

## **A Psychological Investigation on Public-transport Users' Intention to Use Routes with Transfers**

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### **Abstract**

*One of the most common strategies used by authorities to promote ridership of public transport (PT) has been to provide travelers with an integrated multimodal transport system. Effective interconnections are a key element in the success of integrated transport systems. This study seeks to explore the cognitive factors which influence travelers' willingness to make transfers. The theory of planned behavior (TPB) was adopted to investigate the role of perceived behavioral control (PBC) in travelers' intentions to use PT routes with transfers. PBC was measured by being decomposed into its constituting elements: self-efficacy and perceived controllability. The effect of travelers' trip characteristics and socio-demographics on their PBC and intention was assessed. A survey was undertaken in two major transport centers in Auckland, New Zealand. Overall, the analysis demonstrated that the TPB is capable of explaining PT users' intention to use routes with transfers. Travel patterns related to gender, frequency of PT use and current use of transfer routes were seen to have an effect on intention. PT users need to feel capable (strong PBC) of making the transfers. Authorities need to focus on developing attractive transfer routes with comfortable transfers, from a user perspective, to encourage ridership of PT.*

**Keywords:** *public transport, transfers, travel behavior, theory of planned behavior*

### **1. Introduction**

With trip making behavior becoming more spatially and purpose-wise complex, transit operators and planners continue to face the challenge of providing travelers with an attractive public transport (PT) system as a viable alternative to cars [2]. The increase in trip chaining complexity has been identified as a barrier to the ridership of PT [3]. The perceived inconvenience caused by transfers has been shown to influence travelers' decision to use PT in terms of their path and destinations [4, 5]. Literature on transit connectivity has been predominantly focused on travel time and interchange time (waiting and walking time) to improve the ridership of transfer routes [6-9]. In comparison, there have been a limited number of research studies [10-12] which focused on the psychological aspect of travel behavior related to PT. To the authors' knowledge, none of the past studies have investigated

travelers' psychological factors in association with their willingness to use PT routes involving transfers.

The present study adopts the theory of planned behavior (TPB) to explore the relationship between travelers' perceived behavioral control (PBC) and their intention to use PT. TPB has been used as a common psychological model to predict travelers' actual use of PT [10, 11, 13, 14]. A user preference survey has been undertaken in Auckland, New Zealand. The data was analyzed using structural equation modeling (SEM). Findings of the study aim to support decision makers in developing new transfer routes and in improving the quality of existing transfer routes for enabling a more efficient and integrated PT network.

Hereafter, Section 2 outlines the literature review, Section 3 provides the study's methodology, Section 4 describes the data collection process, Section 5 outlines the results and interpretation, Section 6 is discussion and lastly, Section 7 provides the conclusion.

## **2. Literature Review**

### **2.1 Trip attributes related to transfers**

Transfer penalty is defined as the value which encompasses the negative perceptions travelers have about PT routes with transfers [7]. A number of trip attributes have been identified to be major contributors of transfer penalty. Intermodal transfers have been shown to be more onerous than intra-modal transfers [15]. For service quality, trip attributes such as personal safety, reliability of connection, journey time, transfer time and information related to transfers have been shown to be key indicators for travelers' perception of transfer routes [16-20]. Personal safety at stations has been revealed to be the most sensitive factor in travelers' decision to use PT [19, 21-23]. Travel time has been revealed to be another significant determinant of mode and route choice [24]. As such, missed connections and delays were shown to cause anxiety to the user [25]. Hadas and Ceder [26] discussed that missed transfers are a major contributor to the reliability issues of PT services. There is much support for transfer waiting time being valued higher than transfer walking time [6, 9]. Transfer walking time has shown to be more onerous than entry and exit walking time [27]. Other studies have shown that integrated information systems are required to reduce the perceived inconvenience of making transfers [20, 28, 29].

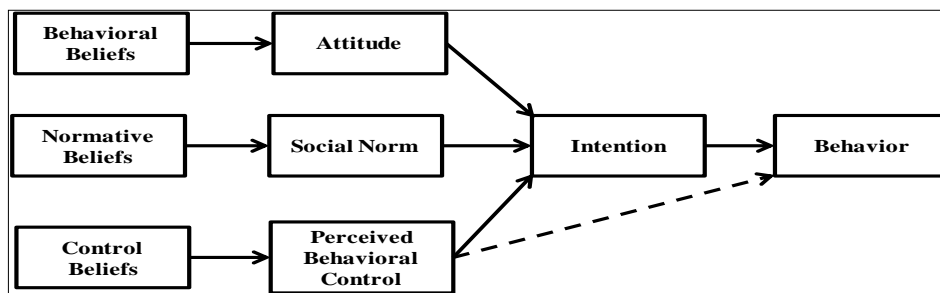
### **2.2 Theory of Planned Behavior**

The TPB is a psychological model which has been used in past travel behavior studies to understand the relationship between travelers' beliefs and their willingness to use PT [12, 30-33]. As shown in Figure 1, behavior is determined by intention and at times, PBC as well. The rationale for a direct link between PBC and behavior is that given a sufficient degree of actual control over the behavior, people are expected to carry out their intentions when requisite opportunities and resources (*e.g.*, time, money, skills) are available [1]. The strength of intention provides an indication of how hard people are willing to try, of how much effort they are willing to exert, in order to conduct the behavior [34]. In other words, intention captures the motivational factors which influence a behavior. According to the TPB, intention is viewed as the resultant of three antecedents: attitude, social norm and perceived behavioral control (PBC). These intention antecedents are based on behavioral beliefs, normative beliefs and control beliefs, respectively [35, 36]. Ajzen [35] claims that these beliefs are the foundation of behavior and changes in these beliefs should lead to change in behavior.

