Sustainable Urban Development: Implementation of Public Bike Sharing System - NZ Case Studies

Chan Kim / MSc, PhD

2019 ITP RESEARCH SYMPOSIUM
WHANAUNGATANGA
community-centred research
RELATIONSHIPS NETWORKS RECIPROCITIES OBLIGATIONS

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Introduction

- Research Background:
  - Sustainable Urban Design
  - Travel behaviour and mode of transport
- **P**ublic **B**icycle **S**haring **S**cheme (PBSS)
- Case Study: Hamilton and Christchurch
  - Survey method and sample
  - Multinomial Logit Model
  - Analysis and implication
- Conclusion & Research Direction

Background

- Increasing traffic volume in urban (and CBD) area causes
  - Traffic congestion
  - Car-related accident rate
  - Environmental problems
- Increasing connectivity from/to Public Transport
- Increasing interest on shared mobility options (e.g. car, bike, e-scooter etc.)

Background: PBSS
What is a Public Bicycle Sharing Scheme

- A mobility service
- Allows citizens to rent and return bicycles
- With no responsibilities of bicycle ownership
- Key Components of a PBSS
  - Public bicycles
  - Docks & stations
  - Operation plans
  - Accessibility
  - Maintenance, Advertisement, and Manual

Background: PBSS
Literature Review

- Research question:

How to come up with the suitable operational plans for a Public Bicycle Sharing Scheme

- Literature review:

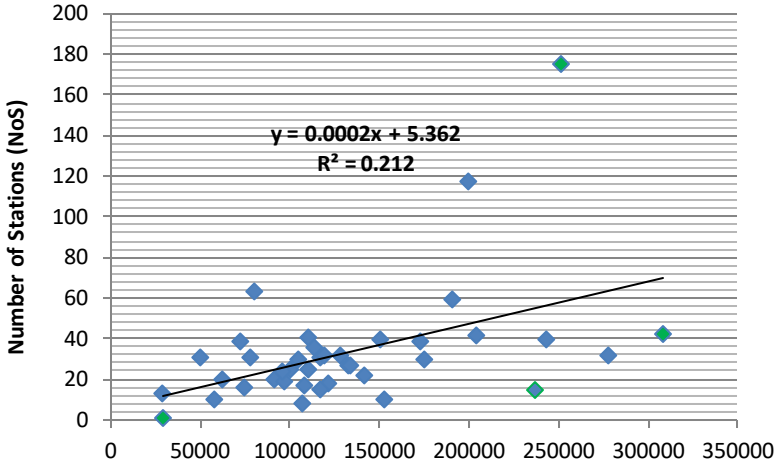
Look into the geographical features and characteristics of PBSS plans in other cities which were similar to Hamilton and Christchurch

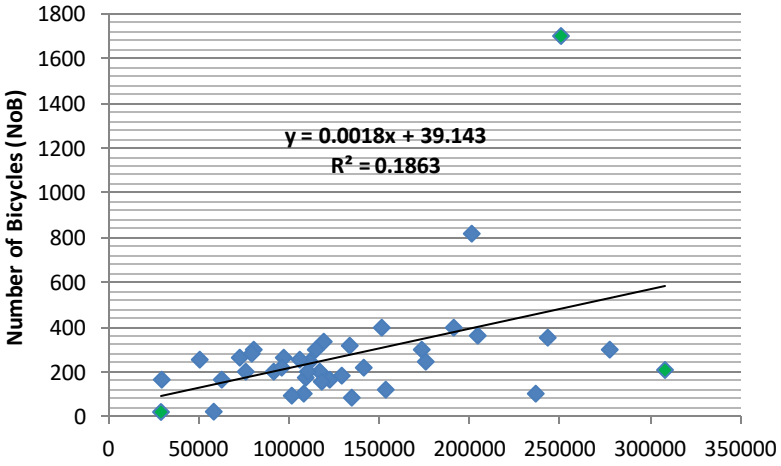
City	Country	Population	Area (km^2)	Pop. Density (hab/km^2)	GDP (USD)
Hamilton	New Zealand	165,400	110.80	1,500.00	33,912
Besançon	France	116,914	65.05	1,811.47	30,625
Kassel	Germany	190,765	107.00	1,864.00	53,133

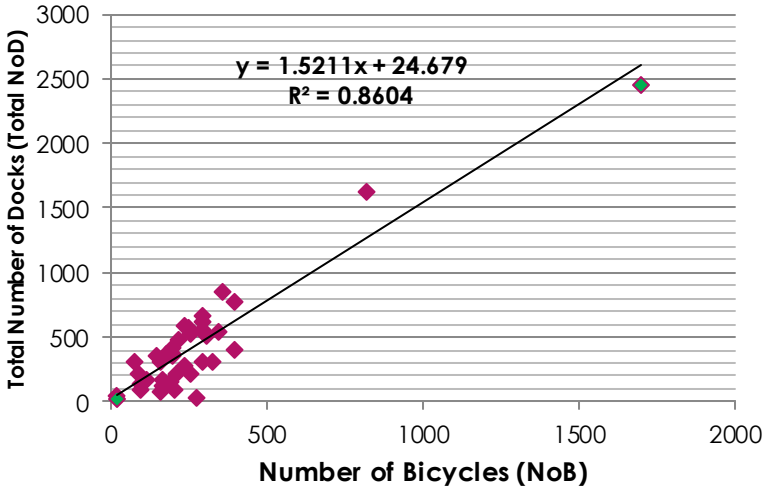
Background: PBSS
Literature Review – Finding and Implication

