Case Studies on Transport Policy 6 (2018) 94–101

Contents lists available at ScienceDirect

Case Studies on Transport Policy

journal homepage: www.elsevier.com/locate/cstp

Congestion pricing practices and public acceptance: A review of evidence

Ziyuan Gu[a,b], Zhiyuan Liu[a,*], Qixiu Cheng[a], Meead Saberi[b]

[a] Jiangsu Key Laboratory of Urban ITS, Jiangsu Province Collaborative Innovation Center of Modern Urban Traffic Technologies, School of Transportation, Southeast University, Nanjing, 210096, China

[b] Institute of Transport Studies, Department of Civil Engineering, Monash University, VIC, 3800, Australia

ARTICLE INFO

Keywords:
Congestion pricing
Public acceptance
Practical implementation

ABSTRACT

Despite numerous theoretical studies, practical implementation of congestion pricing is limited mainly due to the low public acceptance. Existing studies in this respect generally focus on a few selected cases where the results need to be further generalized. With the objective of improving public acceptance of congestion pricing, this paper provides a comprehensive overview of the area-based congestion pricing practices. An in-depth analysis of public acceptance is presented using a qualitative case study approach. Results show that for the successful implementation of congestion pricing, a trial and a referendum are valuable but not necessary, and that an interaction-oriented political process may be more desirable. Four influencing factors, i.e. privacy, equity, complexity and uncertainty, are identified to be critical in establishing strong public support. Taking into account these implementation factors, an extended three-step approach is proposed for further improvement of public acceptance toward congestion pricing.

1. Introduction

Supply-oriented development of urban transportation, namely by road capacity expansion through large-scale construction, has been the traditional way of alleviating urban traffic congestion. Due to limited construction space in the dense urban areas, this is no longer a sustainable solution for developing urban transport systems (Liu et al., 2014a,2014b). As an alternative, demand-oriented development has been widely advocated where congestion pricing is considered one of the most efficient strategies for mitigating traffic congestion (Langmyhr, 1999; Eliasson, 2008; Meng and Liu, 2012). Rather than a compulsory rule for travelers (e.g. traffic signal control), congestion pricing is an economic lever used to influence traffic which has particular advantages over the other transportation demand management (TDM) policies (Yang and Huang, 2005).

Since the seminal studies by Pigou (1920) and Knight (1924), road pricing has been promoted extensively by transport planners and economists due to its effectiveness in reducing traffic congestion, improving air quality, and raising revenues for transport systems (Decorla-Souza and Kane, 1992; Anas and Lindsey, 2011; Wang et al., 2013; Liu et al., 2017). Nevertheless, concerns about the practical implementation of road pricing prevail (Lindsey, 2006), in contrast with the theoretical studies that argue in favor of it (Santos et al., 2010). Experience has shown that technical and financial problems no longer remain the biggest obstacles, but rather the low public acceptance (Altshuler, 2010; Schuitema et al., 2010).

Since the majority of the recent congestion pricing practices are area-based, a number of studies have focused on public acceptance of a single or a few such cases. Sørensen et al. (2014) selected London, Stockholm and Swiss road pricing in the case study on which general management strategies were built. Similarly, Zheng et al. (2014) used London, Stockholm and New York City to develop an analytic understanding of public response to congestion pricing. More specifically, Hensher and Li (2013) focused on the role of referenda based on a comparative analysis of congestion pricing in the UK, Stockholm and Milan, and proposed a two-step approach to facilitate the practical implementation. From a more general perspective, Noordegraaf et al. (2014) presented a detailed analysis of the selected implementation factors based on six road pricing cases, They found that political and public support is most prominent among the six common generic implementation factors. A few other studies can also be found in the literature which are discussed in detail in Section 2.3.