Individuals create beliefs about a behavior by associating it with certain attributes. These beliefs are termed "behavioral beliefs" and form the basis of attitude [37]. Attitude is defined

as the individual's positive or negative evaluation of performing the intended action [35]. For example, Iseki and Taylor [6] has shown that PT users' perceive transfers to be burdensome due to the extra effort required, *i.e.*, generally, there is a negative attitude towards making transfers. Normative beliefs are created from approval or disapproval of important reference group about performing a behavior. These beliefs form the basis of social norm. Social norm is defined as the individual's perception of social obligation to perform or not perform the intended action [35]. For example, Bamberg et al. [30] revealed that pro-environmental reasons, through social norm, have a greater effect on the intention to use PT if travelers are in a society that is aware of the negative environmental consequences caused by cars and supports PT use.

Control beliefs are created based on barriers which are perceived by the individual to undertake an action. When individuals perceive a higher level of control, the control factor is no longer important and the emphasis is placed on whether the individual has the intention to perform the behavior, thus strengthening the intention-behavior relationship. When control beliefs are weak, the individual is unlikely to have the intention to perform the behavior, thus weakening the intention-behavior relationship [35]. PBC refers to an individual's perception of ease or difficulty in performing the intended behavior [1]. For example, Bamberg and Schmidt [14] have shown that PBC is more positive when ease of using PT has been improved through better service quality.

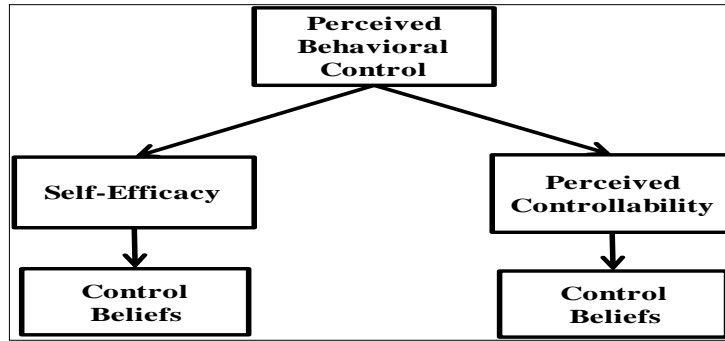


**Figure 1. Theory of Planned Behavior (TPB) (based on [1])**

As illustrated in Figure 2, according to Ajzen [1] PBC is the unitary higher-order of two components, self-efficacy and controllability. Self-efficacy is confidence in one's ability to perform the behavior. Controllability refers to one's control over performance or non-performance of the behavior. There exists sufficient clear and consistent evidence for the distinction between self-efficacy and controllability [1, 38, 39]. Findings by Armitage and Conner [34] have shown that the control beliefs used to measure self-efficacy and perceived controllability overlap. A certain level of correlation also exists between the two components [36]. Ajzen [1] discussed that past studies commonly used different control beliefs to measure self-efficacy and controllability.

### 2.3 Public-transport studies using the theory of planned behavior

A number of studies have included additional factors to the set contained in TPB to predict travelers' intention and actual use of PT. Of these additional factors, habit has been the most common.



**Figure 2. Perceived Behavioral Control (PBC) (based on [1])**

For example, a study by Verplanken *et al.*, [40] investigated habitual aspects versus reason-based aspects, as defined by TPB, to determine mode choice between car and PT. Results showed that the relationship between intention and behavior is mediated by the strength of habit. Intention was shown to be a significant predictor of behavior only when habit was weak or absent; when habit was strong or moderate the predictive power of intention became insignificant. Another study on mode choice by Chen *et al.*, [32] examined travelers' intention to switch from private vehicles to PT. The study used TPB in conjunction with another model, the technology acceptance model (TAM) and included habit as a construct in the combined model. All three constructs of TPB positively and significantly influenced intention. Habit was shown to be a weaker predictor when compared to social norm and attitude and had a significant negative effect on intention. This implied that habit of private vehicle users would, to some extent, hinder their intentions to switch to PT.

Bamberg *et al.*, [41] examined the effects of a fare intervention (discounted pre-paid bus ticket) on students' intention to use the bus. Frequency of prior behavior and habit were included with the constructs of TPB to predict PT use. Results showed that neither prior behavior nor habit had any significant effect on PT use after the intervention. The three antecedents in the TPB were found to have a significant positive effect on intention and accurately predict the reported behavior after intervention. The study concluded that in a stable context, mode choice is based on reason with intervention. Another study by Bamberg *et al.*, [42] investigated the effects of a PT intervention (combination of information and a free ticket) on car users' mode choice in a changed decision context (moving to a new residence). The study explored the frequency of past behavior and habit versus the set of variables in TPB to predict car users' intention to use PT. The results showed the three constructs of TPB accurately predicted intentions and PT use. Past car use was shown to have no significant effect on intention and actual PT use.

Other past studies have included additional factors such as moral norms, personal norms, descriptive norms and pro-environmental beliefs to predict PT travel behavior. For example, Health and Gifford [31] used the TPB to determine the effect of reduced fare, provided by the universal bus pass program (U-pass), on university students' bus ridership. An extension of TPB was used by including variables: descriptive norms, moral (personal) norms, environmental values, perceived responsibility and awareness of car-use. The study concluded that the original three constructs of TPB are capable of explaining the changes in behavior (increase in bus use) after the U-pass implementation. Inclusion of the other variables improved the predictive ability of the model. Similarly, Long *et al.*, [12] adopted an extended version of TPB to determine commuters intention to use the future sky train in Phnom Penh, Cambodia. The additional variables included moral obligation, awareness of

consequences, attitudinal aspect variables, socioeconomics and trip characteristics. Results showed that all three constructs of the TPB were statistically significant determinants of intention, with the model's predictive ability being improved by the additional variables.

To the authors' knowledge, no prior studies have investigated the psychological factors involved in travelers' intention to use PT routes with transfers. It is unknown to what extent the TPB can predict PT users' intention to use transfer routes. Thus, a research gap still exists in the potential of psychological methods to predict travelers' willingness to make transfers. This study contributes by adopting the TPB to examine the psychological factors associated with PT users' intention to make transfers. In order to capture the multi-directional correlations of the psychological factors along with the effects of PT users' socio-demographic and trip characteristics, the SEM technique has been used. The next section discusses the application of SEM.