- To come up with a suitable number of public bicycles, docks and stations
- Compared to 40 overseas cities
  - The distance between stations from 200m to 500m
  - PBSS in CBD: Mainly for leisure
  - PBSS throughout a city: Mainly for commuting

Background: PBSS
Literature Review – Finding and Implication







- Number of Bicycles: 337
- Number of Stations: 39
- Number of Docks: 538
- Ave. Number of Bicycles per Station: 9
- Ave. Number of Docks per Station: 14

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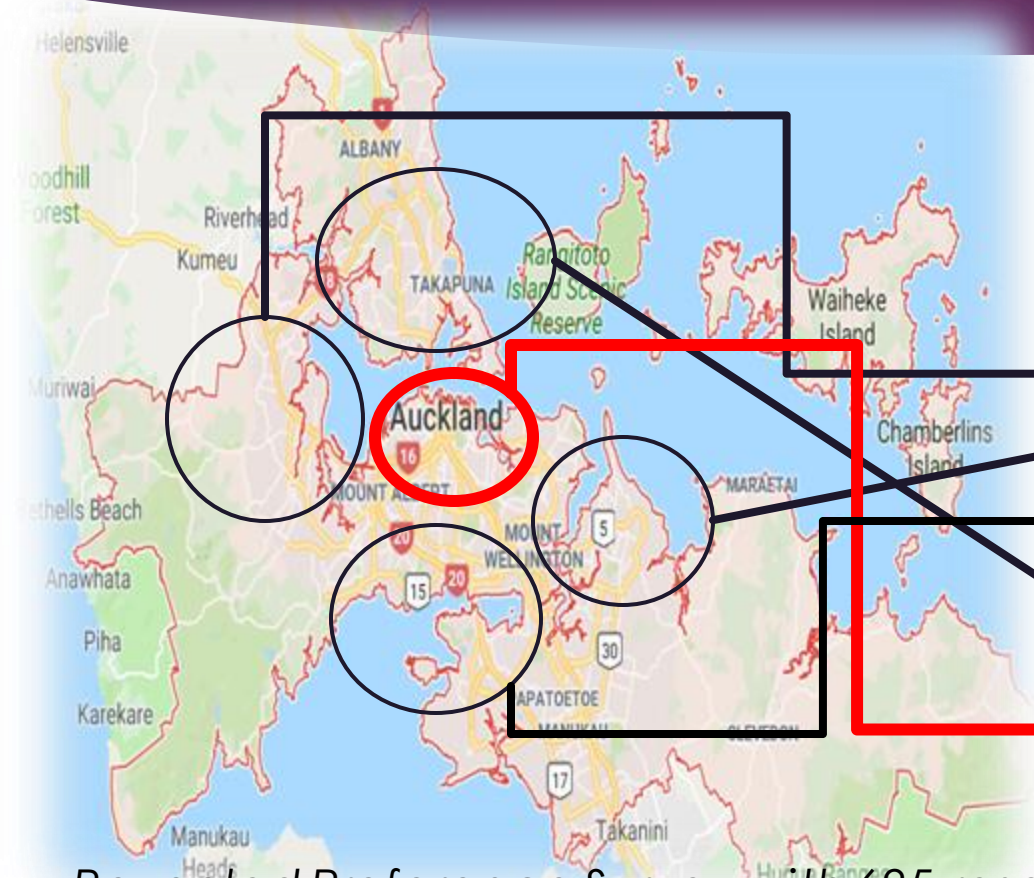
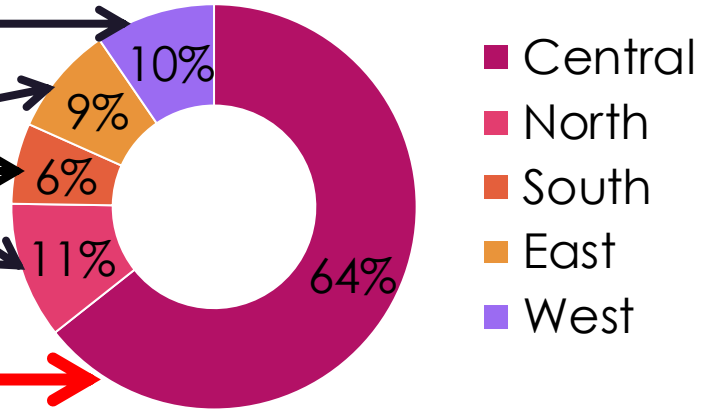
Case Study: User Behaviour

