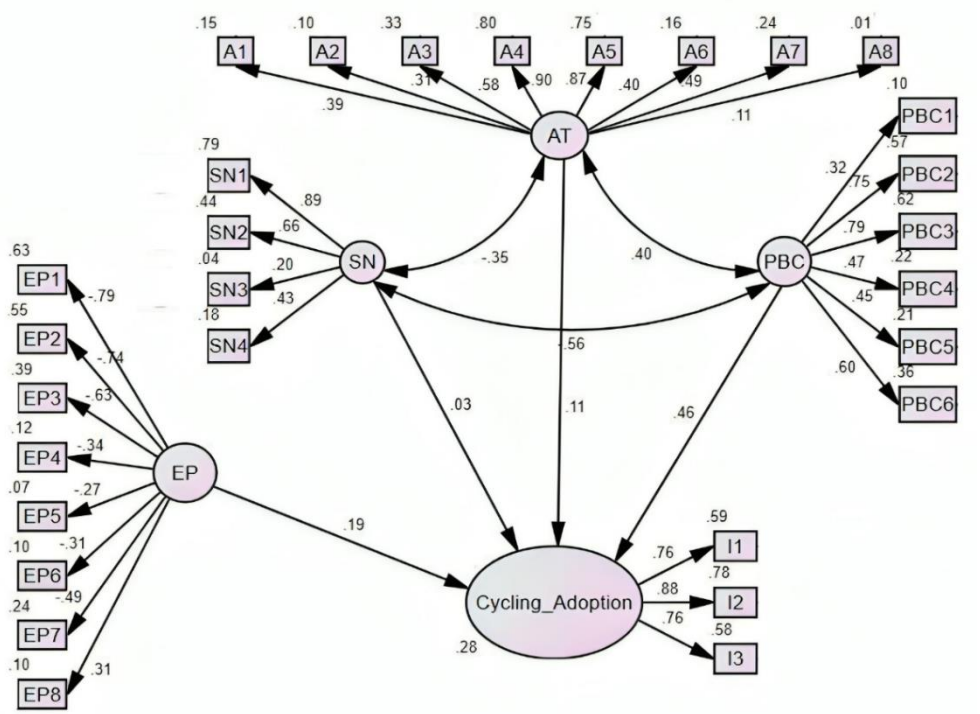

Figure 3. Non-cyclists Path diagram of the identified SEM showing the effect of latent constructs and observed variables AT, PBC, SN and EP on intention to adopt cycling. Model Identification Indices ($\chi 2 = 1367.32$, df = 364, $p < 0.01$; RMSEA = 0.089; Non-normed fit index (NFI) = 0.66; Comparative fit index (CFI) = 0.72)

The mean values of all indicator variables for EP were less than 4 for both groups indicating that both cyclists and non-cyclists were generally critical and not very satisfied about the cycling environment in Sri Lanka. Iwińska et al. (2018) also reported that lack of space to cycle and facilities at destination as barriers for cycling (Iwińska et al. 2018). Cycling can be encouraged through the presence of infrastructure since it increases visibility, enhances convenience, improves safety, and reduces conflict points with automobiles (Dahanayaka & Kankanamge 2018). The importance of proper cycling infrastructure has been emphasized in many studies (Cebeci et al. 2022; Daley et al. 2007; Marqués et al. 2015; Mogaji 2022; Panter et al. 2016). A mean value of 2.69 held by non-cyclists for their perception of cycling safety at intersections indicates possible crossing concern to the non-cyclists at intersections. Several previous studies have highlighted the need to have the intersections designed to cater to the needs of cyclists (Samarasekara 2022; Salawavidana et al. 2009).

Both cyclists and non-cyclists did not agree for two statements namely "cycling is for poor" and "cycling for transportation is prestigious". These results show a deviation from the previous studies where the social stigma of perceiving a poor man's transport mode was identified as a barrier to promote cycling (Salawavidana et al. 2014). This may be a reflection of the recent trend of cycling being famous as a form of micromobility.