### **3. Methodology**

#### **3.1 Reduced theory of planned behavior model**

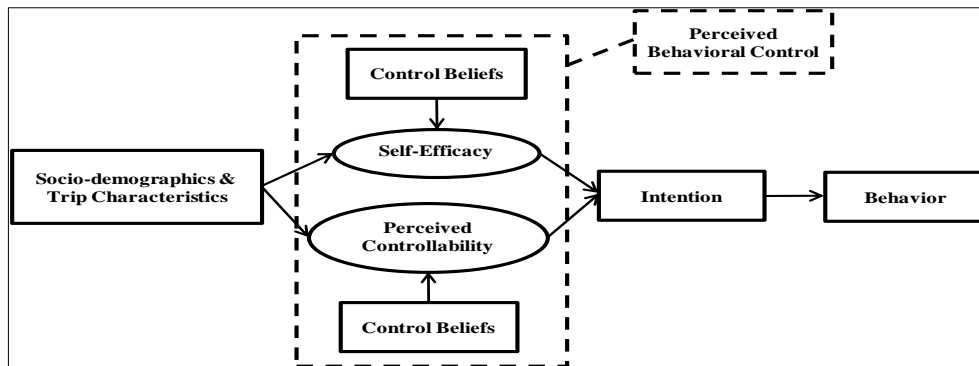
Prior studies [7, 27] have shown that generally PT users' have a negative attitude towards transfers due to the extra effort required in making the connection. Iseki and Taylor [6] explain that the negative attitude towards transfers is associated with PT users perception of outside-vehicle-times to be more onerous than in-vehicle times. Hence, exploration of the attitude-intention relationship was excluded from investigation. Other studies have established that social norm has a significant effect on travelers' intention to use PT [11, 30]. In this study, it was assumed that the social norm-intention relationship in users' decision to use PT remains the same for transfer routes. Exploration of the social norm-intention relationship was also excluded from investigation. Literature [6, 15, 43] has well established that travelers perceive PT transfer routes to be more onerous than PT direct routes, which is represented by the imposed transfer penalty on routes with transfers. Therefore it can be reasoned that the PBC-intention relationship in a traveler's decision to use transfer routes is not the same as the traveler's decision to use PT. The present study investigates PT users' PBC-intention relationship in their willingness to use transfer routes. A study by Terry and O'Leary [38] has confirmed that a SEM containing a two-factor structure of PBC, as separate latent variables, provide a better fit of the data.

The concept behind PBC is that the antecedent of intention represents perception of potential constraints which are both internal (*e.g.*, knowledge, skills, will-power) and external (*e.g.*, time, opportunity, money) [1, 36]. Studies [36, 38, 44] exploring the dimensional structure of PBC have suggested that the construct to be decomposed into: (a) self-efficacy, measured using items of "one's confidence in ability to perform the behavior" and (b) perceived controllability, measured by items of "perceived control over behavior", to improve the explanatory power of TPB. Kraft et al. [36] suggested that self-efficacy can be measured by two types of items: (a) in terms of perceived difficulty (PD); and (b) in terms of individuals' confidence in ability to perform the behavior (CON). Perceived controllability (PC) can be measured by items in terms of perceived control over performance of behavior. PC has been suggested to be predominantly dependent on external factors such as available resources and opportunities [34, 38]. Similarly, for the present study, control beliefs of perceived controllability were measured using operational trip attributes: reliability of connection, transfer walking time and transfer waiting time. Self-efficacy has been suggested to be predominantly dependent on internal factors such as ability, perceived inconvenience and willpower [34, 38]. For the present study, the control beliefs of self-efficacy were

measured using trip attributes which are commonly evaluated by user perception: personal safety at terminals [23] and need for information to make transfers [20].

### 3.2 Hypotheses

This section provides the theoretical rationale for the causal relationships in the conceptualized research model shown in Figure 3. Single-headed arrows illustrate the hypothetical direction of influence.



**Figure 3. Hypothetical model explaining the casual relationship among the latent and manifest variables**

A meta-analysis on social behavior studies has shown that self-efficacy is more closely associated with intention and behavior than perceived controllability [45]. Terry and O’Leary [38] study on exercise found that self-efficacy only predicted intention, while perceived controllability predicted behavior. Armitage and Conner [34] study on low-fat diet showed that both self-efficacy and PC have a significant and positive effect on intention and behavior. Ajzen [1] provided a summary of five studies which used a decomposed version of PBC. The results of the studies showed that the addition of self-efficacy always improved the prediction of intention and that PC was a significant predictor of intention only when combined with self-efficacy. Among more recent studies, Elliot and Thomson [46] examination of offending drivers’ speeding behavior has shown that self-efficacy to be a significant predictor of intention and behavior and the effects of perceived controllability to be insignificant. Okamura *et al.*, [47] investigated the influential factors of seatbelt use and confined the PBC construct to only self-efficacy. Results showed that self-efficacy has a positive significant effect on intention and behavior. According to these points of view, the following hypothesis is proposed.

**Hypothesis 1:** The stronger is PT users’ PC and self-efficacy, the greater will be their intention to use transfer routes.

Applying the TPB to travelers’ decision to use PT routes involving transfers leads to the following hypothesis:

**Hypothesis 2:** The stronger is PT users’ intention of use, the greater will be the probability of actually using a transfer route.