Though public acceptance is considered a significant factor in the implementation of congestion pricing, more investigation is needed as to how area-based congestion pricing has been implemented and how public acceptance has influenced the implementation results. The majority of the related literature only dealt with an individual case where the results about public acceptance need to be further generalized. Though a few studies provided a more comprehensive analysis of different cases, the general implementation factors or the management

* Corresponding author.
E-mail address: zhiyuanl@seu.edu.cn (Z. Liu).

https://doi.org/10.1016/j.cstp.2018.01.004
Received 22 October 2016; Received in revised form 19 May 2017; Accepted 9 January 2018
Available online 12 January 2018

strategies were the focus rather than public acceptance. Therefore, understanding and determining the relationship between congestion pricing and public acceptance in a more generalized manner is a timely issue with practical significance. This paper aims to present, via a qualitative case study approach, an overview of various area-based congestion pricing practices and to analyze public acceptance, which can provide valuable insights into the practical implementation of congestion pricing.

The remainder of this paper is organized as follows. Section 2 presents the methodological framework including the qualitative case study approach. Section 3 analyzes the political process for implementing congestion pricing with emphasis on the effects of a trial and a referendum. Section 4 discusses the four influencing factors identified. Section 5 provides a solution for improving public acceptance toward congestion pricing. Section 6 draws conclusions about the main findings and makes recommendations.

2. Methodological framework

2.1. Terminology

Congestion pricing is one form of road pricing. Jones and Hervik (1992) defined road pricing as policies imposing direct charges on road use, regardless of the set of objectives or the targeted groups of road users. Only a road pricing scheme with the main objective of relieving traffic congestion is considered congestion pricing, which differs from those aimed at collecting toll revenues for infrastructure construction or at improving environmental quality (May, 1992).

Congestion pricing practices can be divided into four categories: facility-based, zonal, cordon-based and distance-based (De Palma and Lindsey, 2011).

i Facility-based schemes are the basic type of congestion pricing. Tolls can be imposed either on roads, bridges, tunnels, etc., or on one part of the targeted facilities (e.g. express lanes in US).
ii Zonal schemes can also be called area charge. Vehicles either entering/exiting the bounded area or traveling within without crossing the boundary are forced to pay a toll. The boundary is often set based on geographical features and urban layouts.
iii Cordon-based schemes seem to enjoy greater popularity than zonal schemes. Vehicles traveling in either the inbound or outbound direction (or both) are required to pay a toll when crossing the cordon. If simply traveling within the bounded area, vehicles are not charged at all. A cordon-based scheme can adopt a single cordon or multiple cordons including radial screenlines for controlling orbital movements.
iv Distance-based schemes are more complex where vehicles are charged based on the distance traveled, either linearly or non-linearly (Meng et al., 2012). In urban areas, distance-based schemes can be enforced using a vehicle positioning system, e.g. the global positioning system or the general packet radio service (Liu et al., 2014a,2014b).

Note that zonal and cordon-based schemes can be combined as area-based charging, and that distance-based schemes can be integrated with either facility-based or area-based charging. To improve readability, acronyms used throughout the paper are summarized in Table A.1 in Appendix A.

2.2. Selection of cases

The first congestion pricing practice is the area licensing scheme (ALS) introduced in Singapore in 1975. It operated until 1998 when the electronic road pricing (ERP) was introduced as an improvement (Liu et al., 2013). Following Singapore's success, several other attempts have been made, but only a few have been implemented successfully. Lessons can be learnt from both the implemented and rejected cases (Van Wee, 2009) and hence, four criteria are used for selection.

Congestion pricing is one type of road pricing that mainly focuses on congestion mitigation. Road pricing with the ultimate goal of collecting revenues or improving environmental quality is out of the scope of this study. Therefore, road pricing in the Norwegian cities and the national tolling schemes for heavy goods vehicles in Europe are excluded.

i The majority of the recent congestion pricing schemes are either zonal or cordon-based. Therefore, facilities-based practices are not discussed in this study. Few schemes are distance-based because of the complexity in implementation. Further, distance-based schemes can be integrated with either of the other three categories.
ii Both the implemented and rejected congestion pricing schemes are included. Schemes with determined practical implementation are defined as implemented cases. The rejected ones are those with a concrete implementation plan, either discussed or trialed, but denied eventually for implementation. Hence congestion pricing schemes in the Netherlands, Copenhagen and Gothenburg are not considered (see Appendix B for details).
iii Congestion pricing schemes should be well-documented in terms of both implementation details and public attitudes for a better understanding of each individual case. As a result, the practices in Sydney, Rome and Valletta are not considered. This is also a limitation in this study that entails consideration in the further analysis.