RP survey on Auckland Bike share user



Regional Proportion



Revealed Preference Survey with 625 responses from Auckland

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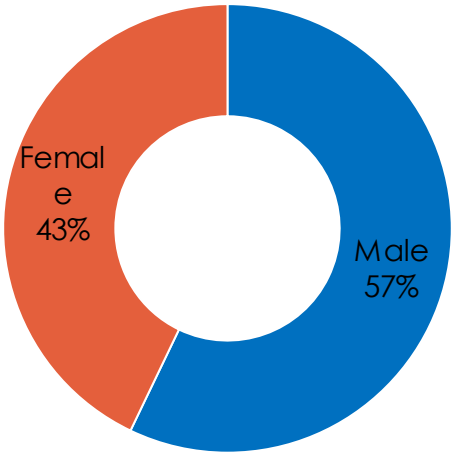
Case Study: User Behaviour

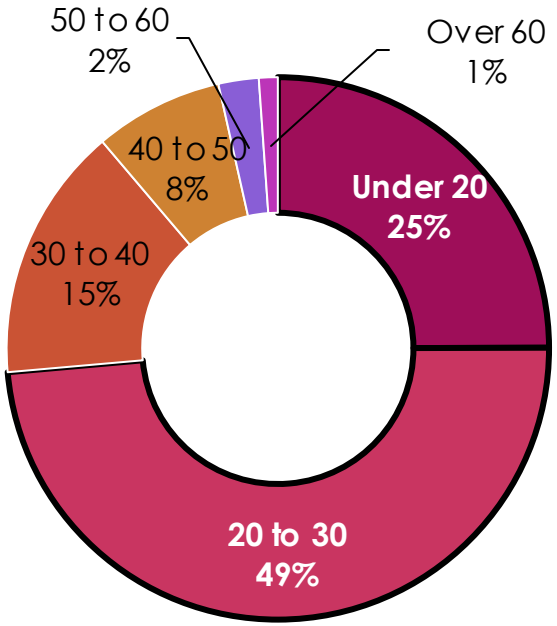
RP survey on Auckland Bike share user

Sociodemographics

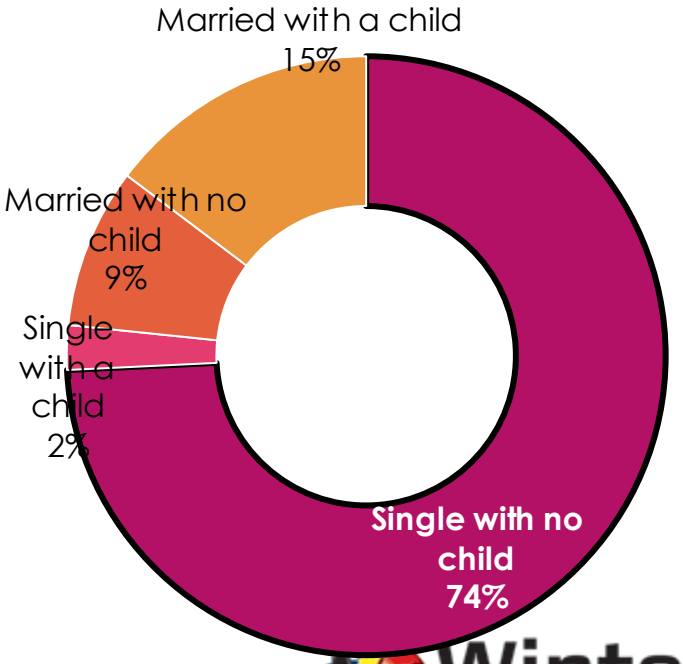
Gender



Age Bracket



Marital Status



Case Study: User Behaviour

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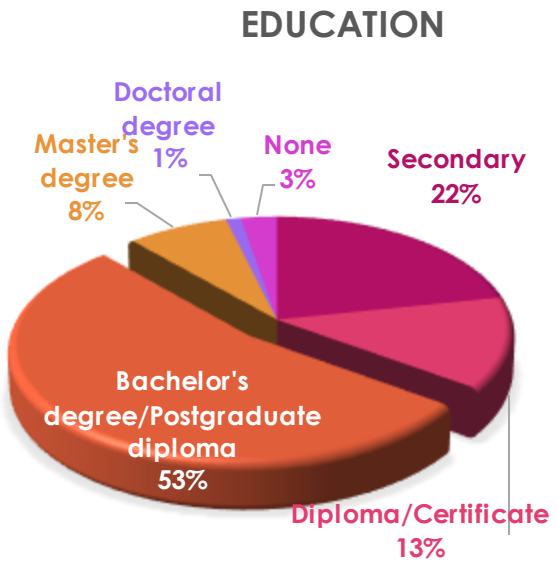
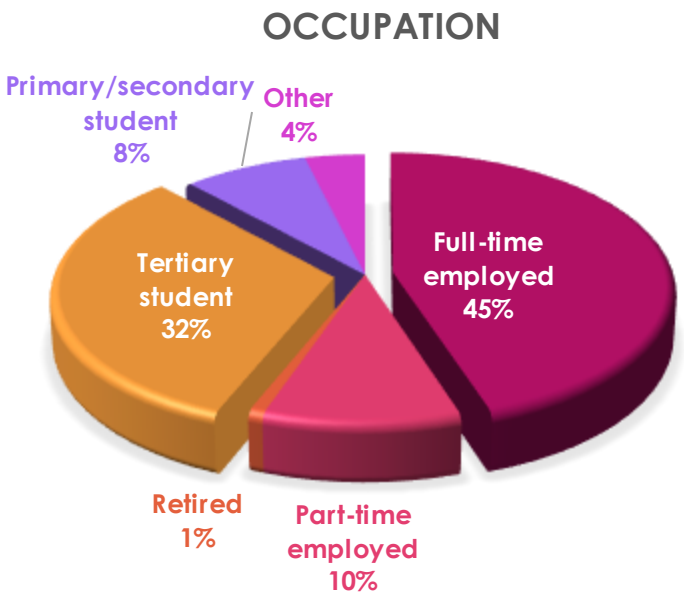
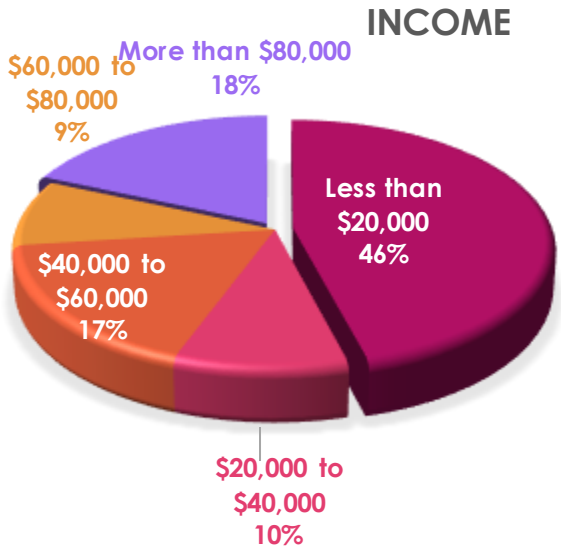
Sociodemographics







