Understanding public response to a congestion charge: A random-effects ordered logit approach

By Zuduo Zheng[a*], Zhiyuan Liu[b], Chuanli Liu[a], Nirajan Shiwakoti[c]

[a]*Civil Engineering & Built Environment School, Science and Engineering Faculty, Queensland University of Technology, 2 George St GPO Box 2434 Brisbane Qld 4001 Australia*

[b]*Institute of Transport Studies, Department of Civil Engineering, Monash University, Clayton, Victoria 3800 Australia*

[c]*Intelligent Transport Systems,* School of Aerospace, Mechanical and Manufacturing Engineering (SAMME)*, RMIT University, Carlton, Victoria 3053 Australia*

Abstract: Public acceptance is consistently listed as having an enormous impact on the implementation and success of a congestion charge scheme. This paper investigates public acceptance of such a scheme in Australia. Surveys were conducted in Brisbane and Melbourne, the two fastest growing Australian cities. Using an ordered logit modeling approach, the survey data including stated preferences were analyzed to pinpoint the important factors influencing people's attitudes to a congestion charge and, in turn, to their transport mode choices. To accommodate the nature of, and to account for the resulting heterogeneity of the panel data, random effects were considered in the models. As expected, this study found that the amount of the congestion charge and the financial benefits of implementing it have a significant influence on respondents' support for the charge and on the likelihood of their taking a bus to city areas. However, respondents' current primary transport mode for travelling to the city areas has a more pronounced impact. Meanwhile, respondents' perceptions of the congestion charge's role in protecting the environment by reducing vehicle emissions, and of the extent to which the charge would mean that they travelled less frequently to the city for shopping or entertainment, also have a significant impact on their level of support for its implementation. We also found and explained notable differences across two cities. Finally, findings from this study have been fully discussed in relation to the literature.

Keywords: Congestion charge; congestion pricing; stated preference; random-effects ordered logit; violin plot

1. Introduction

Traffic congestion is emerging as a major impediment to the achievement of economic goals in many urbanised cities around the world, including Australia. National research has shown that over 60% of the Australian population live in capital cities (CCLM, 2011), and that the total amount of travel undertaken by residents of Australian cities has grown ten-fold in the

* Corresponding author. Tel.: +61-07-3138-9989; fax: +61-07-3138-1170.
E-mail address: zuduo.zheng@qut.edu.au.

last 60 years (BTRE, 2007). The congestion costs (comprising private and business time costs, vehicle operating costs, and air pollution costs), which totaled $9.4 billion in 2005, is expected to double by 2020. At city-specific levels, a rise from $3.0 billion to $6.1 billion for Melbourne, and from $1.2 billion to $3.0 billion for Brisbane has been projected (BTRE, 2007). Besides the enormous economic cost, it was found that stop-and-go driving, a typical phenomenon in traffic congestion, increases the odds of being involved in a crash (Zheng et al., 2010).

As a potentially powerful tool for alleviating traffic congestion, the implementation of a congestion charge – a surcharge on people who travel in certain congested areas with private vehicles – is a policy designed to encourage the usage of alternative transport modes or routes. Such an objective is recognized as 'internalizing the externalities', where the time taken up by congestion, and its negative environmental effects are converted into toll revenue which can be invested back into transport systems (Yang and Huang, 2005; Liu et al., 2013). When drivers analyse their use of private transport by comparing its marginal costs and benefits, they typically exclude from this analysis any external costs that the driving may impose on others. A congestion charge, however, would account for this exclusion.

Besides reduced traffic congestion, benefits resulting from implementing a congestion charge scheme include increases in revenue and transit ridership, improved transit services and travel time (as a result of the improved traffic conditions), and environmental and public health benefits. Overall, benefits of implementing a congestion charge are generally reported to outweigh the associated costs (i.e., implementation and operational costs) (Leape, 2006; Eliasson, 2009).

Despite a well-established rationale and mature technologies for implementing a congestion charge, few cities or states have attempted or actually implemented such a scheme because of social, political or legal issues (Meng and Liu, 2012). The two major challenges for the implementation of a congestion charge are public and political acceptability, rather than technical or administrative issues (Jones 2003). With neither strong political nor public support, implementing a congestion charge in most countries with a democratic political system will be very difficult. This has been confirmed by failed attempts in several cities, such as Hong Kong (Hau, 1990), New York City (NYC), Edinburgh, and Manchester (Hårsman and Quigley, 2010).

This paper investigates public response to congestion charge in two Australian capital cities, Brisbane and Melbourne. In this study, the congestion charge is limited to area charging and cordon boundary charging. However, depending on the region's geographical location, road network structure and the needs of the area, a congestion-charging scheme can be set up in various forms, including but not limited to: area charging; corridor or link-based tolls; and cordon boundary charging (Whitehead et al., 2011a; Liu et al., 2013).

With the rapid growth of traffic congestion in large Australian cities (e.g., Sydney, Melbourne, and Brisbane), introducing a congestion charge is often discussed, although no such scheme has yet been implemented in any Australian city (The Centre for International Economics, 2010). Nor have any trials been undertaken to gauge the current level of public acceptance of such a charge (DOT, 2008). The Transport Research Centre at the University of Melbourne conducted a survey on community attitudes to travel demand measurements in general in 1993 (Luk and Chung, 1997), and reported a positive attitude to implementing the congestion charge in Melbourne. However, this result cannot be used to draw any conclusions as it is now 20 years old, focused on a small area outside the CBD, and had a small sample (n = 76). The Royal Automobile Club of Queensland's (RACQ's) Transport Costs Survey (2009) found that about 50% of respondents "somewhat support" or "strongly support" the congestion charge in Brisbane. The survey data were also used in Whitehead et al. (2011 a, b) which analyzed congestion charge schemes with specific implications for Brisbane. They concluded that a cordon boundary scheme with electronic transponders would be the most appropriate for cities in Australia and proposed a design for such a scheme in Brisbane. However, the respondents in the RACQ survey were members of the RACQ only; thus, the survey was not representative of the broader community. Furthermore, understanding factors in acceptability of congestion charge was not the focus of the RACQ survey.

In this paper, two face-to-face surveys were conducted to solicit public opinions of a congestion charge, should congestion charge schemes be implemented in the Brisbane and Melbourne city areas. The survey data were analyzed to identify important factors relevant to people's attitudes to the charge, and to measure the interrelationship of these factors.

The main contributions of this paper are threefold: (i) contribution to the knowledge of understanding public acceptance of congestion charge, particularly in the context of Australian cities. Strong public support is highly important in the successful implementation of congestion charge, and researchers studied this issue from different perspectives, such as from the engineering perspective by focusing on mitigating traffic congestion, and from environmental policy perspective by focusing on reducing emissions and fuel consumption. In this study, public acceptability of a congestion charge was gauged from both the congestion mitigation and the environment protection perspectives. In addition, values and attitudes are often culture-dependent (Rokeach, 1973). In acceptability of congestion charge, some factors may exert their influences similarly regardless of the culture, and some may become insignificant in a different culture (Fujii et al., 2004). Major factors reported in the literature were mostly in the context of North America or Europe (e.g., Rößger et al., 2008; Kim et al., 2013), despite the continuous debate on and the great need of implementing such scheme in big Australian cities. This study enriches the literature by scrutinizing these factors' impact on public acceptance of congestion charge in the Australian culture. Furthermore, while a few studies investigated cultural difference in congestion charge's acceptability using samples from different countries (e.g., Schmöcker et al., 2012; Kim et al., 2013), few studied the within culture difference with respect to public acceptance of congestion charge. The city comparison implemented in this study fills this gap; (ii) contribution to the data collection method in the field. In this study, stated preference (SP) experiments were utilized to collect respondents' responses to implementing congestion charge scheme under different scenarios. As a mature technique, SP is widely used in market research, and in transport mode choice analysis (Louviere et al., 2000; Hensher, 2005; Train, 2009). However, it has rarely used in investigating acceptability of transport policies (Bristow et al., 2010). More specifically, we are not aware of any previous application of SP to assess the acceptability of congestion charge schemes, and this paper is the first study of this kind. More discussions on advantages and disadvantages of SP are provided later; (iii) contribution to the methodology of analyzing correlated and ordered categorical data. Closely related to the second contribution, the SP data collected in this study are different from the normally collected discrete choice data in a sense that they are ordinal. Using the frequently used method for analyzing discrete choice data (e.g., MNL) produces inefficient and less accurate results because of ignoring the ordering information (Agresti, 2010). Thus, we introduced a powerful statistical method, proportional odds model, to treat an ordered categorical variable as ordinal rather than nominal, which leads to many advantages, such as parsimoniousness, simpler interpretations, greater detection power, and greater flexibility (Agresti, 2010). Furthermore, to account for correlations amongst observations collected from the same respondent, random effects were introduced to the proportional odds model. We believe, introducing/ implementing these powerful statistical methods itself is a significant methodological contribution because these methods are relatively new to researchers in Traffic Engineering despite the trend that this type of data is increasingly generated in transport surveys (Greene and Hensher, 2009).

The paper is structured as follows. The following section details the relevant literature. Subsequent sections describe the questionnaire and the data gathered, the methodology adopted, and the data analysis. The final section discusses main conclusions in relation to the literature.

2. Literature Review

To date, successful congestion charge schemes include: Singapore (1975), London (2003), Stockholm (2006), Milan (2012). Failed trials of the scheme include: Hong Kong (1988); Edinburgh (2005) (see Gaunt et al., 2007); New York (2007); and Manchester (2008) (see Sturcke, 2008). Hensher and Li (2013) provide an excellent review.

Two of the most recent and successful congestion charge schemes (those in London and Stockholm) are now reviewed. A failed attempt in NYC is also reviewed, as this attempt has been widely debated and studied. These cases underscore the importance of gaining public acceptance for implementing a congestion charge scheme.

Meanwhile, important studies on public acceptance of congestion charge are reviewed in this section, too.

2.1. Two success stories

(1) Congestion charge in London

The concept of a congestion charge was first studied in central London in the early 1970s, but did not gain much attention because of the significant spare capacity of public transport at that time. However, the discussion and debate continued and was further developed over time because of rapid population growth, and growing concerns about traffic congestion and its detrimental effect on the London environment. Bhatt et al. (2008) reported that in 1999, 90% of residents thought there was too much traffic in the capital, and that 41% of survey participants believed that the best way of funding public transport improvement in London was through a congestion charge. As a result, in the 1990s, London City was authorized to introduce a congestion charge and to acquire the resulting revenue. In 2000, Ken Livingston was elected as the first Mayor of London with a significant majority. This meant that the political consequences of such a congestion charge were less important, and it was implemented in central London on 17 February 2003, after an 18-month period of extensive public consultation (Bhatt et al. 2008; Santos, 2008).