Travel behavior studies [10, 48-50] have shown that PT users' socio-demographics and trip characteristics have an effect on their travel behavior. Guo and Wilson [7] discussed that frequent riders tend to be more familiar with the PT network and services and therefore perceive transfers to be less onerous than infrequent riders. Findings of a study by Shiftan *et al.*, [51] validated the importance of including socio-demographics and trip characteristics in travel behavior studies. A study by Iseki and Smart [22] showed that socio-demographics and trip characteristics have an effect on PT users' perception of transfers. Van de Walle and Steenberghen [9] explained that the trip characteristics of a household is a factor in mode and route choice. The study stated that households have a tendency to optimize the total time taken to complete all activities by combining trips, for different motives, to chains. Accordingly, for the present study, it is hypothesized that PT users' socio-demographics and trip characteristics have an effect on their control beliefs. The following hypothesis is proposed:

**Hypothesis 3:** PT users' socio-demographics and trip characteristics have a direct effect on their self-efficacy and perceived controllability and an indirect effect on their intention.

### 3.3 Structural equation modeling

Since 1980s, SEM has been commonly used in travel behavior studies [51]. As the TPB contains a chain of mediating causal variables, SEM provides an appropriate statistical tool to determine the relationships among the variables [14]. Golob [52] provides a comprehensive review of the use of SEM in travel behavior studies. Among some recent studies, Yang *et al.* [50] investigated, by using SEM, the relationship among socio-demographics, activity participation and trip chaining for male and female household heads. Islam and Habib [53] used SEM to investigate the hierarchical relationship between trip chain and mode choice. Farag and Lyons [48] used SEM to examine factors affecting the use and non-use of pre-trip information on PT.

SEM analysis is composed of two parts: a measurement model and a structural model. The measurement model explains the effect of the indicators on their latent variables. The structural model determines the relationship between the latent variables [52]. Latent variables are unobserved variables that are not directly measured but are inferred by the relationships or correlations from the relevant manifest (observed) variables [54, 55]. There are two types of latent variables, reflective and formative [56]. Latent variables are formative when changes in the indicators determine changes in the variable. Latent variables are reflective when indicators are seen as functions of the variable, and changes in the variable determine changes in the observable indicators. Diamantopoulos and Siguaw [56] suggested that the choice should be made based on the nature of the construct and its relationship to the measures. For the present study, self-efficacy, PD, PC, PBC, and intention have all been defined to be reflective latent constructs. Socio-demographics, trip characteristics and behavior were defined as manifest variables. To determine goodness-of-fit of SEM, Marcoulides [55] recommends a number of indices be used. Sample size of at least 200 is required to make their use reliable [57].

### 3.4 Measurement items for SEM

Wordings for the measurement items were adapted from relevant prior studies [34, 36, 38] with changes to make them contextually suitable. PBC was represented by two items of CON and PD, and five items of PC. Section 3.2 discussed the trip attributes which were used to measure the control beliefs of self-efficacy and PC. All measurement items were presented in

the context: given travel time savings using routes with transfers, will improvement made to the trip attribute in question cause the PT user to feel more capable of using the connections, *i.e.*, will the relevant control beliefs become more positive. For CON1 and CON2, the term “more confident” was used to capture their sense of ability. For PD1 need for information, the terms “easy or difficult” was used to assess if PT users’ felt more capable of making transfers with better information on connection. Similarly for PD2 perception of security, the term “comfortable or uncomfortable” was used to capture their sense of reassurance for personal safety given good security provisions. Dzieken and Vermeulen [58] discussed that travelers are more willing to use PT given that their fears have been addressed. Intention was measured by two items and behavior was the only construct measured as a dichotomous variable [36]. The items for intention and behavior were presented under the assumption that the transfer routes have high quality information services, minimized transfer waiting and walking times, highly reliable connections and good security facilities.

Table 1 gives the measurement items for the constructs of the research model. All items except the item for behavior were measured using a Likert scale. Participants selected either “Yes/No” for the behavior item. The Likert scale represents one of the most adopted approaches for generating reliable scales of individual differences [59, 60] and has been commonly used in travel behavioral studies [11, 30, 31, 61]. A 5-point Likert scale (“1” for strongly disagree to “5” for strongly agree) was used in the present study.

## 4. Survey Design

### 4.1 Survey Location Background and Procedure

The aim of the user preference survey was to validate the conceptual model illustrated in Figure 3. Two key transport hubs, New Lynn Transport Center and Newmarket Train Station, were chosen from the Auckland PT network as the survey locations due to the high percentage of current PT users who make either an intermodal or intra-modal transfer at both stations. New Lynn Transport Center is the main interchange station in the west and offers high frequency connection to central Auckland. The center provides users with the opportunity to make transfers among the train and bus services. Newmarket Train Station is a key junction in Auckland city’s rail network. The station provides a link between the south, west and central Auckland. The station caters to the Southern and Western lines of the Auckland railway network [62]. Transfers occur between the train services. Site observations, during the morning peak time, revealed the possibility of intermodal (train/bus) transfers due to bus stops with high frequency services (on average every 10 minutes) located near the train station. The two hubs are linked; travelers from the south can transfer at Newmarket Train Station to reach west Auckland at New Lynn Transport Center and vice versa. The other reason for choosing the two interchange stations was due to their similarity in terms of architectural design and the station facilities offered to users.

The target samples of this study were existing and potential users of transfer routes. Target participants were limited to only commuters since this group represents the highest proportion of PT users. Participation was voluntary. After being briefly informed of the research purpose, commuters were invited to participate and complete the survey questionnaire on the spot. The survey was conducted during morning peak hours (7am-10am) in ten working days. The survey approach adopted for the present study is similar to the approach used in past studies on travel behavior [12, 32, 63].