According to the above outcomes, cyclists could be perceived as a group who were confident about cycling and had positive attitudes towards cycling, and they did not concern highly about safety. Further, their family / colleagues were supportive about cycling. Also, they had time to cycle and were privileged to have a lifestyle that supports cycling. These closely resembled the category of "the enthused and confident' category of Roger Gellers classification which has been presented in previous research work (Dill & McNeil 2013). The non-cyclists on the other hand were concerned about overall safety and safety at intersections. Also, they were not happy about the condition of cycling environment especially in terms of space to cycle. These closely reflect the category of "the interested but concerned" as per Roger Geller's classification.

3.3 Decision to cycle or not

In this research MTPB was used to understand how an individual's cycling decision identified in terms of intention to cycle could be predicted based on four psychological constructs. Data related to cycling intention was analyzed using SEM and the resultant path diagrams showed how the decision to cycle could be influenced by the four psychological constructs. The path diagrams also show how each of the psychological constructs could be predicted using a set of indicator variables. As discussed below, the two separate MTPB models developed are used to understand the underlying factors behind the cycling decisions of cyclists and non-cyclists. These outcomes

would be helpful to identify the potential interventions to encourage people to cycle. The path coefficients can further be used to identify the degree of effectiveness in such interventions.

Figure 2 shows the MTPB model for cyclists. Table 3 gives the Maximum likelihood estimates while identifying the psychological constructs that significantly affect the decision to cycle ($p<0.05$). Accordingly, regular cyclists' decision to cycle is affected by their AT, PBC and EP. As per the path coefficients shown in Figure 2, when the attitude is increased by 1, the intention to cycle would be increased by 0.29. The path coefficients of PBC and EP were 0.29 and 0.11 respectively. This indicates that efforts to increase AT and PBC are likely to lead to more cycling increases in comparison to EP.

Such increases to the psychological constructs should be instrumented through indicator variables. For AT, the path coefficients of indicator variables ranged between 0.32 to 0.74 all of which could be considered promising. As an example, the highest coefficient of 0.74 was for the indicator variable Cycling is an enjoyable activity. If this indicator variable was increased by 1, it could lead to an increase of 0.74 in the attitude. Cebeci et al., (2022) have found health, social, fun and challenge and environmental awareness were positive drivers for cycling. Positive attitudes about cycling have been identified as a motivator for cycling in several previous studies (Iwińska et al. 2018; Karanikola et al. 2018). Accordingly, interventions targeting to improve attitudes towards cycling can bring about positive results. Education campaigns, awareness sessions, information dissemination focusing on improving attitudes such as cycling has health benefits, identify cycling as a form of exercise, form of convenient and comfortable travel mode, a faster and safer mode, with lesser pollution could contribute to higher cycling rates.

Similarly, interventions based on the first two indicator variables of PBC could be instrumented by introducing cycling training programs to increase the capability and confidence of cyclists. Except for the last indicator variable, the path coefficients for the EP were negative and ranged between 0.06 to 0.76. The negative factor reflected an unsatisfactory environment for cyclists. Thus, improvements by making a dedicated space for cycling, improving the connectivity of cycling space, having safer parking spaces at the destination, introducing streetlights and controlling the speed of fast-moving vehicles and having shade in the cycling area could make a cycling environment more attractive to the cyclists.

According to the MTPB model for the non-cyclists given in Figure 3, the cycling decision of a person who does not cycle is affected only by the EP and PBC. The path coefficients for PBS and EP were 0.46 and 0.19 respectively. This shows that any efforts to increase cycling among these non-cyclists could be based on PBC and should focus more on improving their ability to cycle such as through training programs. Interventions by improving the cycling environment as mentioned above could

also become effective. Attitude, which was an influential factor for cyclists is not a significant factor for the non-cyclists. A previous study which focused on cycling in Lagos suggested that to improve cycling, the governments can teach people how to cycle (Mogaji 2022).