Although the congestion charge in London was initially criticized by various stakeholders and interest groups for its negative impact on the economy, a survey of a business group – which accounted for 22% of the city's GDP – found that the majority (over 90%) of its members felt either no impact or a positive impact on their business; only 9% reported a negative impact on their business (Litman, 2006). Furthermore, Bhatt et al. (2008) found that the level of acceptability of the London congestion charge increased from about 40% before the charge, to more than 50% eight months after its introduction.

(2) Congestion charge in Stockholm

The congestion charge system in Stockholm has been politically debated over the last two decades. In 1991, the Social Democrats and a local Green Party cooperated with the elected alliances and initiated the *Dennis Agreement*, which proposed the comprehensive introduction of a toll system; however, because of political changes, this was not implemented until the Green Party again won sufficient seats in 2002, and prompted the Social Democrats to agree to an experimental congestion charge. Along with the enhancement of public transport services, a full-scale, seven-month trial was conducted from January to July 2006, and a comprehensive investigation ensued to determine the interrelationships of factors relating to travel behaviour and decision making (Bhatt et al., 2008). It was reported that residents who resided in the charging zone, who were college-educated, of working-age, or believed they saved time as a result of the toll system were more in favour of the system. In contrast, residents who were immigrants, male, resided outside of the charging zone, or paid more for the system, were less likely to favour it (Hårsman and Quigley, 2010).

Interestingly, different levels of public acceptance of the congestion charge in Stockholm were found before and during its trial (Eliasson et al., 2009; Schuitema et al., 2010). More specifically, in autumn 2005, 55% of residents stated that implementing a congestion charge scheme was a "very or rather bad decision"; however, in April 2006, 53% of residents stated that the trial was a "very or rather good decision". This increase in acceptance of the charge was driven by its better-than-expected benefits (e.g., less congestion, more parking space), and by the fact that participants were generally more concerned with its effectiveness, rather than its personal cost (Schuitema et al., 2010). With its continuing worsening traffic congestion, and encouraged by the success of the trial and the widely discussed success of the London scheme, Stockholm eventually decided to adopt the congestion scheme by referendum in 2007 (Hårsman and Quigley, 2010).

2.2. The failed attempt in New York City

New York City (NYC) is consistently ranked as one of the most congested American cities, with the dire prediction that traffic demand will almost exceed the capacity of the city's subway, river crossings, and commuter rail lines by 2030 (Clee, 2007). Some civil and advocacy groups have been promoting a transportation congestion charge since the 1980s. Encouraged by its success in London (discussed above), more and more groups are now advocating its implementation in NYC (Schaller, 2010).

To mitigate NYC's notorious congestion, and as part of his comprehensive sustainability plan, Mayor Michael Bloomberg proposed (in 2007) to charge a fee for vehicles travelling into, or within, the Manhattan central business district. This was the first area-wide road charge scheme proposed for a major North American city. If this proposal had been implemented, NYC would have been the first American city, and only the fourth large city in the world, to charge for driving into the central city.

The Mayor introduced the congestion charge proposal in the State Legislature in June 2007. The City and the Metropolitan Transportation Authority (MTA) applied for funding from the U.S. Department of Transportation and were awarded $354 million in August 2007, conditional on the implementation of the congestion charge system by March 31 2009. The Traffic Congestion Mitigation Commission held 14 public hearings and modified Bloomberg's original plan, and this obtained a wide range of support; for example, in late March 2008, public opinion polls showed that NYC residents supported a congestion charge by a 67-27% margin (Schaller, 2010).

However, although both proponents and opponents of NYC's congestion charge scheme agreed on the importance of achieving the goals of congestion reduction, cleaner air and increased funding for mass transit improvements, it eventually failed as it was never put to a vote on the New York State Assembly. The most vocal opposition came from elected officials and civic groups in four NYC boroughs outside Manhattan; these boroughs were more auto-dependent than neighborhoods closer to Manhattan and did not have the rapid or convenient transit access to Manhattan jobs. They questioned regional equity issues, and whether funds would be spent effectively on transit service improvements. Despite the support of the majority of residents and politicians, therefore, a relatively small group was able to block the proposal through the Assembly (Schaller, 2010). This highlights the complexity of gaining public support (and political support, which is beyond the scope of this study) for implementing a congestion charge scheme.

In summary, the successes of the congestion charge scheme in London and Stockholm, and its failed introduction in NYC clearly reveal the importance of gaining strong political and public support for its implementation. Although appealing, surveying policy makers on this often-controversial policy is extremely sensitive, at least in the Australian context, which is also evidenced by the scarcity of the literature on this issue. On the other hand, political support is generally directly linked to public support for two main reasons. First, in democratic countries, general public are voters. Second, getting a strong public support is the first step of securing politicians' support. Intuitively, for the security of their own positions, it is hard for politicians to endorse any transport policy that is lacking of public support. Thus, it is critical to accurately measure and understand public acceptance to a congestion charge before a city implements such a scheme. A large body of literature studied factors that significantly influence public acceptance of congestion charge, as discussed below.

2.3 Public acceptance of congestion charge

Depending on researchers' background, congestion charge can be regarded as a policy for mitigating traffic congestion (as in this study), or for environment protection (i.e., environmental taxation). For readers who are interested in design of policy measures to address environment problems (e.g., climate change), see Sterner (2003), Dresner et al. (2006), Aldy et al. (2010), Schwanen et al. (2011), and Ferraro and Miranda (2013) among many others. This section concentrates on studies that specifically discuss factors influencing public acceptance of congestion charge.

Significant progresses have been made on understanding public acceptance of congestion charge from different perspectives. Freedom, fairness, trust in government, problem awareness, perceived effectiveness, complexity, and socio demographic background are important factors that were frequently mentioned in the literature, as summarized in Table 1.

In addition, public transport quality is an obvious factor that can significantly influence public acceptance of congestion charge as evidenced in successful congestion charge schemes (e.g., London and Stockholm) (Bhatt et al., 2008; Eliasson et al., 2009; Litman, 2011). Concerns on public transport quality were also often discussed in the failed attempt of implementing a congestion charge in NYC (Clee, 2007). Furthermore, public transport quality can be related to several factors in Table 1, such as freedom, fairness, and problem awareness.

Table 1

3. Survey

Because no congestion charge has been implemented in Brisbane or Melbourne, a series of stated preference (SP) experiments were designed to investigate respondents' level of support for implementing such a scheme. This was achieved by providing various combinations of hypothetical benefits and costs incurred by the scheme. Compared with revealed preference (RP) methods, SP methods are less reliable. However, two primary advantages of using SP include: (i) Creating sufficient variation needed for estimation of underlying preference parameters; (ii) For new products (as in this study) that do not exist in the current market, providing a scientific alternative to gauge consumers' responses and preferences. In addition, thanks to more than thirty years of implementation and refinement, well-developed methodologies have been available to counter bias in their application. Thus, SP methods are widely accepted, and utilized in many disciplines (Louviere et al., 2000; Train, 2009).

As discussed previously, lots of factors can have influences on public acceptance of congestion charge. However, to maintain simplicity and readability (thus reliability of the SP data), only three typical features of a congestion charge system were considered in the SP experiments: the amount of congestion charge, fuel cost (journey time) reduction[†], and bus fare decrease. To make these SP experiments more realistic, the survey instructed respondents to think their most recent trips from their homes to the city area, and to treat other factors that are not considered in the SP scenarios as unchanged. An orthogonal fractional factorial design[‡] using the survey design package Ngene (ChoiceMetrics, 2012) was generated, consisting of nine SP tasks in total. In each SP experiment, two transport modes (i.e., car and bus) with specific attribute levels were available. Two attributes for car were considered (note that the numbers in parentheses are attribute levels): fuel cost (journey time) percentage reduction compared with their most recent trip (-10%, -30%, -50%[§]), and congestion charge (AU$5, AU$10, AU$15); other costs such as parking are not explicitly included because in a recent nationwide travel behavior survey (Zheng et al., 2014), it is found that the averages of parking cost in five capital cities (i.e., Sydney, Melbourne, Brisbane, Perth, and Adelaide) are close to zero. One attribute for bus was considered: percentage of fare reduction compared with their most recent trip (-10%, -30%, -50%). Participants were asked to answer two questions: How strongly would they support the congestion charge; and how likely would they be to take the bus to the city rather than drive. (A typical SP experiment is shown in Table 2.)

Table 2

† To make them closer to the real-world decision making process, in the SP scenarios presented to respondents, we intentionally combined fuel cost and journey time (instead of treating them as two separate factors) to remind respondents that these two factors are linearly correlated as often assumed in the literature (e.g., Henser et al., 2011).

‡ Rather than randomly choosing choice tasks from the full factorial that often generates a huge number of choice tasks, orthogonal fractional factorial design is a method for designing choice tasks in such a way that the attribute levels are orthogonal (i.e., no correlations between the levels of the two attributes); thus, the workload can be substantially reduced without significantly compromising the survey design's quality (ChoiceMetrics, 2012).

§ "Pivoting off" attribute levels of the most recent trip (rather than arbitrarily providing hard numbers) is a strategy often used by researchers to enhance the realism of SP scenarios (Henser, 2004; Hensher and Rose, 2007; Train and Wilson, 2009).

Unlike previous studies that attempted to explicitly measure the psychological determinants listed in Table 1, the focus of our survey was (perceived) benefits (e.g., congestion reduction, vehicle emission reduction), costs (e.g., negative impact on economy, unfairness to the poor, pressure on the existing transit system), revenue redistribution (e.g., improving public transport service and road infrastructure, improving the city environment), and behavioral adaptations (e.g., using public transport more, carpooling more, travelling to city less, and avoiding working in the city) of implementing a congestion charge. These four aspects are extremely important for acceptability of congestion charge, and were amongst main debating points when London was planning to implement the congestion charge (Litman, 2006). These factors appeared to be the issues that respondents were most concerned with during our pre-test, and they are also closely related to several determinants (such as freedom, fairness, effectiveness, and problem awareness) previously discussed. In addition, in our survey there were questions relating to socio-demographic characteristics (e.g., gender, annual income, education, employment status, car ownership, and primary transport mode for travelling to the city) to better capture individual heterogeneity. Note that in contrast to questions in the SP experiments where specific features (i.e., benefits and cost) of a congestion charge scheme are introduced, the primary purpose of these questions was to gauge respondents' support level and attitudes to implementing a congestion charge in these two cities in general because there was no existing congestion charge scheme in either city.

To facilitate a direct and objective city comparison, the same questionnaire was used in both cities with one exception: an additional question was added at the end of the questionnaire for Melbourne participants to gather their attitudes to the current toll highways in that city.

The survey questionnaire took 10 to 15 minutes to complete. To increase the response rate, each eligible participant was provided AU$10 cash reward as an incentive. Several pedestrian streets in the Brisbane and Melbourne CBDs were selected as sites to conduct the survey. Pedestrians were randomly selected and approached. During the survey process, it was found that drivers were largely under-represented. Thus, the approach was then adjusted to screen participants beforehand, and several car parks in the two cities were chosen as survey sites to increase the representation of drivers.