**Table 1. Measurement statements and indicators for manifest variables**

Reference for variable	Variable	Variable Statements
	<b>Self-Efficacy</b>	
[20, 23]	Need for Information(CON1)	I will feel more confident to use transfer routes with high quality information services.
	Perception of Security (CON2)	I will feel more confident to use transfer routes with good security facilities at stations/stops.
	Need for Information (PD1)	With high quality information services, how easy or difficult will it be for you to use transfer routes?
	Perception of Security (PD2)	With good security facilities, how comfortable or uncomfortable will it be for you to use transfer routes?
	<b>Perceived Controllability</b>	
[9, 21, 25]	Reliability (PC1)	I will feel more 'in-control' (less anxious) about using transfer routes with highly reliable connections.
	Transfer Walking and Waiting Time (PC2)	Personally, I will feel more 'in-control' (less anxious) about making the transfer if:
	(PC3)	(i) next vehicle is scheduled to arrive in 5 minutes and walking to next vehicle takes 2-5 minutes.
	(PC4)	(ii) next vehicle is scheduled to arrive in 10 minutes and walking to next vehicle takes 2-5 minutes.
	(PC5)	(iii) next vehicle is scheduled to arrive in 10 minutes and walking to next vehicle takes 5-10 minutes. (iv) next vehicle is scheduled to arrive in 15 minutes and walking to next vehicle takes 5-10 minutes.
	<b>Intention</b>	
[30, 31, 64]	(Inten1)	(i) Given this opportunity, I am willing to use transfer routes for my daily trips ( <i>e.g.</i> , work, recreation).
	(Inten2)	(ii) I intend to use transfer routes to combine most of my daily trips ( <i>e.g.</i> , work, recreation).
	<b>Behavior</b>	
	(Decision)	I will choose to use transfer routes for most of my daily trips ( <i>e.g.</i> , work, recreation).

The questionnaire consisted of two sections, Section A and B. Section A contained socio-demographic and trip characteristic questions. Section B consisted of measurement items for PBC, intention and behavior. The questionnaire was designed to be completed within 10 minutes.

#### 4.2 Respondents

The number of questionnaires distributed was 300, of which results of 263 participants were usable for data analysis. Of the participants, 54% are female. About 41% of the participants are in the age group of 18 to 24 years old, 43% are in the age group from 24 to 44, 12% in the age group from 45 to 64 and only around 4% of participants are more than 64 years old. Approximately 31% of the participants' annual household income is less than NZD\$30,000, around 35% are between NZD\$30,001 – \$70,000, 20% are between NZD\$70,001 - \$100,000 and about 14% have an annual household income greater than NZD\$100,000. Around 65% of the participants have access to a car. As for their trip characteristics, about 80% of the participants are frequent riders, and around 46% currently use a transfer route. Approximately 78% of the participants make at least one trip in addition to their main trip. Of the 78%, about 26% of the participants use only car for the additional

trips, around 20% uses only PT, 38% uses both PT and car to make the additional trips and 16% uses other mode of transport.

## 5. Results

### 5.1 Factor Analysis

Prior to conducting a factor analysis, the data was assessed for suitability. For self-efficacy, the Bartlett's Test of Sphericity was significant (p-value: 0.00) and the Kaiser-Meyer-Olkin measure of sampling adequacy was 0.60. For PC, although the Bartlett's Test of Sphericity was significant (p-value: 0.00), the value for the Kaiser-Meyer-Olkin measure was 0.49 (below the recommended value of 0.6). Therefore factor analysis was undertaken only for self-efficacy and the five PC items were included in the model as five observed variables. A confirmatory factor analysis (CFA) was run in SPSS with Maximum likelihood extraction and direct oblimin rotation to check for discriminant validity among the factors. Results in Table 2 from the pattern and structure matrix show that there is discriminant validity among the latent variables.

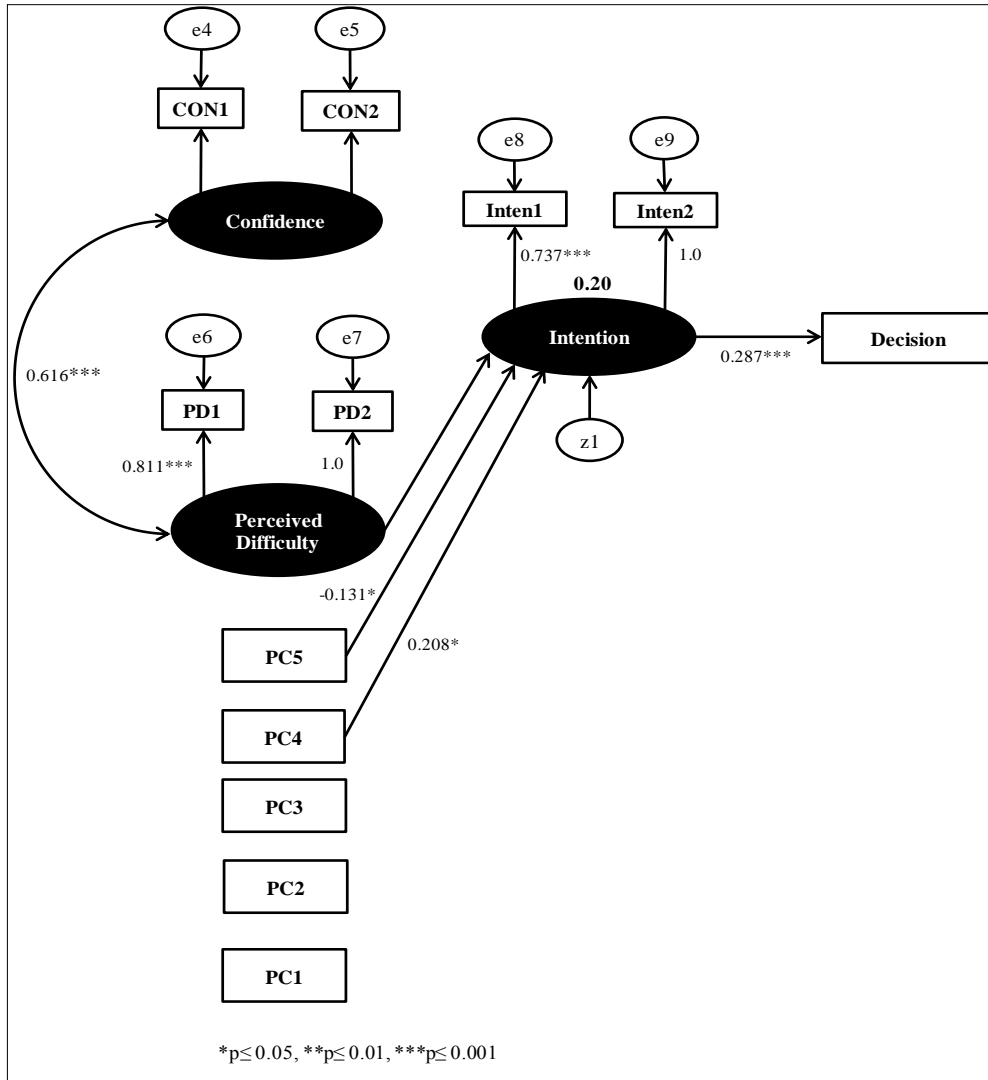
**Table 2. Pattern and Structure Matrix**