Nine congestion pricing schemes are ultimately selected. Table 1 shows the categorized results of these selected cases.

2.3. A qualitative case study approach

To analyze public acceptance of each case, a qualitative case study approach (Seale et al., 2004) is employed which has been widely used in the literature, e.g. Sørensen et al. (2014). The rationale is that studies based on a certain number of cases may serve as a sound foundation for the generalization of conclusions, given that the cases in question are closely related to the research focus. Therefore, analysis can be conducted based on the qualitative empirical evidence in the related literature. Table 2 summarizes the key references for each case. For further details about each case including the implementation impacts, please refer to Tables C.1 and C.2 in Appendix C.

Existing literature (Noordegraaf et al., 2014; Sørensen et al., 2014; Hysing, 2015) has shown that two implementation factors are valuable for further development of congestion pricing, i.e. a trial and then a referendum, which are thus chosen in this study as the evaluation criteria for each case. Based on the literature in Table 2, Table 3 shows for each case if any trial or referendum was conducted during implementation.

A comprehensive overview of the related literature, which is provided in Table 4, has shown that public acceptance toward congestion pricing is heavily influenced by four factors, i.e. privacy, equity, complexity and uncertainty. Further investigation is conducted for each case to see if these factors were present (either considered or ignored), the results of which are shown in Table 5. As expected, three factors are found common while the fourth one (privacy) seems case-specific.

Table 1
Categorized congestion pricing schemes selected in this study.

	Zonal	Cordon-based
Implemented	Singapore (ALS) London, UK	Singapore (ERP) Stockholm, Sweden Milan, Italy
Rejected	New York City, USA	Hong Kong, China Edinburgh, UK The Greater Manchester, UK

Table 2
Key references for each selected case.

Scheme	Key references
Singapore (ALS)	Seik (1997); Willoughby (2000); Goh (2002); Santos (2005)
London	Banister (2003); Beevers and Carslaw (2005); Santos and Fraser (2006); *Peters and Gordon* (2009)
New York City	Odioso and Smith (2008); *Peters and Gordon* (2009); Larson and Sasanuma (2010); Schaller (2010); Zheng et al. (2014)
Singapore (ERP)	Seik (2000); Phang and Toh (2004); *De Palma and Lindsey* (2011); Liu et al. (2014a,2014b)
Stockholm	Eliasson (2008); Eliasson et al. (2009); Isaksson and Richardson (2009); De Palma and Lindsey (2011); Eliasson and Jonsson (2011); Börjesson et al. (2012)
Milan	Rotaris et al. (2010); Hensher and Li (2013); Percoco (2013); Percoco (2014)
Hong Kong	Dawson and Catling (1986); Harrison (1986); Borins (1988); Hau (1990); Ison and Rye (2005); *Noordegraaf et al.* (2014)
Edinburgh	McQuaid and Grieco (2005); Ryley and Gjersoe (2006); Gorman et al. (2008); Rye et al. (2008); *Noordegraaf et al.* (2014)
The Greater Manchester	Ahmed (2011); Hepburn (2014); Sherriff (2015)

Note: References in italic deal with multiple cases.

Table 3
A summary showing if any trial or referendum was conducted during implementation for each selected case.

Scheme	Trial	Referendum	Implementation
Singapore	×	×	√
Stockholm	√	√	√
Milan	×	√	√
London	×	×	√
New York City	×	√*	×
Hong Kong	√	√	×
Edinburgh	×	√	×
The Greater Manchester	×	√	×

Note: √ = yes, × = no; *More exactly, multiple hearings and votings (though without the final open vote of the full Assembly).

Hence a detailed qualitative analysis is presented in Section 3 using Tables 2–5.

3. Political process for implementing congestion pricing

3.1. Trial and referendum

Unlike Stockholm where both a trial and a referendum were carried out, the congestion pricing scheme in Milan involved a referendum only. More interestingly, congestion pricing in Singapore and London even involved neither of the two implementation factors. Nevertheless, Table 3 shows that all of the above schemes have been implemented successfully which hence deserve more investigation.