The survey in Brisbane started on 29 June and ended on 27 September 2012. In total, 150 valid responses were obtained. Respondents consisted of 55 car users and 95 commuters who used either public or active transport (See Liu & Zheng (2003) for more information on the survey). The survey in Melbourne was conducted in April 2013 across a time span of 18 days. In total, 173 valid responses were obtained. Basic information about the surveys and main variable used in this paper are summarized in Table 3 and Table 4, respectively.

Table 3

Table 4

To visually compare the two cities' survey results, violin plots were produced, as shown in Figure 1. As a combination of a box plot and a kernel density plot, a violin plot is an effective tool to graphically represent and compare information related to data distribution (Hintze and Nelson, 1998). Figure 1 reveals that (i) the respondents from Brisbane were generally older, richer, and better educated than their counterparts from Melbourne; (ii) the respondents from both cities generally agreed that implementing a congestion charge can help reduce traffic congestion, protect the environment by reducing vehicle emissions, and that revenue raised from implementing a congestion charge should be used to improve public transport services and road infrastructure. Meanwhile, the respondents from both cities generally disagreed that implementing a congestion charge is not good for the economy because people would travel to the city less frequently. In addition, they voiced their concern of the existing public transport systems in either city could not cope with the increased volume of passengers caused by implementing the congestion charge; (iii) while the respondents from Brisbane were generally not against the idea that revenue raised from implementing a congestion charge should be used to improve the environment, those from Melbourne were divided over this issue. Similarly, most of the respondents from Brisbane did not think that working in the city would be a less attractive option because of a congestion charge, while the respondents from Melbourne were divided over this issue, too; (iv) the respondents from both cities were divided over the following statements: implementing a congestion charge is unfair to poorer people; the congestion charge would make them seek carpooling with other people more often for travelling to the city; the congestion charge would make them use public transport more often for travelling to the city; and the congestion charge would make them travel to the city for shopping or entertainment less frequently. These individual heterogeneities and city differences are discussed more in Section 5.2 and Section 6.

Figure 1

4. Methodology

4.1 Ordered choices and proportional odds model

The two dependent variables in which this study was interested are ordinal: the extent to which a participant supports the congestion charge (*CCSupport*) and the extent to which a participant would take a bus, instead of driving to the city (*BusSupport*). Both were measured on a 5-point Likert scale: 1 for the most negative, and 5 for the most positive.

In contrast to interval scales, ordinal scales have two distinctive features: 1) a clear ordering of the levels exists; and 2) the absolute distances among different levels are unknown and unobservable. There is a rich literature and many well-known methods (e.g., Multinomial Logit, MNL) for effectively and efficiently modeling categorical data by treating them as nominal. However, ignoring the ordering information can produce different and less powerful results. Meanwhile, treating an ordered categorical variable as ordinal rather than nominal has many advantages, such as parsimoniousness, simpler interpretations, greater detection power, greater flexibility, and more similarity to ordinary regression analysis. Agresti (2010) provides a detailed discussion on the importance of utilizing the ordinality.

A typical formulation of the ordinal data modeling problem is motivated by the latent regression perspective, as mathematically defined in Equation (1):

$$Y = j \; if \; \alpha_{j-1} < Y^* \leq \alpha_j \qquad (1)$$

Where Y^* is a continuous latent variable that is assumed to underlie the observed ordinal data. More specifically, $Y^* = \beta' X + \epsilon$ and X is a vector of explanatory variables, β is a vector of coefficients, and ϵ is an error term. j is an ordinal response. α is a set of cutpoints of the continuous scale for Y^*. In other words, *Y* is observed to be in category *j* when the latent variable falls in the *j*th interval.

In modeling ordinal dependent variables, a widely-used method of maintaining the category order is to apply the logit transformation to the cumulative probabilities, as defined in Equation (2):

$$logit[P(Y \leq j)] = \log \left({P(Y \leq j)}/{1 - P(Y \leq j)} \right) \qquad (2)$$

Note that the ordinary binary logit is a special case of Equation (2) when the response outcomes are collapsed into two groups, *Y<=j* and *Y>j*.

A typical model for the cumulative logits is shown in Equation (3):

$$logit[P(Y \leq j)] = \alpha_j + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_n x_n = \alpha_j + \beta' X \qquad (3)$$

where *j=1,…,c-1;c* is the total number of categories. $x_1, x_2, \ldots, x_n$ are *n* explanatory variables; $\beta_1, \beta_2, \ldots, \beta_n$ are corresponding coefficients.

Equation (3) implies that for different *j*, the explanatory variables have a common effect, as reflected by the common β, which has significant impact on interpreting the model's results, as illustrated by the following example.

Suppose we have two points from the explanatory variables, X_a and X_b (note that *X* is a vector), then

$$logit[P(Y \leq j|X_a)] - logit[P(Y \leq j)|X_b] = \beta'(X_a - X_b) \qquad (4)$$

Equation (4) indicates that the odds of making response *Y<=j* at X_a are *exp*($\beta'(X_a - X_b)$) times the odds at X_b. That is, the log odds ratio is proportional to the distance between these two points. This proportionality remains constant across different categories. Because of this property, the model in Equation (3) is often referred to as a 'proportional odds model'. This type of model has been extensively studied and widely used in the literature (Greene and

Hensher, 2009; Agresti, 2010) – mainly because of its parsimoniousness and easy interpretation. Thus, it is also employed in this study.

4.2 Random-effects ordered logit

The SP data collected in Brisbane and Melbourne are essentially panel data because 9 observations were made for each individual. Naturally, the observations from the same individual may be correlated. Furthermore, different individuals may have different cutpoints in their responses. The fixed effects model discussed above cannot capture such correlation and subjectivity. To overcome this issue, the model in Equation (3) has been extended by introducing a random variable into the underlying latent variable model, as shown in Equation (5):

$$logit[P(Y_{it} \leq j)] = \alpha_j + (u_i + \beta_1 x_{1it} + \beta_2 x_{1it} + \cdots + \beta_n x_{nit}) = \alpha_j + (u_i + \beta' X_{it}) \qquad (5)$$

where Y_{it} denotes the response for observation *t* for individual *i*; $x_{1it}, x_{1it}, \dots, x_{nit}$ denote the values of the *n* explanatory variables for that observation; u_i denotes the random effect for individual i, which is unobserved and usually assumed to vary among individuals according to a normal distribution $N(0, \sigma_u^2)$. As the variance σ_u^2 increases, the correlation between two observations from the same individual also tends to increase.

ML (Maximum Likelihood) can be used to estimate the parameters in Model (5). However, u_i is estimated as the expectation of its posterior conditional distribution (given the observations) which requires numerical integration or Monte Carlo approximation. (Interested readers can refer to Agresti (2010) for more detail.)

5. Data analysis

5.1 Data description

Information that has been collected through the survey includes: socio-demographic data (e.g., gender, age, income, education); current travel behavior (e.g., the primary transport mode to the city); perspectives on the current transport systems; attitudes to the potential benefits and costs of implementing a congestion charge scheme; and the SP experiments on the impact of implementing a congestion charge. The main variables used in this study are listed in Table 4, and responses to the attitudinal variables are provided in Table 5.

5.2 Modeling and interpretation

The models in this study are developed mainly using the R-package "ordinal". This package is open-source, highly flexible, and well-maintained. Thus, it is often used to analyze ordinal data (Christensen, 2013).

(1) Public acceptance of congestion charge

A series of random-effects ordered logit models were developed to model public acceptance of congestion charge as a function of a variety of factors, including the cost and benefits of a congestion charge, socio-demographic features, and attitudes. After estimating and comparing several random-effects ordered logit models, the model with the best performance was selected; this is presented in Table 6. As shown in this table, the model demonstrates an excellent fit to the data. Notable random effects exist in the data, as evidenced by the significant variance (4.625).

Table 5

Table 6 shows that *'charge increase'*, *'fuel consumption (journey time) decrease'*, and *'bus fare decrease'* significantly affect respondents' acceptance of congestion charge. More specifically, for a given respondent, for a unit increase of charge, the estimated odds of Response 5 "strongly support" instead of other categories (e.g., "support", "neutral") or Response 4 "support" instead of Responses 1, 2, or 3 will decrease by *(1- exp(-0.203)) ×100%=18%*; for a unit decrease in fuel consumption and in bus fare, the estimated odds of Response 5 "strongly support" instead of other categories (e.g., "support", "neutral", etc.) or Response 4 "support" instead of Responses 1, 2, or 3 will increase by *(exp(0.029)-1)×100%=2.9%* , and *(exp(0.027)-1)×100%=2.7%*, respectively.

Meanwhile, socio-demographic features also have a significant impact on respondents' acceptance of the congestion charge. When controlling for other factors, for a respondent whose primary transport mode is public transport, or cycling and walking, the estimated odds of Response 5 "strongly support" instead of other categories (e.g., "support", "neutral") or Response 4 ("support") instead of Responses 1, 2, or 3 will increase respectively by *301%* and *298%*, relative to a respondent whose primary transport mode is private vehicles, and has the same random effects value.

Perceptions (attitudes) also have a notable influence on respondents' acceptance of implementing the congestion charge. Overall, the stronger respondents believe that implementing the charge can help protect the environment by reducing vehicle emissions, the more supportive of the charge they become. In contrast, the stronger respondents believe that the congestion charge would decrease their travel to the city for shopping or entertainment, the less supportive of it they become. More specifically, for a given respondent, for a unit increase in the respondent's level of support for the statement that *implementing a congestion charge can help protect the environment by reducing vehicle emissions*, the estimated odds of Response 5 "strongly support" instead of other categories (e.g., "support", "neutral") or Response 4 "support" instead of Responses1, 2, or 3 will increase by *203%*. However, for a unit increase in the respondent's level of support for the statement that *the congestion charge would make me travel to the city for shopping or entertainment less frequently*, the estimated odds of Response 5 "strongly support" instead of other categories (e.g., "support", "neutral") or Response 4 "support" instead of Responses 1, 2, or 3 will decrease by *36%*.

Table 6

(2) Public acceptance of bus transport

Similar to the model for public acceptance of the congestion charge, a series of random-effects ordered logit models were estimated and compared, with the intent of measuring the relationship between public acceptance of bus transport and potential contributing factors (e.g., cost and benefits of congestion charge, socio-demographic features, and attitudes). The final model is summarized in Table 7. Notable random effects exist in the data, as evidenced by the significant variance (9.875).