	Pattern Matrix			Structure Matrix		
	Factor 1	Factor 2	Factor 3	Factor 1	Factor 2	Factor 3
CON1	0.15	-0.01	<b>0.55</b>	0.36	0.21	<b>0.60</b>
CON2	-0.16	0.01	<b>1.04</b>	0.24	0.32	<b>0.98</b>
PD1	<b>1.03</b>	-0.02	-0.06	<b>1.0</b>	0.25	0.33
PD2	<b>0.39</b>	0.14	0.30	<b>0.54</b>	0.35	0.50
Inten1	0.04	<b>0.66</b>	0.04	0.24	<b>0.68</b>	0.28
Inten2	-0.07	<b>1.03</b>	-0.07	0.19	<b>0.99</b>	0.25

### 5.2 Structural equation models

The structural equation models were constructed using AMOS (version 19.0). The notations are given in Table 1. Due to the survey data not being multivariate normal, a Bollen-Stine bootstrapping method was used to compute the standard errors, bias-corrected confidence intervals, and p-values for the structural paths being tested [65]. In development of the final model, the model began with all possible structural paths. The non-significant paths, based on the bootstrapped p-value, were removed one-by-one in order of least significant path until all structural paths retained in the model were significant (p-value  $\leq$  0.05). The factor loading for CON2, PD2 and Inten2 was set to 1. Figure 4 illustrates the final basic model without trip characteristics and socio-demographic items. The regression coefficients are included in the figure.

Only the structural paths to intention from PD, PC4 and PC5 were statistically significant. The coefficient for PD and PC4 is positive indicating that, in general, participants who chose a higher Likert scale (with higher scales corresponding to more agreement with statements) for PC4 and the items of PD were more likely to select a higher Likert scale for the items of intention. The coefficient for PC5 is negative revealing that, in general, higher Likert scale selection for the variable corresponded to lower Likert scales being chosen for the intention items. Specifically, the results show that, holding all other variables in the model constant, a one unit increase in the PC5 measure is associated with a decrease of .13 units in the mean value of intention. The path between intention and decision is shown to be positive and significant.



**Figure 4. Final basic SEM**

To this final basic model, the socio-demographic and trip characteristic items were included as independent variables feeding into the five variables of PC and the two constructs of self-efficacy, CON and PD. Results showed that these observed variables had statistically insignificant effects on the latent variables. The socio-demographic and trip characteristic items were then assessed for any effect on intention directly. Only gender, frequency of PT use and current use of transfer routes had a significant ( $p\text{-value} \leq 0.05$ ) effect on the intention items. Incorporating the effects of gender, frequency and use of transfer routes increased the explained variance in intention from 20% to 27%. In both the basic final model and the model including trip characteristics and socio-demographic items, the structural path from CON to intention was statistically insignificant. However, CON and PD are significantly correlated (Pearson correlation = 0.616,  $p\text{-value} < 0.001$ ). This means that the latent variable PD could be replaced by CON and the results would be similar ( $R^2$  for intention = 0.26). The final model was developed by including self-efficacy as the higher-order construct for CON and

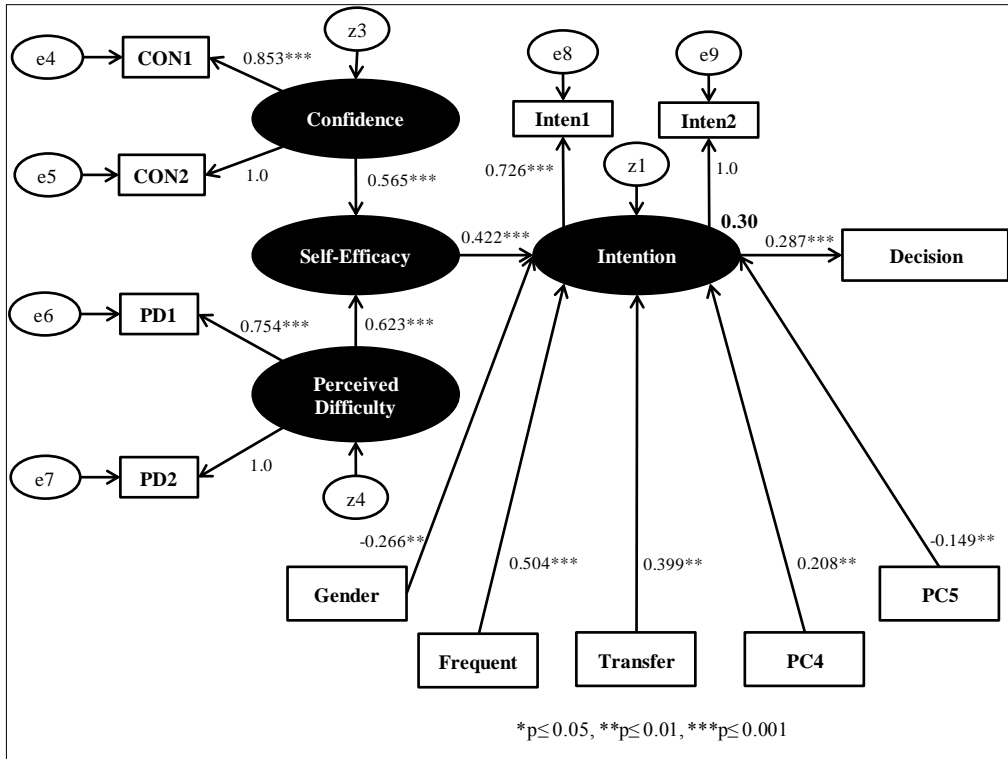
PD. The two statistically significant items for PC (PC4 and PC5) were included as single variables. From the socio-demographic and trip characteristic items, gender, frequency and transfer were included as single variables. Inclusion of self-efficacy as a higher order construct increased the explained variance in intention from 27% to 30%. Figure 5 illustrates the final model with the significant regression coefficients. The negative coefficient for the path from PC5 to intention indicates that, holding all other variables constant, one unit increase in the PC5 measure will decrease the mean value of intention by 0.15 units. Males were seen to have a lower mean intention value than females; the mean intention measure for males is 0.27 units lower than that for females. All other observed variables had a positive effect on intention. Of the trip characteristic variables, results indicate that frequency of PT use has a greater effect (0.50) on intention than use of current transfer routes (0.40). Results showed that CON2 has a greater factor loading than CON1 on the latent variable CON and PD2 has a greater factor loading than PD1 on the latent variable PD. PD was seen to have a slightly higher factor loading (0.62) on self-efficacy than CON (0.57) and self-efficacy has a higher factor loading (0.42) on intention than the two PC variables. The path from intention to decision is positive. In general, holding all other variables constant, one unit increase in the mean value of intention is associated with 0.30 units increase in the mean decision value.