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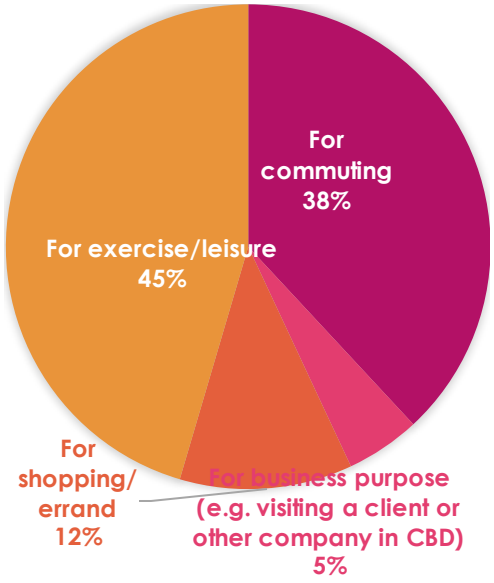
Case Study: User Behaviour

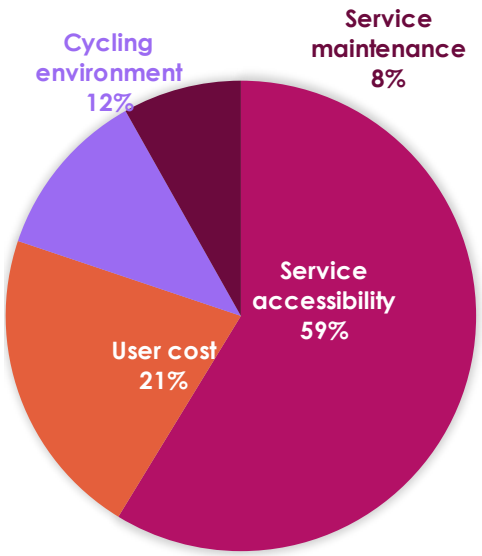
RP survey on Auckland Bike share user

Mode Use: Using the PBSS

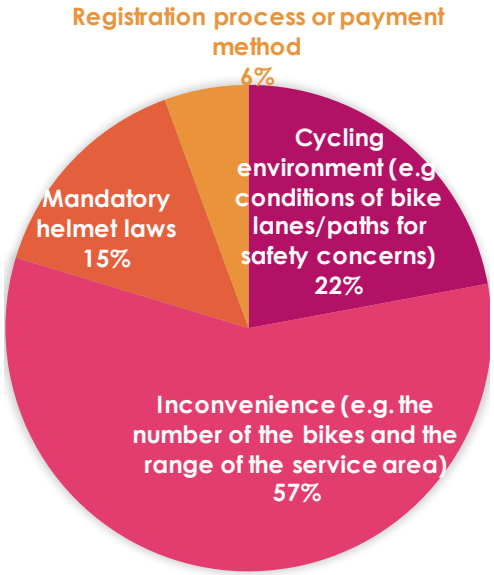
Main Purpose



Key Factors



Restriction



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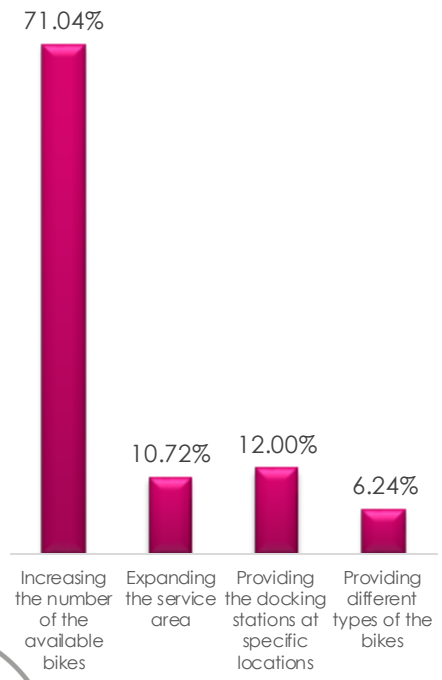
Case Study: User Behaviour