Table 7 shows that *'congestion charge increase'*, *'fuel consumption decrease'*, and *'bus fare decrease'* significantly affect respondents' likelihood of taking a bus to the city. More specifically, for a given respondent, for a unit increase of charge, the estimated odds of Response 5 "very likely (taking a bus)" instead of other categories (e.g., "likely", "neutral") or Response 4 "likely (taking a bus)" instead of Responses 1, 2, or 3 will increase by *9.9%*; for a unit decrease in fuel consumption, the estimated odds of Response 5 "very likely (taking a bus)" instead of other categories (e.g., "likely", "neutral") or Response 4 "likely" instead of Responses 1, 2, or 3 will decrease by *1.3%*; for a unit decrease in bus fare, the estimated odds of Response 5 "very likely" instead of other categories (e.g., "likely", "neutral") or Response 4 "likely" instead of Responses 1, 2, or 3 will increase by *5.2%.*

Meanwhile, it is observed that the primary transport mode also has a significant influence on the likelihood of taking a bus. Relative to a respondent whose primary transport mode is private vehicle, and controlling for other factors including random effects, for a respondent whose primary transport mode is public transport, or cycling and walking, the estimated odds of Response 5 "very likely (taking a bus)" instead of other categories (e.g., "likely", "neutral") or Response 4 "likely (taking a bus)" instead of Responses 1, 2, or 3, will increase by $exp(3.663)=39$ times, and $exp(3.546)=35$ times, respectively.

The influence of perceptions or attitudes on respondents' likelihood of taking a bus is significant. The stronger respondents believe that *implementing a congestion charge can help protect the environment by reducing vehicle emissions,* the more likely they will be to take a bus to the city. More specifically, for a unit increase in a respondent's level of support for the statement, the estimated odds of Response 5 "very likely (taking a bus)" instead of other categories (e.g., "likely", "neutral") or Response 4 "likely (taking a bus)" instead of Responses 1, 2, or 3 will increase by *96%.*

Furthermore, respondents' level of support for implementing the congestion charge has a strong impact on their likelihood of taking a bus. For a given respondent, a unit increase in the level of support for the implementation of the congestion charge increases the estimated odds of Response 5 "very likely (taking a bus)" instead of other categories (e.g., "likely", "neutral") or Response 4 "likely (taking a bus)", instead of Responses 1, 2, or 3 by *45%.*

However, this result should be treated with caution because the direction of causality between respondents' level of support for implementing the congestion charge and their likelihood of taking a bus is ambiguous. This complexity is also reflected in the fact that the respondents from both cities were divided over the statement that the congestion charge would make them use public transport more often for travelling to the city, as shown in Figure 1. To shed some light on this ambiguity, we divided the respondents to two groups: bus riders whose primary transport mode is bus and non bus riders whose primary transport mode is not bus. For each group, the correlation between these two factors were calculated and summarized in Table 8. To make the results more reliable, both Pearson (it assumes a linear relationship between two variables) and Spearman (no linearity is assumed) correlations were calculated. As this table shows, significant and positive Pearson (and Spearman) correlations between these two factors are obtained for each group, which confirms the modelling result in Table 7. However, these positive correlations for each group should be interpreted differently: For bus riders, these correlations indicate that the more likely they take a bus, the greater support they give for implementing the congestion charge; for non bus riders, the causality should be the opposite: the greater support they give for implementing the congestion charge, the more likely they take a bus.

To gain more insight on the causality path of between respondents' level of support for implementing the congestion charge and their likelihood of taking a bus, correlation between *TransitMore* and user group status (i.e., bus riders vs. non bus riders) was also tested to gauge user group status' potential impact on stated would-be transit usage because of the implementation of a congestion charge scheme. As shown in Table 8, a significant and positive correlation exists between user group status and *TransitMore*. This result complements the discussion above and indicates that the direction of causality between these two factors is likely to be different for different user groups. Such consistency of these analyses from different perspectives underscores the reliability and trustworthiness of our study.

Table 7

Table 8

(3) City difference

To visually compare the two cities' support level of implementing a congestion charge, violin plots were produced, as shown in Figure 2. Although the violin plots show notable similarities between the two cities' attitudes to a congestion charge and to bus use, they clearly indicate that respondents from Brisbane are generally more favorably disposed to both; this is consistent with the results shown in Table 6 and Table 7. The models in Table 6 and Table 7 clearly show the city differences in public acceptance of a congestion charge and the likelihood of taking a bus. As shown in Table 6, controlling for other factors and for random effects, a respondent from Melbourne is generally less supportive of a congestion charge compared with a respondent from Brisbane (i.e., the estimated odds will decrease by *95%*). As shown in Table 7, controlling for other factors and random effects, a respondent from Melbourne is generally less likely to take a bus compared with a respondent from Brisbane (where the estimated odds will decrease by *53%*).

As shown in Figure 1, between the respondents from Brisbane and from Melbourne, there exist notable differences in age, income, education, attitudes and perceptions towards implementing a congestion charge scheme. Some of these differences may have impact on the different support levels to implementing a congestion charge scheme in these two cities. To better understand factors that may contribute to such city difference, interactions between city and respondents' background, attitudes, and perceptions, and these interactions' contribution to the city difference in acceptability of a congestion charge were scrutinized. Result (see Table 6) shows that interactions between *BadEconomy* and *City* (i.e., *BadEconomyMelbourne*), between *TransitMore* and *City* (i.e., *TransitMoreMelbourne*), and between *Education* and *City* (i.e., *EducationMelbourne*) are significant factors. More specifically, while for the respondents from Brisbane, their acceptability of a congestion charge was not influenced by: education, the extent to which they agreed with the following statements: implementing a congestion charge is not good for the economy because people would travel to the city less frequently, and the congestion charge would make them use public transport more often for travelling to the city, this is not the case for the respondents from Melbourne. Generally, if a respondent from Melbourne more strongly believed that a congestion charge would have negative impact on economy, this person's support level to a congestion charge would decrease; if a respondent from Melbourne stated that public transport would be more frequently used for travelling to the city, this person's support level to congestion charge would increase; in addition, a respondent from Melbourne with a higher educational background shows a higher level of acceptance of congestion charge compared with these with a lower educational background.

Figure 2

Another possible reason for the city difference is that toll roads are prevalent in Melbourne, while they are rare in Brisbane. Thus, respondents' attitudes to the current toll roads in Melbourne may have a significant influence on their attitudes to the implementation of a congestion charge. To test this hypothesis, a separate model was developed for respondents in Melbourne (a separate model for respondents in Brisbane was also developed and summarized in Table A, Appendix), so as to capture the relationship between attitudes to tolls and attitudes to a congestion charge, as shown in Table 9. Again, significant random effects exist in the data (variance=3.465). Compared with the model in Table 6, attitudes to existing tolls were, indeed, strongly correlated with levels of support for congestion charge. For a given respondent, the stronger their support for the current toll highways in Melbourne, the more supportive they were of the congestion charge. More specifically, for a unit increase in a respondent's level of support for the current toll highways in Melbourne, the estimated odds of Response 5 "strongly support (implementing the congestion charge)" instead of other categories (e.g., "support", "neutral") or Response 4 "support (implementing the congestion charge)" instead of Responses 1, 2, or 3 increases by *98%.* This finding is not surprising because both congestion charge and tolls are road pricing, and experience with one can naturally have impact on perceptions to the other (Small and Gomez-Ibanez 1998; FHWA 2014).

It is also worthy of pointing out that in this model *BadEconomy*, *TransitMore*, and *Education* again appear to be significant with signs consistent with what are in Table 6, which indicates the reliability of our analysis.

Table 9

Finally, to further explain the city differences, a correlation matrix is produced as shown in Table 10. This table reveals that correlation patterns among these factors are similar across Brisbane and Melbourne. Some factors are significantly correlated with each other in both cities (e.g., *BadEconomy* and *ToCityLess*). The main difference is that in Melbourne *Tolls* is significantly correlated with *ReduceEmis*, *ToCityLess*, and moderately correlated with *Education* (i.e., a respondent with a higher educational qualification tends to have a higher support level to the existing toll highways, compared with one a lower educational qualification.). Thus, confounding effect from significant correlations between some of the factors may also (partially) cause the city differences.

Table 10

6. Discussion and conclusions

Gaining public support is critical for successfully implementing a congestion charge. To better understand factors that have a potentially significant influence on public support for the charge, a paper-based survey was conducted in two Australian capital cities – Brisbane and Melbourne. The respondents' level of support for a congestion charge and their propensity for taking a bus to city areas have been measured on the 5-point Likert scale through a series of stated preference experiments, and the use of socio-demographic and attitudinal information. Based on the survey data, the random-effects ordered logit models have been applied to identify significant factors, and to quantify their relationship with respondents' level of support for a congestion charge and their likelihood of taking a bus. The data analyses show that significant correlation and subjectivity exist within the responses in the survey data; this indicates the necessity of considering random effects. Major findings from the analysis are discussed below in relation to the literature reviewed.

First, as expected, the amount of the congestion charge and the direct financial benefits of implementing the congestion charge – a decrease in fuel consumption (travel time) for private vehicle users, and a decrease in bus fare for transit users – have an important and positive influence on respondents' level of support for implementing the congestion charge and on their likelihood of taking a bus to city areas. The financial cost can have significant impact on personal freedom. If the amount of the congestion charge is high, some people will be forced to give up the freedom of driving. Our finding is consistent with the literature that acceptability of congestion charge decreases if people regard it as an infringement of personal freedom (Jakobsson et al., 2000; Brehm, 1966; Steg, 1996; Tertoolen et al., 1998; Baron and Jurney, 1993; Kim et al., 2013).

Similarly, our analysis shows that anticipated behavioural adaptation induced by the congestion charge influences acceptability because such behavioral adaptation can be undesirable (e.g., (forced) lower frequency of travelling to the city) to an individual and thus be regarded as the infringement of personal freedom, too. More specifically, the more respondents agree with that congestion charge would make them travel to the city for shopping or entertainment less frequently, the less unlikely they would support congestion charge.

Meanwhile, respondents' perception of the congestion charge's contribution in protecting the environment by reducing vehicle emissions has a significant impact on their support for its implementation. Generally, the greater extent to which respondents agreed with that congestion charge can protect the environment by reducing vehicle emissions, the higher level of support they showed for the congestion charge. In contrast, congestion charge's role in reducing congestion has no significant influence on acceptability. This finding has two implications: on the one hand, it confirms that perceived effectiveness is a significant determinant of a congestion charge's acceptability as widely reported in the literature (e.g., Bartley, 1995; Taylor et al., 2010). On the other hand, when policy makers are implementing a congestion charge, they need to be cautious about what is the targeted problem (effectiveness). The targeted problem (effectiveness) can be different in different cities. After reviewing existing congestion charge schemes for FHWA, Bhatt et al. (2008) commented that pollution rather than congestion may be the most central problem for pricing. As revealed in our study, when promoting congestion charge in Brisbane and Melbourne, it seems to be more appropriate to emphasize the effectiveness on reducing vehicle emissions. Reducing congestion should be treated as secondary. This is not surprising because traffic congestion in Brisbane or in Melbourne is not particularly serious, compared with those in other big cities, such as New York City, and Beijing. There are excellent public transport systems in both cities. In addition, Australia is a nation well-known for its sustainability consciousness, and its public is generally keen for environment protection. For example, the environment is often ranked a top issue to voters (ABC, 2013); the world's first Green party is in Australia and the environmental movement in Australia is the first in the world to become a political force (Australian Greens, 2014). A message to policy makers is that to increase its acceptability, a congestion charge scheme needs to be designed to and promoted to meet scheme concerns.