Comparing the model fit indices, AIC and BIC, and the Bollen-Stine p-values have shown that the final SEM is a better fitting model than the basic final model with socio-demographic and trip characteristic variables. The AIC and BIC values of the final SEM are smaller. For the final SEM, the AIC and BIC values are 302.70 and 318.18, respectively. For the basic final model with socio-demographic and trip characteristic variables, the AIC and BIC values are 320.06 and 337.10, respectively. The Bollen-Stine bootstrap p-value for the final SEM is greater ( $p\text{-value} = 0.345 > p\text{-value} = 0.190$ ) suggesting no evidence of lack of fit. Other model fit indices have also indicated the final SEM to be a well-fitted model. The GFI value is 0.96, AGFI is 0.90, NFI is 0.91, CFI is 0.97 and the RMSEA is 0.04.

Table 3 gives the total effects which are significant ( $p\text{-value} \leq 0.05$ ). It should be noted that for the final SEM, the total effects is equal to the direct effects. All other variables, except for PC5, have a significant positive effect on decision via intention. For PC5, participants who chose a higher Likert scale were more likely to select “no” for the decision variable.

### 5.3 Ordinal logistic regression

To investigate the effects of trip characteristic and socio-demographic items on CON, PD and PC, separate ordinal logistic regressions were performed. For the variables, CON1, CON2, PD1, PD2, PC1 and PC3 it was found that there were very few participants in the strongly disagree category and so the strongly disagree category was combined with the disagree category to give a dependent variable with 4 categories. Results showed that the trip characteristics and socio-demographic items did not have any statistically significant effects on CON1, PD1, PC3 and PC4. Table 4 provides a summary of the variables which had a significant effect on the dependent variables CON2, PD2, PC1, PC2 and PC5.



**Figure 5. Final SEM with socio-demographics and trip characteristics**

For CON2, age, gender, access to a car and current use of transfer routes had a statistically significant effect on the variable. Increasing the value of age corresponded to an increasing probability of participants being in one of the higher Likert scales. Female participants were more likely to choose one of the higher CON2 Likert scales than males. Participants without access to a car or who currently do not use transfer routes were less likely to be in one of the higher Likert scales. For PD2, only gender and current use of transfer routes had a statistically significant effect on the variable. On average, holding all other variables in the model constant, females have a greater probability of being in one of the higher PD2 Likert scales than males. Participants who currently do not make a transfer were less likely to choose one of the higher PD2 Likert scales.

**Table 3. Significant Total Effects among variables**

	Self-Efficacy	Frequency	Gender	Transfer	PC4	PC5	Perceived difficulty	Confidence	Intention
Perceived difficulty	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Confidence	0.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Intention	0.42	0.50	NS	0.40	0.21	-0.15	0.00	0.00	0.00
Inten2	0.42	0.50	NS	0.40	0.21	-0.15	0.00	0.00	1.00
Inten1	0.31	0.37	NS	0.29	0.15	-0.11	0.00	0.00	0.73
PD2	0.62	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
PD1	0.47	0.00	0.00	0.00	0.00	0.00	0.75	0.00	0.00
CON2	0.57	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00

CON1	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.85	0.00
Decision	0.12	0.14	NS	0.11	0.06	-0.04	0.00	0.00	0.29

Note: not significant (NS) when p-value > 0.05

**Table 4. Statistically significant independent variables with regression coefficients**

	Age	Income	Gender	Use of transfer routes	Frequency of PT use	Access to car
CON2	0.02*	-	0.72**	-0.88***	-	-0.51*
PD2	-	-	0.49*	-0.67**	-	-
PC1	-	0.27*	-	-	-	-
PC2	0.37*	0.24*	-	0.52*	-	-
PC5	-	-0.33**	-	-	-0.84**	-

Note: \*p-value ≤ 0.05, \*\*p-value ≤ 0.01, \*\*\*p-value ≤ 0.001

For PC1, only income had a significant and positive effect on the variable. For PC2, age, income and current use of transfer routes had a statistically significant effect on the variable. Results showed that increased value of age and income corresponded with participants being more likely to choose one of the higher Likert scales. Participants who currently used transfer routes were also more likely to select one of the higher Likert scales. For PC5, income had an opposite effect; holding all other variables in the model constant, increased value of income corresponded to an increased likelihood of the participants being in one of the lower Likert scales. Frequency of PT use also had a significant effect on the variable. Participants who made less than 3 trips per week with PT were less likely to choose one of the higher Likert scales.