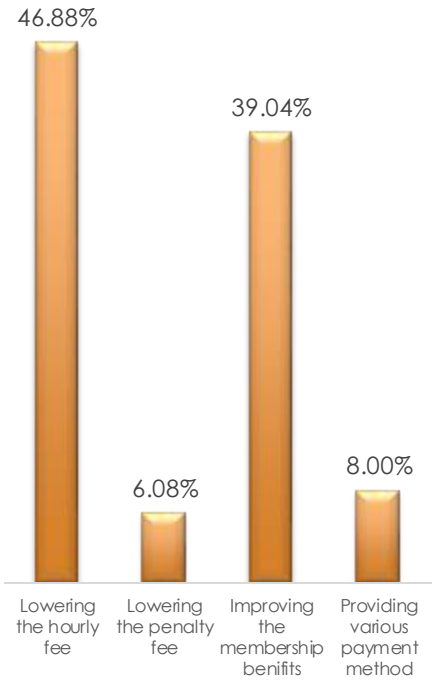
RP survey on Auckland Bike share user

PBSS Key Factors

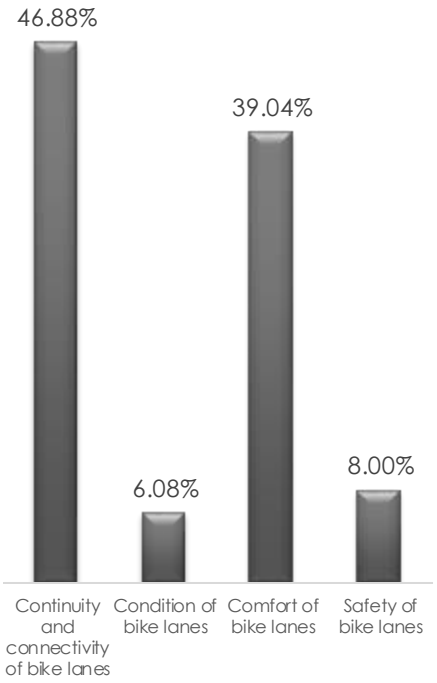
Service Accessibility



User Cost or Expense



Cycling Environment



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Preliminary Study Findings

- **Operation Plan for Hamilton**
  - Location and spacing of the station: 200-500m near the PT stops
  - Number of bicycle, docks and station: 337 bicycles with 538 docks and 39 public stations
- **Use behaviour from Auckland PBSS user survey**
  - Mainly young students and full-time employed with short work experience
  - Increasing the number of available bicycles would be most beneficial in terms of service accessibility and maintenance.
  - The connection and segregating or securing enough space of cycle lane/path should be provided.
  - Lower the hourly fee and providing the membership benefits would encourage more users.

Research Questions & Methodology

- Research Question: how to design PBSS in the urban CBD area in particular
  - How to facilitate modal connectivity by introducing a micro mobility
  - How to improve the flexibility of public transport users
- Apply the key design requirements to two cities, Hamilton and Christchurch
- Stated Preference survey and Econometric Modelling

Methodology
Multinomial Logit Regression Model (MNL)

- The Multinomial Logit Regression Model (MNL) is the most widely used modelling methodology to measure transport users' mode choice behaviour.

$$P(y_i = j) = P_{ij} = \frac{\exp(x_i \beta_j)}{\sum_{k=0}^{J} \exp(x_i \beta_k)} \text{ for } j = 0, \ldots, J$$

$$\Omega_{ij|iq} = \exp(x_i[\beta_j - \beta_q])$$

  - Liu and Lin (2019), Zhou et al., (2018), Du and Cheng (2018) – China
  - Abolhassani et al., (2019) – Iran
  - Schneider et al., (2019) – U.S.A.

also, Romero et al., (2012), Faghih-Imani and Eluru (2015), etc

Description of Stated Preference Survey (September, 2018)

Section Two – *Public Bike Sharing System*

INSTRUCTION

The following survey will provide vital information to help to determine if a "Public Bike Sharing" system in the Christchurch and Hamilton CBD is viable. This section of questions asks you to compare possible transport options for accessing the Christchurch/Hamilton main CBD area. Each question provides three alternative options. Please choose which type of transport option you would prefer by ticking a box to indicate your choice.

The first column in each question represents ***'current'*** (***status quo***) access pattern to the Christchurch/Hamilton CBD. Assume that you are accessing the CBD by Bus and need to ***walk*** a moderate distance, approximate 1000 meters (15 minutes) from Bus stop to your final destination.

The second column in each question represents ***'alternative'*** CBD transit option under the Public Bike Sharing system. Assume that you are accessing the CBD by Bus and you will need to walk from a bus stop to the nearest bike station, then using a ***traditional bicycle*** to travel approximate 1000 meters (5 minutes) to the nearest bike station from your final destination.