Generally the respondents in both cities were not concerned with congestion charge's unfairness to the poor. Distributional or equity effect of congestion charge was investigated by many researchers, and the most debated question is whether congestion charge is unfair to the poor. This was also one major concern voiced when people were protesting over the congestion charge in London (Banister, 2003; Litman, 2011). Contradictory conclusions were drawn by different studies (Richardson, 1974; Arnott et al., 1994; Eliasson and Mattsson, 2006). Eliasson and Mattsson (2006) developed a method to quantitatively assess equity effects of congestion charge, and concluded that the initial travel patterns and revenue redistribution are two most important factors for the net impact of congestion charge. This can well explain the phenomenon discovered in our survey: respondents' seemingly indifference to congestion charge's unfairness to the poor. Both cities currently have excellent public transport systems (e.g., public bike-hire system, passenger train services and busways in Brisbane that comprise grade-separated bus-only corridors; the world's largest tram network, bus and coach service, the metro railway network, and public bike-hire system in Melbourne) (TransLink, 2014; PTV, 2014), which provides decent alternatives for people with financial difficulty to meet their travel needs. Moreover, public transport service's quality would be further improved by using part of the revenue collected from congestion charge, which in turn would benefit the poor. These facts can also explain that no linkage between support level of congestion charge and sufficiency of the existing public transport systems was detected in either city (respondents had some concern with congestion charge's pressure on the existing transport systems as shown in Figure 1; however, such concern is not strong enough to influence their support level of congestion charge).

Revenue redistribution is often regarded as a key factor for public acceptance of congestion charge (Zhao et al., 2010; Pike, 2010). However, our analysis shows that revenue redistribution has little impact on respondents' acceptance of congestion charge in both cities. A possible reason is that revenue redistribution is related to perceived fairness of the congestion charge scheme (Eliasson and Mattsson, 2006), which means that impact of revenue redistribution can have been (partially) captured by that of perceived fairness. Another possible reason is that respondents' preferences for revenue redistribution can be different from the two provided in the survey. As Bhatt et al. (2008) argued that revenues directed towards transit and/or road infrastructure improvements may gain support amongst some people, but may compete with other preferences amongst others.

Strong linkage exists between respondents' support for the congestion charge and the likelihood of their taking a bus. Although this is consistent with the often-reported observation that patronage of public transport increases after the introduction of a congestion charge scheme (e.g., London, Stockholm), the direction of causality between them is ambiguous. For non bus riders, the greater support they give for implementing the congestion charge, the more likely they take a bus. However, for bus riders, the causality should be reverse: the more likely they take a bus, the greater support they give for implementing the congestion charge.

Our analysis also reveals the significant influences of respondents' sociodemographic background on acceptability of congestion charge. For example, respondents' current primary transport mode for travelling to the city areas has a pronounced impact on their support for implementing congestion charge. Respondents whose primary transport mode is public transport or cycling and walking show much stronger support for the congestion charge than their counterparts who primarily drive to the city. This supports the conclusion in Eliasson and Mattsson (2006) that initial travel pattern is a critical factor determining a congestion charge's net effects on people's everyday life. While Rentzou et al. (2011) found income influences the level of acceptance in Athens, most studies (e.g., Jaensirisak et al., 2005; Bhatt et al., 2008) did not find any significant influence of income on acceptability of congestion charge. Our analysis also shows that acceptability of congestion charge does not vary significantly across different income groups. Education can also be a significant factor in acceptability of congestion charge; however, we were unable to find its impact amongst respondents in Brisbane.

While a few studies investigated cultural difference in congestion charge's acceptability using samples from different countries (e.g., Schmöcker et al., 2012; Kim et al., 2013), another unique contribution of this study is that our analysis clearly shows the existence of notable difference across cities within the same culture. Controlling for other factors and random effects, a respondent from Melbourne is generally less supportive of the congestion charge, compared with a respondent from Brisbane. Similarly, controlling for other factors and random effects, a respondent from Melbourne is generally less likely to take a bus compared with a respondent from Brisbane. Our analysis shows that this phenomenon can be (partly) explained by sociodemographic differences, perceptional (attitudinal) differences, and specifics of the current transport systems (e.g., the prevalence of toll highways in Melbourne, compared with the situation in Brisbane). The existence of city difference even within the same culture highlights the complexity of understanding, promoting, and gaining acceptability of congestion charge. Factors and their relative importance should be location-specific and scheme-specific. This also partly explains why contradictory conclusions were often reported in the literature.

Finally, because of the SP method used in this study to gauge respondents' sensitivity to different amounts of congest charge, results from this study can be useful for predicting travel demand by considering congestion charge's impact. More specifically, congestion charge's impact on travellers' mode choices can be better estimated using the results (or methods) of this study, such as the percentage of increased demand on bus, and the percentage of decreased demand on car. In addition, these results can also be utilized to assess the effectiveness (benefits) of implementing a congestion charge, such as its effectiveness on congestion mitigation, on fuel conservation, and on environment protection. However, caution should be exercised for any predicting activities based on SP experiments because inconsistency may exist between people's stated preferences and their actual choices (Train and Wilson, 2009).

The findings from this study can provide valuable guidance for policy makers in developing effective promotional strategies to increase public support for the congestion charge. However, the findings need to be verified by using a larger sample. Meanwhile, it should be noted that gaining political support is also a vital issue; however, this political aspect of the issue was beyond the scope of this work, and is a topic for future research.

Acknowledgements: The authors were grateful for two anonymous reviewers' insightful and constructive comments, which have significantly improved this paper's quality. This research was partially funded by the United States Studies Centre at the University of Sydney, by the Early Career Academic Development program at Queensland University of Technology, and by the Faculty of Engineering Seed Funding Scheme at Monash University. The efforts by Ms. Xiaoying Cao, Ms. Alisa Redsell, Mr. Sam Hughes on collecting survey data in Melbourne are appreciated. Also, the first author would like to thank Dr Rune Haubo Bojesen Christensen at Technical University of Denmark for discussions on using the R-package "*ordinal*".

References

ABC (2013). Vote compass: the most important issues to voters. http://www.abc.net.au/news/2013-08-09/vote-compass-data-results-important-issues/4872896; accessed on 27/03/2014.

Agresti, A. (2010). Analysis of ordinal categorical data. Second Edition. John Wiley & Sons.

Aldy, J. E., Krupnick, A. J., Newell, R. G., Parry, I. W. H., Pizer, W. A. (2010). Designing climate mitigation policy. Journal of Economic Literature 48 (4), 903 – 934.

Arnott, R., de Palma, A., Lindsey, R. (1994). The welfare effects of congestion tolls with heterogeneous commuters. Journal of Transport Economics and Policy 28, 139–161.

Australian Greens (2014). History. http://greens.org.au/our-story. accessed on 27/03/2014.

Banister, D. (2003). Critical pragmatism and congestion charging in London. International Social Science Journal, 55(2), 174–174.

Baron, J., Jurney, J. (1993). Norm against voting for coerced reform. Journal of Personality and Social Psychology 64, 347–355.

Bartley, B., (1995). Mobility impacts, reactions and options, traffic demand management options in Europe: the MIRO project. Traffic Engineering and Control 36, 596–603.

Bhatt, K., Higgins, T., Berg, J. T. (2008). Lessons learned from international experience in congestion pricing. US Department of Transportation & Federal Highway Administration.

Bonsall, P.W., Lythgoe, W.F. (2009). Factors affecting the amount of effort expended in responding to questions in behavioural choice experiments. Journal of Choice Modelling 2 (2), 99–119.

Bonsall, P.W., Shires, J., Ngoduy, D., Link, H., Becker, A., Papaioannou, P., Xanthopoulos, P. (2007). Optimal complexity of prices for transport infrastructure, Deliverable 6 of GRACE. Leeds.

Brehm, J.W. (1966). A theory of psychological reactance. Academic Press, New York.

Bristow, A. L., Wardman, M., Zanni, A. M., Chintakayala, P. K. (2010). Public acceptability of personal carbon trading and carbon tax. Ecological Economics 69, 1824 – 1837.

BTRE, (2007). Estimating urban traffic and congestion cost trends for Australian cities, Bureau of Transport and Regional Economics, Department of Transport and Regional Services, Canberra, Australia.

ChoiceMetrics, (2012). Ngene 1.1.1 User Manual & Reference Guide, Australia.

Christensen, R.H.B. (2013). Analysis of ordinal data with cumulative link models – estimation with the R-package ordinal. http://cran.r-project.org/web/packages/ordinal/index.html (accessed on March 1 2013)

Clee, A. (2007). Driving away the traffic: What lessons can New York learn from London and Stockholm's experiences with congestion charging? Tufts University.

Council of Capital City Lord Mayors (CCLM) (2013.) National Urban Policy discussion paper, Australia.

Department of Transport, (2008). Investing in Transport - Chapter 4: Melbourne's roads - more traffic, more congestion. [Online] Available at: http://www.transport.vic.gov.au/research/research-and-policy-development-publications/investing-in-transport-report/investing-in-transport-chapter-4-melbournes-roads-more-traffic,-more-congestion.

Dresner, S., Dunne, L., Clinch, P., & Beuermann, C. (2006). Social and political responses to ecological tax reform in Europe: an introduction to the special issue. Energy Policy, 34(8), 895-904.

Eliasson, J. (2009). A cost–benefit analysis of the Stockholm congestion charging system. Transportation Research Part A, 43(4), 468-480.

Eliasson, J., Hultkrantz, L., Nerhagen, L., Rosqvist, L. S. (2009). The Stockholm congestion–charging trial 2006: Overview of effects. Transportation Research Part A, 43(3), 240-250.

Eliasson, J., Mattsson, L. (2006). Equity effects of congestion pricing quantitative methodology and a case study for Stockholm. Transportation Research Part A 40, 602 – 620.

Ferraro, P. J., Miranda, J. J. (2013). Heterogeneous treatment effects and mechanisms in information-based environmental policies: Evidence from a large-scale natural field experiment. Resource and Energy Economics, 35(3), 356-379.

Federal Highway Administration (FHWA), 2014. Road pricing. U.S. Department of Transportation. http://www.fhwa.dot.gov/ipd/revenue/road_pricing/; accessed on 10 October 2014.

Francke, A., Kaniok, D. (2013). Responses to differentiated road pricing schemes. Transportation Research Part A 48, 25 – 30.