In a study to explore the adults' intention to adopt cycling to work, in Ghana found very similar outcomes where PBC was identified as the most influential psychological factor. Further perception of the environment was also found to have a significant influence on cycling adoption. However, the SN and AT did not have a significant influence (Acheampong 2017). Previous studies have also found the role of PBC on decision to cycle (Pucher & Buehler 2011).

For both groups, SN did not have such influence on cycling decisions. Although previous work (Bandara et al. 2016) has indicated social stigma to be a cause for less popularity of cycling, the present study did not support it. Negative effects of social factors have decreased over the years, and cycling is gradually becoming a socialization tool (Cebeci et al. 2022). Worldwide there is a renewed interest towards cycling as a preferred form of micro mobility. Observations in Colombo revealed the presence of many new cyclists such as professionals, and leisure riders on road (Samarasekara 2022). As given in Table 2, findings related SN3 and SN4 also confirm the same point. Therefore, it could be assumed that subjective norms, especially social pressure may no longer be a major influential factor for cycling.

3.4 Recommendations for interventions to promote cycling

Sri Lanka still needs multiple interventions to promote cycling. Findings in this study suggested that having proper cycling infrastructure itself may not promote cycling. Family support, social support and having positive attitudes may also be important to motivate people to cycle.

Based on the outcomes following interventions can be recommended to promote cycling in Sri Lanka.

3.4.1 Interventions for both cyclists and non-cyclists

• Introducing cycling training programs to increase the capability and confidence of cyclists. This kind of program may be introduced at earlier levels or take the form of paid programs.

• Improve the cycling infrastructure such as allocating dedicated space for cyclists, establishing connectivity of cycling spaces such as cycle lanes, introduce safer parking spaces at destination, install streetlights, ensure that cycling areas are shady and install traffic calming mechanisms to control the speed of fast-moving vehicles.

• Design intersections incorporating the needs of cyclists

• Introduce some programs and audits to improve cycling safety

• Conduct education programs to increase the awareness of cyclists' safety to drivers of other vehicles

3.4.2 Interventions for cyclists

• Conduct education campaigns, awareness sessions and distribute information highlighting positive aspects of cycling such as health benefits, as a form of exercise, form of convenient, comfortable, faster and less polluting travel mode.

3.4.3 Interventions for non-cyclists

• Introduce measures to improve the safety of cycling spaces including intersections and also make the non-cyclists aware of these.

This research profiled the qualities of cyclists and non-cyclists while eliciting details about factors affecting their decision to cycle. According to Madhuwanthi et al. (2013), the modal share of cyclists in Colombo Metropolitan area has been low at 1.5% in comparison to other personal modes. Thus, most of the Sri Lankan population may belong to non-cyclist category. Thus, in enacting the interventions priority should be given to interventions appropriate for non-cyclists.

4 CONCLUSION AND RECOMMENDATIONS

This study intended to explore the factors that affect cycling by studying the perceptions of cyclists and non-cyclists separately using the MTPB. Results revealed that cyclists were confident about cycling and had positive attitudes towards cycling, and their family/ colleagues were supportive about cycling. Cyclists' lifestyle was supportive for cycling and also had time to cycle. The non-cyclists had concerns about overall safety and safety at intersections. Both groups perceived that their environment did not support cycling. Non-cyclists were especially concerned about not having a space to cycle. The cyclists showed characteristics of the typology "enthused and confident" as per classification of Roger Gellers while the non-cyclists may be classified as "the interested but concerned" type.

The average cycling distance found in this study for most of the travel purposes was less than the average cycling distance found in other countries. Further it is lower than the average trip length of some of the key trips in the Colombo Metropolitan region indicating that possible challenges to convert such trips cycling.

The MTPB revealed that in deciding to cycle, the cyclists' attitude, perceived behavioral control and environmental perception while the non-cyclists' decision was influenced only by the latter two. While most of the previous studies highlighted the importance of introducing cycling infrastructure, this study identified importance of ability to cycle as well as having a positive perception about cycling. The study recommended a set of interventions that could be used to encourage people to cycle.

Using an island wide sample, the present study investigated the cycling decision in an aggregate manner. Future studies can study the presence of any regional specific trends using disaggregated analysis.

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