Finally, the last column in each question represents ***'alternative'*** CBD transit option under the Public Bike Sharing system. Assume that you are accessing the CBD by Bus and you will need to walk from a bus stop to the nearest bike station, then using an ***Electric bicycle*** to travel approximate 1000 meters (5 minutes) to the nearest bike station from your final destination.

There are 8 of these questions. There are no right or wrong answers. But if you are unsure or have problems answering these questions, please do feel free to ask your surveyor for help with the questionnaire. Please try to answer all questions.

Below are three different options for your trip to CBD. These options include information on Parking and Transport Cost, Walking Distance, and Service Frequency. If the options below are the only options available for your trip, which would you prefer?

		OPTIONS		
CHOICE SET		CURRENT (Bus + Walk)	Traditional Bike	Electric Bike
1	**Service Cost ($/hour)** *Total Fare (= Bus fare + bike service fare)*	$2.40	$2.40	$2.90
	Bicycle Accessibility (metres) *Walk distance to reach a bike station from bus stop and a bike station to your final destination*	-	< 25 m	< 50 m
	Bicycle Availability (%) *The likelihood of finding a bike at the station*	-	50 %	100 %
	YOUR SELECTION:			

- **3** options: current, traditional bike, E-bike
- **3** attributes: Cost, Bike Accessibility, Availability
- **8** hypothetical choice sets
- **2** Cities: Hamilton and Christchurch
- Total of **486** survey samples
  - **185** Sample from Christchurch
  - **301** Sample from Hamilton

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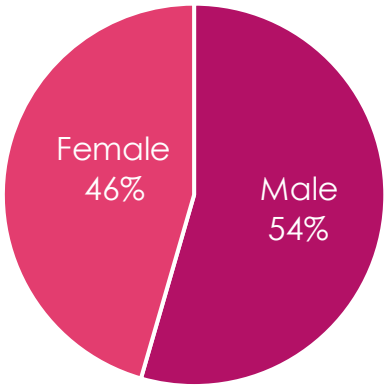
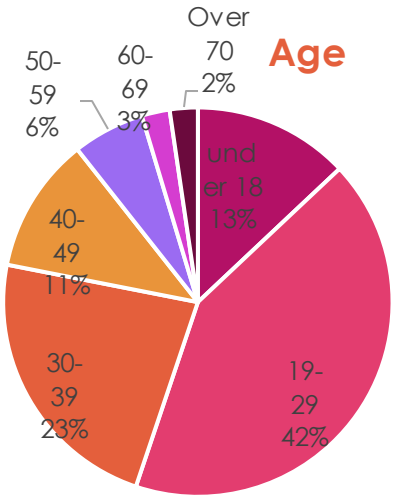
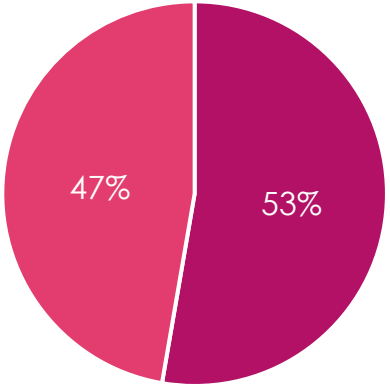
Sample Analysis
Sociodemographics