Fujii, S. (2005). A condition for development of trust in government. Japanese Journal of Experimental Social Psychology 45 (1), 27-41.

Fujii, S., Gärling, T., Jakobsson, C., Jou, R.C. (2004). A cross-country study of fairness and infringement on freedom as determinants of car owners' acceptance of road pricing. Transportation 31, 285–295.

Gärling, T., Jakobsson, C., Loukopoulos, P., Fujii, S. (2008). Acceptability of road pricing. In: Verhoef, E., Bliemer, E., Steg, L., Van Wee, B. (Eds.), Pricing in Road Transport: Multidisciplinary Perspectives. Edward Elgar, Cheltenham.

Gaunt, M., Rye, T. & Allen, S. (2007). Public acceptability of road user charging: The case of Edinburgh and the 2005 Referendum. Transport Reviews: A Transnational Transdisciplinary Journal, 27(1), 85-102.

Greene, W. H., Hensher, D. A. (2009). Modeling ordered choices: A primer. Cambridge University Press.

Hårsman, B. and Quigley, J. M. (2010). Political and public acceptability of congestion pricing: Ideology and self-interest. Journal of Policy Analysis and Management, 29(4), 854–874.

Hatori T, Fujii S. (2008). The mass man as defector: Implications of Ortega's ''the rebellion of the masses'' on social dilemma research. International Journal of Psychology 4(3): 431.

Hau, T.D. (1990). Electronic Road Pricing: Developments in Hong Kong 1983-1989. Journal of Transport Economics and Policy, 24(2), 203-214.

Hensher, D. A. (2004). Accounting for stated choice design dimensionality in willingness to pay for travel time savings. Transportation Research Part B, 38, 425-446.

Hensher, D. A. and Li, Z. (2013). Referendum voting in road pricing reform: A review of the evidence. Transport Policy, 25, 186-197.

Hensher, D. A. and Rose, J. (2007). Development of commuter and noncommuter mode choice models for the assessment of new public transport infrastructure projects: A case study. Transportation Research Part A, 41, 428-443.

Hensher, D.A., Rose, J.M., Collins, A.T. (2011). Identifying commuter preferences for existing modes and a proposed Metro in Sydney, Australia with special reference to crowding. Public Transport 3(2), 109 – 147.

Hensher, D. A., Rose, J. M., Greene, W. H. (2005). Applied choice analysis: A primer. Cambridge University Press.

Hintze, J. L., and Nelson, R.D. (1998). Violin plots: A box plot-density trace synergism. The American Statistician, 52(2):181-84.

Ittner, H., Becker, R., Kals, E. (2003). Willingness to support traffic policy measures: the role of justice. In: Schade, J., Schlag, B. (Eds.), Acceptability of Transport Pricing Strategies. Elsevier, Oxford.

Jaensirisak, S., Wardman, M., May, A. D. (2005). Explaining Variations in Public Acceptability of Road Pricing Schemes. Journal of Transport Economics and Policy, 39(2), 127-153.

Jakobsson, C., Fujii, S., Gärling, T. (2000). Determinants of private car users' acceptability of road pricing. Transport Policy 7, 133–158.

Jones, P.M. (2003). Acceptability of road user charging: Meeting the challenge. In J. Schade and B. Schlag (Eds) Acceptability of Transport Pricing Strategies, 27-62. Pergamon, Oxford.

Kim J., Schmöcker, J., Fujii, S., Noland, R.B. (2013). Attitudes towards road pricing and environmental taxation among US and UK students. Transportation Research Part A 48, 50 - 62.

Leape, J. (2006). The London congestion charge. The Journal of Economic Perspectives, 20(4), 1-176.

Litman, T. (2011). London congestion pricing: Implications for other cities. Victoria Transport Policy Institute.

Liu, Z. and Meng, Q. and Wang, S. (2013). Speed-based Equation Chapter 1 Section 1 Toll Design for Cordon-Based Congestion Pricing Scheme, Transportation Research Part C, 31, 83-98.

Liu, C. and Zheng, Z. (2013). Public acceptance towards congestion charge: a case study of Brisbane. The 13th COTA International Conference of Transportation Professionals, Shenzhen, China.

Livingstone, K. (2004). The challenge of driving through change: Introducing congestion charging in central London. Planning Theory & Practice, 5(4), 490-498.

Louviere, J. J., Hensher, D. A., Swait, J. D. (2000). Stated choice methods: Analysis and applications. Cambridge University Press.

Luk, J. and Chung, E. (1997). Public acceptance and technologies for road pricing, Vermont South, Victoria, Australia: ARRB Transport Research Ltd.

Martino, A., Chiffi, D., Boscherini, E., Suter, S., Hajdul, M., Bonsall, P., Evangelinos, C., Wieland, B. (2008). Report of charge differentiation for HGV and motorway toll differentiation to combat time space congestion. Deliverable 8.3-9.2, DIFFERENT – User Reaction and Efficient Differentiation of Charges and Tolls: Milano, Bern, Poznan, Dresden, Leeds.

Manners, P. (2010). Congestion pricing: why and how. Centre for International Economic, Canberra, Australia.

Meng, Q. and Liu, Z. (2012). Impact Analysis of Cordon-based Congestion Pricing Scheme on Mode-Split of Bimodal Transportation Network, Transportation Research Part C, 21(1), 134-147.

Pike, P. E. (2010). Congestion charging: Challenges and opportunities. The International Council on Clean Transportation.

PTV (2014). Public Transport Victoria. http://ptv.vic.gov.au/. Accessed on 04 April 2014.

Rentziou, A., Milioti, C., Gkritza, K., Karlaftis, M. G. (2011). Urban Road Pricing: Modeling Public Acceptance. Journal of Urban Planning and Development, 137, 56-64.

Richards, M. G. (2006). Congestion charging in London: the policy and the politics, Palgrave Macmillan.

Richardson, H.W. (1974). A note on the distributional effects of road pricing. Journal of Transport Economics and Policy 8, 82–85.

Road and Traffic Authority New South Wales (2010). Time of day tolling. [Online] Available at: http://www.rta.nsw.gov.au/usingroads/downloads/todtolling/tod_janjan0910.pdf.

Rokeach M. (1973). The Nature of Human Values. New York: The Free Press.

Rößger, L., Schade, J., Obst, D., Gehlert, T., Schlag, B., Bonsall, P.W., Lythgoe, B. (2008). Psychological constraints of user reactions towards differentiated charging. Deliverable 4.2. EU-Project DIFFERENT, Dresden, Leeds.

Santos, G. (2008). The London congestion charging scheme. Chapter 8 of the Book: Road congestion pricing in Europe – implications for the United States, edited by Richardson, H.W., and Bae, C-H. C., 159-175.

Schade, J., Schlag, B. (2003). Acceptability of transport pricing strategies. Elsevier, Oxford.

Schade, J., Schlag, B. (2000). Public acceptability of traffic demand management in Europe. Traffic Engineering and Control 41 (8), 314–318.

Schaller, B. (2010). New York City's congestion pricing experience and implications for road pricing acceptance in the United States. Transport Policy, 17, 266-273.

Schmöcker, J.-D., Pettersson, P., Fujii, S. (2012). Comparative analysis of proximal and distal determinants for the acceptance of coercive charging policies in the U.K. and Japan. International Journal of Sustainable Transportation 6 (3), 156–173.

Schuitema, G., Steg, L., Forward, S. (2010). Explaining differences in acceptability before and acceptance after the implementation of a congestion charge in Stockholm. Transportation Research Part A, 44(2), 99-109.

Schwanen, T., Banister, D., Anable, J. (2011). Scientific research about climate change mitigation in transport: A critical review. Transportation Research Part A 45, 993 – 1006.

Small, K. A., Gomez-Ibanez, J. A. (1998). Road pricing for congestion management: the transition from theory to policy, In: Button, K.J., Verhoef, E.T. (Eds.), Road Pricing, Traffic Congestion and the Environment: Issues of Efficiency and Social Feasibility. Edward Elgar, Cheltenham, pp. 213–246.

Steg, E.M. (1996). Behaviour change for reducing the use of motor-cars: Theoretical analysis and empirical study on problem awareness, willingness-to-change and evaluation of policy measures. Ph.D. Thesis, University of Groningen, The Netherlands.

Steg, L. (2003). Factors influencing the acceptability and effectiveness of transport pricing. In: Schade, J., Schlag, B. (Eds.), Acceptability of Transport Pricing Strategies. Elsevier, Oxford.

Sterner, T., Coria, J. (2012). Policy instruments for environmental and natural resource management. RFF Press.

Sturcke, J. (2008). Manchester says no to congestion charging. [Online]
Available at: http://www.guardian.co.uk/politics/2008/dec/12/congestioncharging-transport.

TransLink (2014). http://translink.com.au/. Accessed on 04 April 2014.

Taylor, B.D., Iseki, H., Kalauskas, R. (2010). Addressing equity issues in political debated over road pricing. Paper presented at the 89th annual meeting of the Transportation Research Board, Washington, DC.

Tertoolen, G., Kreveld, D.V., Verstraten, E.C.H. (1998). Psychological resistance against attempts to reduce private car use. Transport Policy 7, 243–257.

Train, K. E. (2009). Discrete choice models with simulation, 2nd ed. Cambridge University Press, New York.

Train, K. E., Wilson, W. W. (2009). Monte Carlo analysis of SP-off-RP data. Journal of Choice Modelling 2 (1), 101 – 117.

Yang, H. and Huang, H. J. (2005). Mathematical and Economic Theory of Road Pricing. Elsevier.

Whitehead, J. E., Bunker, J. M., Chung, E. (2011a). The Brisbane Cordon Scheme: Part A - Preliminary Investigation. eddBE2011 Proceedings, 295-300.

Whitehead, J. E., Bunker, J. M., Chung, E. (2011b). The Brisbane Cordon Scheme: Part B - Investigation into Feasibility and Effects. eddBE2011 Proceedings, 301-306.

Xenias, D., Whitmarsh, L. (2013). Dimensions and determinants of expert and public attitudes to sustainable transport policies and technologies. Transportation Research Part A 48, 75 – 85.

Zhao, Z., Shi, A., Jian, W. (2010). Development and inspiration of road congestion pricing revenue redistribution theory research. Journal of Transportation Systems Engineering and Information Technology 10 (4), 93 – 100.

Zheng, Z., Ahn, S., Monsere, C.M. (2010). Impact of traffic oscillations on freeway crash occurrences. Accident Analysis and Prevention, 42(2), 626-636.

Zheng, Z., Washington, S., Hyland, P., Sloan, K., Liu, Y. (2014). A tale of five cities: a nationwide comparison of urban travel behavior in Australia. Transportation. Under review.