## 6. Discussion of Results

Taken together, results from the final model support the adoption of TPB to explain PT users' intention to use routes requiring transfers. In line with past findings, the two constructs of self-efficacy were seen to have discriminant validity and similarity (Pearson correlation = 0.62, p-value < 0.001). Similar to the findings by Ajzen [1] and other studies [34, 45], it is evident from the analysis that self-efficacy is more closely associated with intention and behavior than perceived controllability. Of the items measuring confidence in one's ability to perform the intended behavior and perceived difficulty, both items on security (CON2 and PD2) were seen to have a greater factor loading on their respective latent variables than the items on information (CON1 and PD1). This finding emphasized the importance of personal security for travelers at connection points. Only two observed variables of perceived controllability had a significant effect on intention, "next vehicle in 10 mins plus a 5-10 mins walk" (PC4) and "next vehicle in 15 mins plus a 5-10 mins walk" (PC5). The "next vehicle in 10 mins plus a 5-10 mins walk" (PC4) variable had a positive effect and while the other significant variable (PC5) had a negative effect, as can be seen in Figure 5. This finding is in accordance with the design of the measurement items. The "next vehicle in 15 mins plus a 5-10 mins walk" (P5) variable was designed to be the worst connection scenario of the four items related to transfer waiting and walking time. The unexpected findings from the analysis were the statistically insignificant paths from the variables reliability of connection (PC1), "next vehicle arrives in 5 mins plus a 2-5 mins walk" (PC2), and "next vehicle arrives in 10 mins plus a 2-5 mins walk" (PC3) to intention. The response frequency tables of the variables revealed that 81%, 65% and 64% of the participants "agreed" and "strongly agreed" to the statements for the variables, respectively. Closer look at the analysis showed that the

responses for the variable “next vehicle arrives in 10 mins plus a 2-5 mins walk” (PC3) did not correspond with the responses for the two intention measurement items; thus the path from PC3 to intention was statistically insignificant. As for the variables reliability of connection (PC1) and “next vehicle arrives in 5 mins plus a 2-5 mins walk” (PC2), the answer lies in the high correlation with self-efficacy. The statistically significant Pearson correlations are 0.70 and 0.35, respectively. The structural paths from the variables reliability of connection (PC1) and “next vehicle arrives in 5 mins plus a 2-5 mins walk” (PC2) would become statistically significant if the self-efficacy latent variable was removed from the model. Taken together, the results seem to support Hypothesis 1: The stronger is PT users’ perceived controllability and self-efficacy, the greater will be their intention to use transfer routes. The significant positive coefficient (0.29) for the path from intention to decision supports Hypothesis 2.

Contrary to Hypothesis 3, it was found that socio-demographics and trip characteristics have direct effects on intention. Only gender, frequency of PT use and current use of transfer routes had significant effects on intention. The positive effect of frequency and current use of transfers on intention indicates that positive control beliefs are related to regular use of PT. Such finding is consistent with past studies which have shown that the transfer penalties given by infrequent PT users tends to be higher than those given by regular users [7, 24]. Regular PT users tend to be more familiar with the system and therefore are less likely to face uncertainties when transferring [7]. Male participants were seen to be less willing to use transfer routes than female participants. A probable reason for the gender effect is the different travel patterns between men and women, due to household responsibilities, child care and employment status. For example, a study by Nobis and Lenz [66] discussed that women tend to chain their trips more often than men. Also, women living in a household with children were seen to use more PT than men.

The ordinal regression models revealed some effects of socio-demographics and trip characteristics on the measurement items, representing the control beliefs, for self-efficacy and perceived controllability. The effect of gender and current use of transfer routes on PD2 and CON2 were positive and negative, respectively. This finding suggests that good security at connection points will have a greater positive impact on female PT users to make transfers. As for the negative effect from current use of transfer routes, a probable reason is that PT users are not satisfied with the current safety and security provisions at the connection points. For the controllability variables, income had a consistent significant effect. The effect of income on the variables reliability of connection and “next vehicle arrives in 5 mins plus a 2-5 mins walk” were positive and negative for the variable “next vehicle in 15 mins plus a 5-10 mins walk”. Such findings are in line with the design of the measurement items. Higher income PT users generally hold a greater value for travel time [67].

## 7. Conclusion

This paper provides the development of a psychological model which explains the relationship between public transport (PT) users’ perceived barriers of making transfers and their resulting willingness to use routes with transfers. The theory of planned behavior (TPB) was adopted and the data was analyzed using structural equation modeling. Overall, the analysis demonstrated that the TPB is capable of modeling PT users’ intention to use routes with transfers. PT users’ perception of trip attributes such as personal safety, information, reliability of connection, transfer waiting time and transfer walking time were shown to be appropriate measures to represent control beliefs of perceived behavioral control. Results showed that high quality trip attributes, related to transfers, create positive self-efficacy and perceived controllability which increases PT users’ intention to use routes with transfers.

Personal security was seen to have a greater influence on PT users' confidence and perceived difficulty than high quality information. As for transfer waiting and walking time, PT users' preferred the transfer time to be within 10 minutes. Travel patterns related to gender, frequency of PT use and current use of transfer routes were also seen to have an effect on intention.

Findings of the study have two main implications. Firstly, that the TPB is a suitable model to investigate the psychological factors involved in travelers' intention to use PT transfer routes. Secondly, that PT users need to feel capable (strong control beliefs) of making the transfers. Travelers' perceived benefits of using the transfer routes have to be greater than their perceived difficulty of making the connections. Therefore, authorities need to focus on developing attractive transfer routes (*e.g.*, reduced total travel time savings) with comfortable transfers, from a user perspective, to encourage ridership of PT.

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