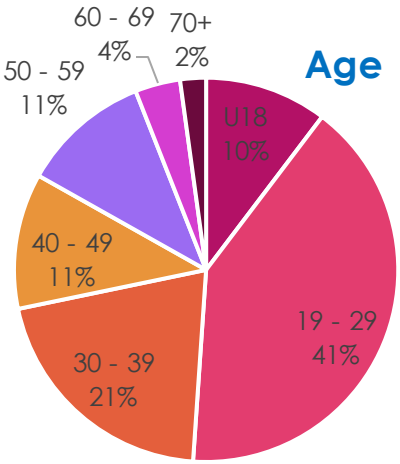
Hamilton



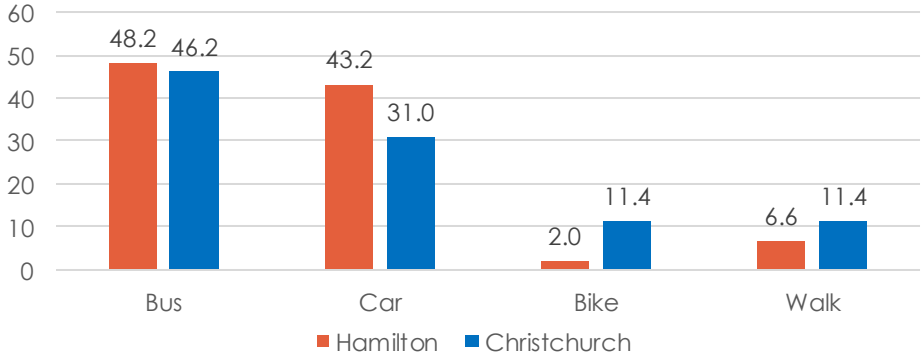


Christchurch



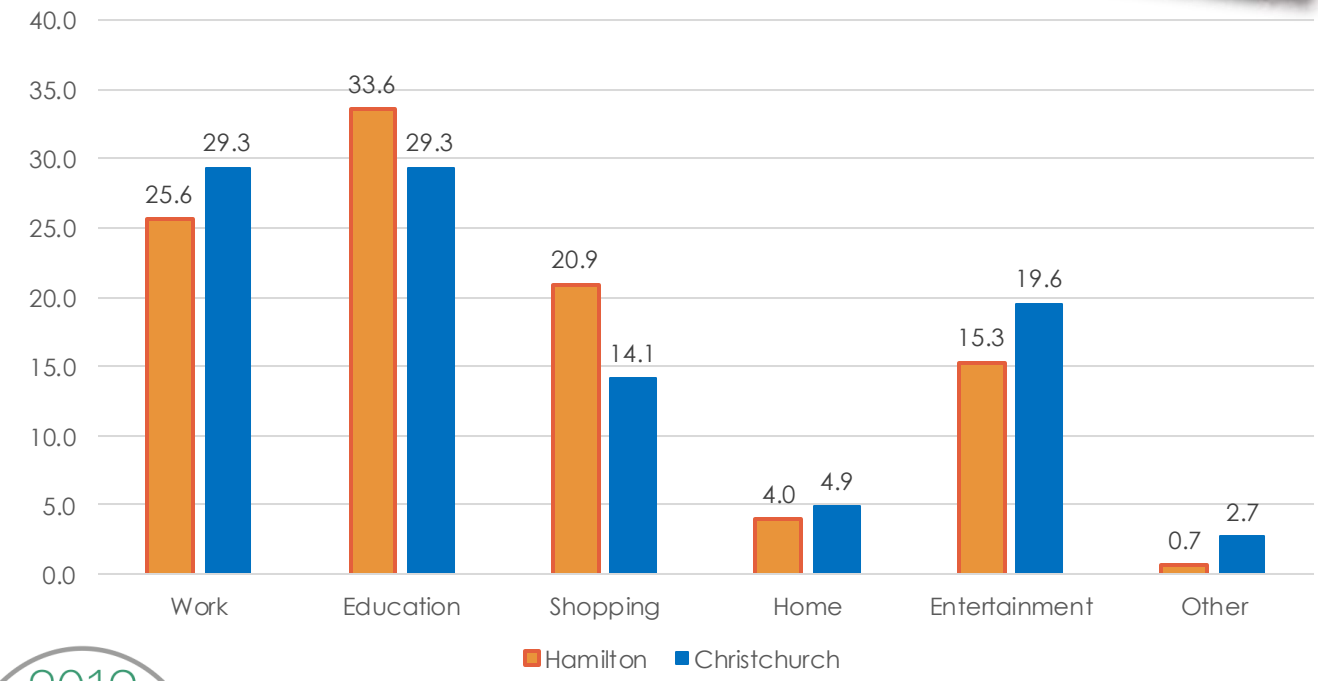


Mode of Transport to CBD



Sample Analysis
Sociodemographics

Trip Purpose to CBD



Hamilton

(301 responses)

Christchurch

(184 responses)

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Multinomial Logit Modelling
Results & Analysis

	Hamilton		Christchurch	
Attributes	**Coefficient**	**Std. Error**	**Coefficient**	**Std. Error**
COST	-1.963***	0.000	-1.233***	0.319
ACCESSABILITY	-0.088***	0.007	-0.088***	0.040
AVAILABILITY	0.082***	0.015	0.107***	0.039
ASC TRAD BIKE	0.267***	0.173	-0.143*	0.075
ASC EBIKE	1.246***	0.293	0.408***	0.133
Model Statistics				
Log Likelihood		-2532.73		-1590.35
Pseudo- R^2		0.016		0.023
AIC/N		2.109		2.171
Observations		2408		1472

***P<.01, **P<.05, *P<.10

- The MNL modelling results use to calculate the likelihood probability by using a utility function for each option.

$$U = a_0 + a_1X_1 + a_2X_2 + a_3X_3 + \varepsilon$$

Where

a_0 is the ASC coefficients

X_1 is the cost of service,

X_2 is accessibility for the distance to access the bikes (or E-bikes),

X_3 is the availability, X_3 is the availability for the percentage chance that there will be a bike or E-bike available

- The model share for the utility function of three options is given by the proportion function.

$$P_m = \frac{e^{U_1}}{e^{U_1} + e^{U_2} + e^{U_3}}$$

Multinomial Logit Modelling
Results & Analysis

Hamilton

- Both **E-bike and Trad-bike** is more **attractive** than Bus only service

Christchurch

- **E-bike** is more **attractive** than Bus only service but **Trad-bike** is **less attractive**

- All of the coefficients of the generic attributes have the expected sign and are **statistically significant** in the MNL model
- The coefficients of the **cost** and **accessibility** variables are **negative**, indicating that alternatives with a higher cost or longer walking distance are less likely to be chosen.
- The coefficients of the **availability** variable are **positive**, as CBD users are expected to favour choosing modes with higher bike availability.