Table A

Table

Table 1 Main factors influencing public acceptance of congestion charge

Factor	Summary findings reported in the literature
Freedom	Acceptability (and effectiveness) of congestion charge will decrease if people regard it as an infringement of personal freedom, as widely reported in the literature (Jakobsson et al., 2000; Brehm, 1966; Steg, 1996; Tertoolen et al., 1998; Baron and Jurney, 1993; Kim et al., 2013).
Fairness (Equity)	Perceived fairness is critical for acceptability of congestion charge. If a congestion charge scheme is perceived to be able to bring benefits to the majority, it is generally regarded as fair and consequently receives higher public support (Ittner et al., 2003; Fujii et al., 2004; Schade, 2003; Jakobsson et al., 2000); two important factors on equity impact of congestion charge are initial travel patterns and revenue redistribution (Eliasson and Mattsson, 2006).
Trust in government	Trust in government can be related to fairness. Fujii (2005) reported that people's trust in government influences acceptability of congestion charge. Based on a survey of British and Japanese students, Schmöcker et al. (2012) explicitly treated trust in government as a determinant and found that government trust is significant in acceptability of congestion charge for the Japanese participants. This result was tested in Kim et al. (2013) using the New Jersey sample. Kim et al. (2013) reported that government trust has strong influence on perceived fairness and thus is critical for obtaining acceptability.
Problem awareness	Congestion charge will be more acceptable if the public is aware of the problems that can be mitigated by implementing such a scheme, such as traffic congestion, air pollution, and climate change (Schade and Schlag, 2000; Steg, 2003; Gärling et al., 2008). Problem awareness can be further broken down as social problem awareness, self problem awareness, and personal problem awareness. Among them, social problem awareness is more relevant to acceptability of congestion charge (Gärling et al., 2008).
Perceived effectiveness	If a congestion charge scheme is perceived by the public as being effective in achieving the targeted goals (e.g., congestion mitigation, revenue collection, etc.), it is more likely to be supported (Bartley, 1995; Taylor et al., 2010)
Details of the proposed scheme & Complexity	Details of the scheme can have significant influence on public acceptance because they can have direct or indirect impact on benefits and costs (including freedom and fairness) (Bhatt et al., 2008; Clee, 2007; Litman, 2011). Meanwhile, the scheme's complexity can be related to perceived effectiveness. Linkage between cognitive barriers and acceptability of congestion charge was revealed (Bonsall et al., 2007; Bonsall and Lythgoe, 2009; Martino et al., 2008; Rößger et al., 2008). Recently, Francke and Kaniok (2013) investigated participants' responses to differentiated road pricing schemes based on a laboratory experiment. They reported that participates had difficulty in calculating the charges if the pricing schemes were differentiated both geographically and temporally, although learning effects on participates' capability of evaluating the highly differentiated schemes were observed. Overall, participants preferred a distance-based road pricing scheme with a fixed charge per kilometer.
Socio demographic	Age, gender, and driving frequency have significant impact on how participants would respond to the road pricing schemes (Francke and Kaniok, 2013). Xenias and Whitmarsh (2013) compared attitudes to sustainable transport between two groups: experts and non-expert and found notable differences between these two groups in how sustainable transport policy/technologies should be designed, which implies the danger of established top-down development and implementation of policy and underscores the importance of early public engagement. A person's political bias, personality can also influence acceptability of congestion charge (Hatori and Fujii, 2008; Hårsman and Quigley, 2010)

Table 2 Example: The stated preference experiment

Mode	Fuel cost (journey time)	Bus fare	Congestion charge
Travel by car	Decreased by 30%		$ 15
Travel by bus		Decreased by 10%	

How strongly would you support the congestion charge on a 5-point scale?

1	2	3	4	5
☐	☐	☐	☐	☐
Not support at all	Not support	Neutral	Support	Strongly support

How likely would you take a bus, instead of driving on a 5-point scale?

1	2	3	4	5
☐	☐	☐	☐	☐
Very unlikely	Unlikely	Neutral	Likely	Very likely

Table 3 Basic survey information

City	Year	Time	Sample size	Gender	Transport Mode
Brisbane	2012	June 29 to September 27	150	M=58;F=92	DC=55; PT=92; BW=3
Melbourne	2013	April	173	M=87; F=86	DC=75; PT=78; BW=19
Total	-	-	323	M=145; F=178	DC=130; PT=170; BW=22

Note: M=male; F=female; DC=drive & carpooling; PT= public transport; BW= cycling & walking.

Table 4 Main study variables

Variable names	Description	Comments
City	Brisbane or Melbourne	0=Brisbane; 1=Melbourne
Gender	Male or female	0=M; 1=F
Age	Age group	1: 16-17 years; 2: 18-30 years; 3: 31-40 years; 4: 41-50 years; 5: 51- 60 years; 6: 60+ years
EDU	Highest completed educational qualification	1: Grade 10 or below; 2: Grade 11; 3: Grade 12/School Certificate; 4: Technical qualification/certificate; 5: Undergraduate university degree; 6: Post-graduate university degree
Income	Pre-tax personal annual income	1: Less than \$20 000; 2: \$20 001-\$70 000; 3: \$70 001 or more
Race	Race/ethnicity	1: Australian or Pacific Tropical Islander; 2: North-West European; 3: Southern or Eastern European; 4: North African or Middle Eastern; 5: South-East Asian; 6: North-East Asian; 7: Southern or Central Asian; 8: North or South American; 9: Sub-Saharan African
Job	Employment status	1: Full-time (paid employment); 2: Part-time (paid employment); 3: Self-employed; 4: Not in the work force; 5: retired; 6: student
Car_acc	Car access status	1: don’t have access to a car; 2: have access to my own car; 3: have access to company vehicles; 4: have access to a shared car; 5: have access to more than 1 car
House_str	Current household structure	1: Single person household; 2: Couple (with no child living at home); 3: Couple (with children at home); 4: Single parent family (with children living at home); 5: Living at home with parents; 6: Other
Mode	Primary transport mode	1: drive; 2: carpooling; 3: public transport 4: cycling & walking (2 & 1 are combined due to the low response from 2)
ForTransit	To what extent the respondent agrees with the statement: *I believe revenue raised from implementing a congestion charge should be used to improve public transport services and road infrastructure.*	Ranged from 1-5: 1 for strongly disagree; 5 for strongly agree
ForEnv	To what extent the respondent agrees with the statement: *I believe revenue raised from implementing a congestion charge should be used to improve the environment (e.g., planting more trees).*	Same as above
ReduceCong	To what extent the respondent agrees with the statement: *I believe implementing a congestion charge can help reduce traffic congestion.*	Same as above
ReduceEmis	To what extent the respondent agrees with the statement: *I believe implementing a congestion charge can help protect the environment by reducing vehicle emissions.*	Same as above
UnfairPoor	To what extent the respondent agrees with the statement: *I*	Same as above

Variable names	Description	Comments
	believe implementing a congestion charge is unfair to poorer people because poorer people would more likely be forced not to drive to the city.	
BadEcon	To what extent the respondent agrees with the statement: *I believe implementing a congestion charge is not good for the economy because people would travel to the city less frequently.*	Same as above
TransitSuf	To what extent the respondent agrees with the statement: *I believe the existing public transport systems can cope with the increased volume of passengers caused by implementing the congestion charge.*	Same as above
TransitMore	To what extent the respondent agrees with the statement: *The congestion charge would make me use public transport more often for travelling to the city.*	Same as above
CarpoolMore	To what extent the respondent agrees with the statement: *The congestion charge would make me seek carpooling with other people more often for travelling to the city.*	Same as above
ToCityLess	To what extent the respondent agrees with the statement: *The congestion charge would make me travel to the city for shopping or entertainment less frequently.*	Same as above
LessCityWork	To what extent the respondent agrees with the statement: *Working in the city would be a less attractive option to me because of a congestion charge.*	Same as above
Charge	Amount of congestion charge	$5; $10; or $15
Fuel	Percentage of fuel cost decrease	Decreased by 10%, 30%, or 50%
Fare	Percentage of bus fare decrease	Decreased by 10%, 30%, or 50%
CCSupport	To what extent the respondent would support the congestion charge in the hypothetical scenario presented in each table (see Table 1 for an example)	Ranged from 1-5: 1 for not support at all; 5 for strongly support.
BusSupport	To what extent the respondent would take a bus to the city (instead of driving) in the hypothetical scenario presented in each table (see Table 1 for an example)	Ranged from 1-5: 1 for very unlikely; 5 for very likely
Tolls	To what extent the respondent supports the current toll highways	This question was only asked in Melbourne

Table 5 Responses in each category of the attitudinal variables used in this study

Variable	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Missing
ForEnv	14	58	92	109	48	2
ReduceCong	16	39	63	150	54	1
ReduceEmis	12	45	74	145	46	1
UnfairPoor	11	80	91	109	30	2
BadEcon	20	169	59	62	12	1
TransitSuf	90	138	44	44	5	2
TransitMore	32	69	67	120	34	1
CarpoolMore	43	86	74	95	23	2
ToCityLess	32	110	52	90	38	1
LessCityWork	45	112	58	82	25	1

Table 6 Outputs of the random-effects ordered logit model for public acceptance of congestion charge

Overall goodness-of-fit				
LL(0) = -3628.8; Log likelihood = -3199.1; AIC = 6430.1				
Random effects				
Intercept	Variance=4.625; Standard deviation=2.151			
Non-random parameters in utility functions				
Attributes	Parameters	Standard error	z	Prob |z|>z*
Charge***	-0.203	0.010	-19.799	<0.001
Fuel***	0.029	0.002	11.858	<0.001
Fare***	0.027	0.002	11.129	<0.001
City**	-3.058	1.130	-2.705	0.007
PublicTransit***	1.389	0.283	4.914	<0.001
CyclingWalking**	1.381	0.550	2.510	0.01
ReduceEmis***	1.107	0.134	8.241	<0.001
ToCityLess***	-0.440	0.115	-3.834	<0.001
BadEconomyMelbourne*	-0.366	0.193	-1.898	0.05
TransitMoreMelbourne*	0.338	0.156	2.168	0.03
EducationMelbourne**	0.476	0.168	2.842	0.004

Note: 1) Mode is converted to two dummy variables by using Level 1 (driving & carpooling) as the reference level: PublicTransit is for public transport and CyclingWalking for cycling & walking; 2) Threshold coefficients: 1|2 → -1.433, 2|3→1.339, 3|4 → 2.898; 4|5→5.920; and 3) Significance codes: <0.001 '***' 0.01 '**' 0.05 '*'

Table 7 Outputs of the random-effects ordered logit model for public acceptance of bus transport

Overall goodness-of-fit				
LL(0) = -3117.1; Log likelihood = -2776.6; AIC = 5579.2				
Random effects				
Intercept	Variance=9.875; Standard deviation=3.143			
Non-random parameters in utility functions				
Attributes	Parameters	Standard error	z	Prob |z|>z*
Charge***	0.094	0.011	8.318	<0.001
Fuel***	-0.013	0.003	-4.925	<0.001
Fare***	0.051	0.003	17.793	<0.001
City*	-0.750	0.381	-1.967	0.05
PublicTransit***	3.663	0.405	9.053	<0.001
CyclingWalking***	3.546	0.775	4.575	<0.001
ReduceEmis***	0.671	0.185	3.623	<0.001
CCSupport***	0.370	0.060	6.197	<0.001

Note: 1) Mode is converted to two dummy variables by using Level 1 (driving & carpooling) as the reference level: PublicTransit is for public transport and CyclingWalking for cycling & walking; 2) Threshold coefficients: 1|2 → 1.650, 2|3→4.958, 3|4 → 6.375; 4|5→9.375; and 3) Significance codes: <0.001 ‘***’ 0.01 ‘**’ 0.05 ‘*’

Table 8 Correlations i) between *CCSupport* and *BusSupport*; and ii) between user group status and *TransitMore*

		Pearson		Spearman	
		correlation	p	correlation	p
CCSupport and *BusSupport*	Bus riders	0.34	<0.001	0.36	<0.001
	Non bus riders	0.33	<0.001	0.33	<0.001
user group status and *TransitMore*		0.2	<0.001	0.19	<0.001

Table 9 Outputs of the random-effects ordered logit model for public acceptance of congestion charge in Melbourne

Overall goodness-of-fit				
LL(0) = -1980.2; Log likelihood = -1672.8; AIC = 3377.6				
Random effects				
Intercept	Variance=3.465; Standard deviation=1.862			
Non-random parameters in utility functions				
Attributes	Parameters	Standard error	z	Prob |z|>z*
Charge***	-0.231	0.014	-16.087	<0.001
Fuel***	0.034	0.003	10.085	<0.001
Fare***	0.023	0.003	6.863	<0.001
PublicTransit**	1.026	0.353	2.907	0.004
CyclingWalking**	1.476	0.543	2.717	0.007
ReduceEmis***	1.069	0.171	6.269	<0.001
Tolls***	0.684	0.162	4.212	<0.001
BadEconomy**	-0.518	0.184	-2.817	0.005
TransitMore*	0.277	0.142	1.954	0.05
Education*	0.313	0.151	2.069	0.04

Note: 1) Mode is converted to two dummy variables by using Level 1 (driving & carpooling) as the reference level: PublicTransit is for public transport and CyclingWalking for cycling & walking; 2) Threshold coefficients: 1|2 → 2.958, 2|3→5.666, 3|4 → 7.332; 4|5→10.297; and 3) Significance codes: <0.001 '***' 0.01 '**' 0.05 '*'

Table 10 Correlation matrix for explaining city differences

	ReduceEmis	ToCityLess	BadEconomy	TransitMore	Education	Tolls
ReduceEmis		-0.06 (0.40)	-0.19 (0.01)	0.27 (<0.001)	0.04 (0.63)	0.19 (0.01)
ToCityLess	-0.25 (0.002)		0.45 (<0.01)	0.03 (0.72)	0.13 (0.09)	-0.22 (0.005)
BadEconomy	-0.19 (0.018)	0.31 (<0.001)		-0.08 (0.29)	0.08 (0.30)	-0.11 (0.14)
TransitMore	0.40 (<0.001)	-0.01 (0.94)	-0.11 (0.19)		-0.01 (0.87)	0.12 (0.13)
Education	-0.05 (0.51)	-0.09 (0.26)	-0.10 (0.24)	-0.07 (0.38)		0.13 (0.09)

Note: i) shaded cells are for Melbourne, and un-shaded cells for Brisbane; ii) numbers in parentheses are *p* values.

Table A Outputs of the random-effects ordered logit model for public acceptance of congestion charge in Brisbane

Overall goodness-of-fit				
LL(0)= -1641.2; Log likelihood = -1481.7; AIC = 2987.4				
Random effects				
Intercept	Variance=5.33; Standard deviation=2.31			
Non-random parameters in utility functions				
Attributes	Parameters	Standard error	z	Prob |z|>z*
Charge***	-0.173	0.015	-11.700	<0.001
Fuel***	0.023	0.004	6.378	<0.001
Fare***	0.032	0.004	8.986	<0.001
PublicTransit***	1.561	0.434	3.598	<0.001
CyclingWalking	2.024	1.495	1.354	0.176
ReduceEmis***	1.035	0.206	5.012	<0.001
ToCityLess***	-0.668	0.173	-3.853	<0.001

Note: 1) Mode is converted to two dummy variables by using Level 1 (driving & carpooling) as the reference level: PublicTransit is for public transport and CyclingWalking for cycling & walking; 2) Threshold coefficients: 1|2 → -2.101, 2|3→0.831, 3|4 → 2.297; 4|5→5.389; and 3) Significance codes: <0.001 '***' 0.01 '**' 0.05 '*'

Figure

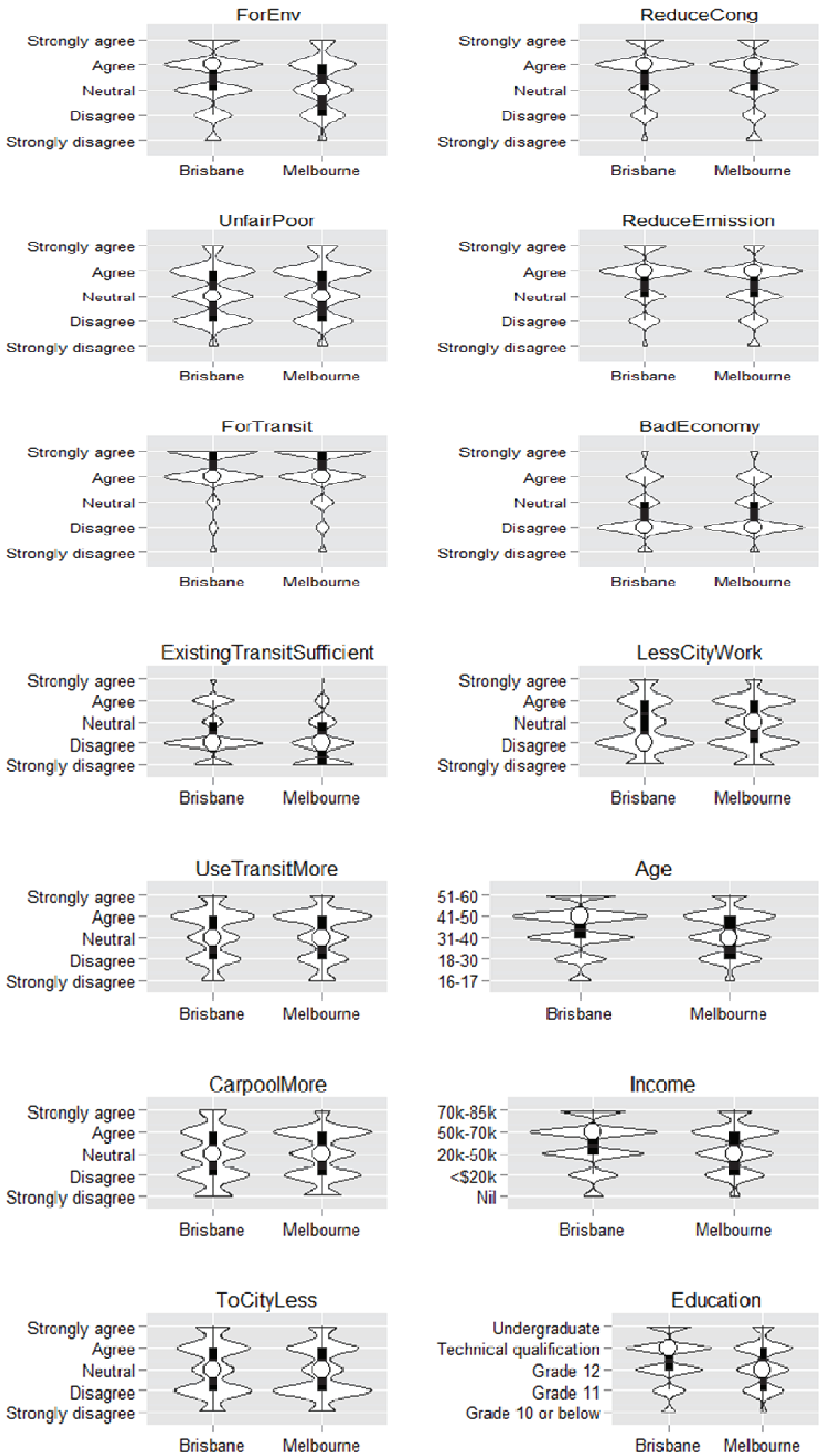

Figure 1 Comparison of the respondent profiles; the white dot is the median, and the solid black rectangle is a box plot that goes from the 25th percentile to the 75th percentile of the data.

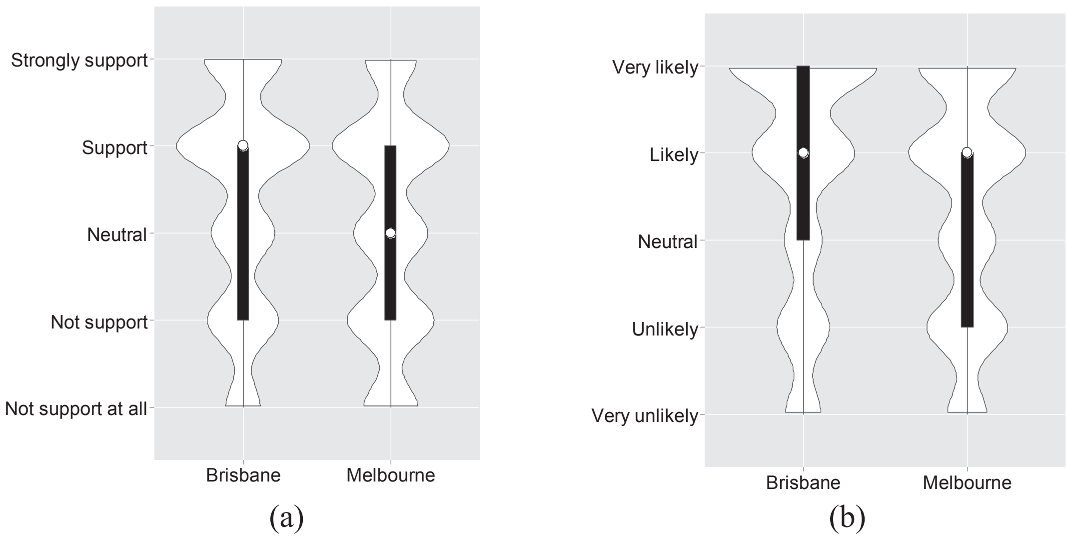

Figure 2 The violin plots: (a) levels of support for congestion pricing; (b) likelihood of taking a bus. The white dot is the median, and the solid black rectangle is a box plot that goes from the 25th percentile to the 75th percentile of the data.