MNL Modelling
Modal Share

- Utility Function: $U_n = a_0 + a_1X_1 + a_2X_2 + a_3X_3 + \varepsilon$
- Modal Share: $P_m = \frac{e^{U_1}}{e^{U_1}+e^{U_2}+e^{U_3}}$
- Base Scenario:

	SQ (Bus Only)	ALT 1 (Bus + Trad- Bike)	ALT 2 (Bus + E- Bike)
Cost ($/trip)	$ 2.40	$ 2.40	$ 2.40
Availability (%)		50 %	50 %
Accessibility (metre)		50 m	50 m

Hamilton

SQ (Bus Only)	ALT 1 (Bus + Trad- Bike	ALT 2 (Bus + E- Bike)
22 %	21 %	57 %

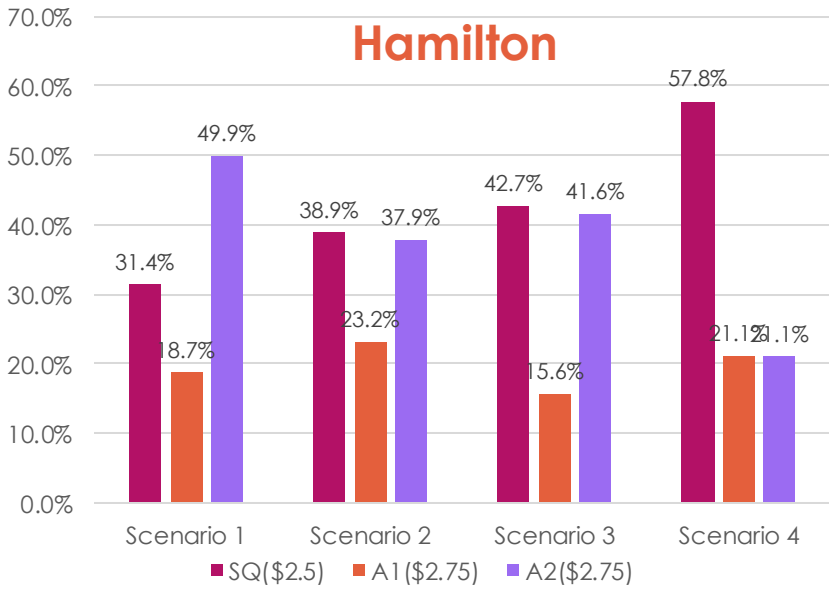
Christchurch

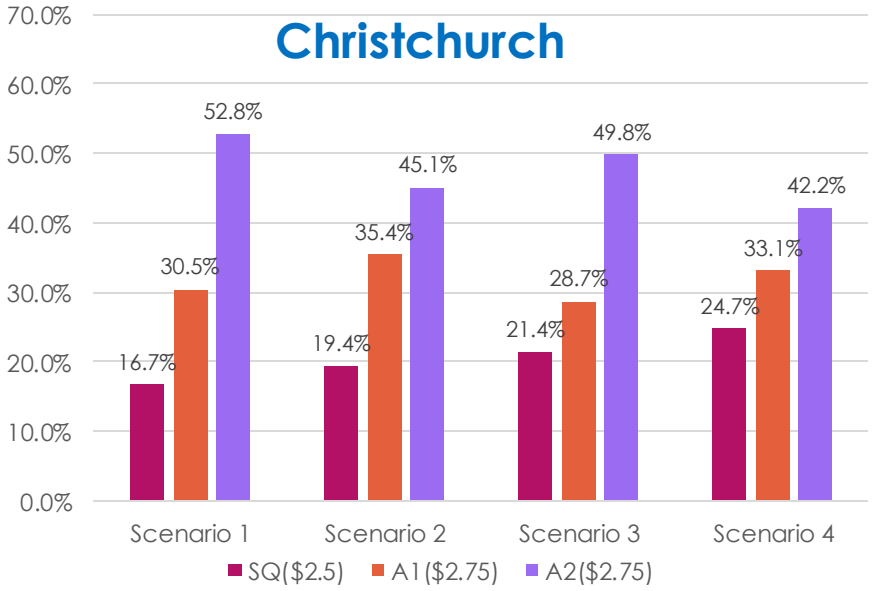
SQ (Bus Only)	ALT 1 (Bus + Trad- Bike	ALT 2 (Bus + E- Bike)
13%	32%	55%

MNL Modelling
Policy Application

Modal Share Scenario: Service Fare

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
SQ(Status Quo): Bus only	$ 2.5	$ 2.5	$ 2.5	$ 2.5
Alt1: Bus + Traditional Bike	$ 2.75	$ 2.75	$ 3.0	$ 3.0
Alt2: Bus + E-Bike	$ 2.75	$ 3.0	$ 3.0	$ 3.25





Conclusion

- Preliminary Survey Analysis shows that the majority of people surveyed would consider using a PBSS service
- There will be a greater need for more E-Bike options in urban CBD.
- Service fare, follow by the Walking distance to access the service and Bicycle availability at the station, is one of the biggest reasons why existing public transport needs to be improved to meet the growing demands for public transport.
- 'Tailored' operational plan will be required regarding
  - Location of the docks and station, Bicycle tracking system, booking methods, etc

Limitation & Research Direction

- Limited Sample size and the location samples are collected
- Advanced econometric models (ML, GMXL etc.) allow researchers to analyse and predict how people's choices are influenced by personal characteristics and by the alternatives available to them
- Measure Willingness-to-pay (WTP) to evaluate elasticity of demand based on new service (Traditional Bike and E-bike)

Thank you

QUESTIONS OR COMMENTS

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