The current congestion pricing scheme in Milan, the Area C, has a predecessor under the name of Ecopass from 2008 to 2011. The Ecopass was proposed mainly to deal with urban air pollutions rather than congestion mitigation (Rotaris et al., 2010). During implementation, residents in Milan gained real benefits and were generally in favor of the proposal (Percoco, 2013). As with Milan, the current ERP in Singapore was introduced based on the ALS. Two unique factors in Singapore largely contribute to the successful implementation of congestion pricing: (i) "Singaporeans are generally literate, well-informed and law-abiding citizens who are normally cooperative and supportive of government policies. There is ample public respect for the country's laws and statutes" (Seik, 1997), and (ii) the government is powerful (Phang and Toh, 2004). The success of London's congestion pricing scheme without any trials or referenda is also largely dependent on the predominant power of the mayor who strongly supported congestion pricing and who played a decisive role during its implementation (Banister, 2003; Noordegraaf et al., 2014).

One of the reasons why congestion pricing in New York City, Edinburgh and the Greater Manchester were rejected may be a lack of a congestion pricing trial as shown in Table 3. As will be discussed in Section 4.4, a trial renders to the public a valuable opportunity to experience the real benefits resulting from pricing and a better understanding of the potential effectiveness. This publicized information plays a critical role in the implementation of congestion pricing because it eases the public's anxiety about how congestion pricing may affect in a positive manner their daily life. As argued by De Palma and Lindsey

Table 5
Factors mentioned in selected cases.

Selected cases	Privacy	Equity	Complexity	Uncertainty
Singapore	√	√	√	
London	√	√		√
New York City		×	√	
Stockholm		√	√	√
Milan		√	√	√
Hong Kong	×	×		×
Edinburgh		×	×	×
The Greater Manchester			×	√

Note: √ = considered, × = ignored, blank = not mentioned.

Table 4
An overview of the influencing factors.

Factors	Descriptions	Related literature
Privacy	Privacy is among the main causes of opposition to congestion pricing, since the transactions used may record travelers' personal information, resulting in an invasion of privacy.	Hau (1990); May (1992); Jones (1998); Banister (2003); Litman (2006); Liu et al. (2014a,2014b); Noordegraaf et al. (2014)
Equity	The issue of equity in congestion pricing comprises two aspects: the distribution of tolls among different sociodemographic groups and the tolling mechanisms.	Giuliano (1992); Poole (1992); Weinstein and Sciara (2006); Ungemah and Collier (2007); Hensher and Li (2013); Liu et al. (2014a,2014b); Zheng et al. (2014); Hysing (2015)
Complexity (simplicity)	To achieve a theoretically efficient tolling mechanism, a number of proposed congestion pricing schemes cannot be well-understood by public.	Decorla-Souza and Kane (1992); May (1992); Bonsall et al. (2007); Eliasson (2008); Martino (2011); Francke and Kaniok (2013); Hensher and Li (2013); Zheng et al. (2014)
Uncertainty	Voters are familiar with the status quo but uncertain about the proposed congestion pricing in terms of effectiveness and revenue allocation.	Ingberman (1985); Samuelson and Zeckhauser (1988); Decorla-Souza and Kane (1992); Giuliano (1992); Poole (1992); Small (1992); Jones (2003); Allen et al. (2006); Gaunt et al. (2007); Odeck and Kjerkreit (2010); De Borger and Proost (2012)

(2011), congestion pricing influences travelers' travel choices including number of trips, mode of transport, time of day, route, etc., and even their decisions on workplace and residence.

Though both a trial and a referendum were held in Hong Kong, the proposed congestion pricing scheme was still rejected for three important reasons: (i) due to the economic decline in conjunction with several other measures (e.g. transit development) to ease traffic congestion, congestion severity described by the government during that period seemed to be exaggerated leading to a mistrust in the local government (Borins, 1988), (ii) concerns about the invasion of road users' privacy were prevalent among various groups of stakeholders since "the invasion of privacy and fear of a 'big brother' government were foremost in people's minds" (Hau, 1990), and (iii) the government did not provide adequate publicized information about the scheme which largely deteriorated its advocacy among the public (Noordegraaf et al., 2014).

3.2. Discussions and implications of the political process

Though a trial and a referendum have been recognized in the literature as two key elements in the political process for implementing congestion pricing (Noordegraaf et al., 2014; Sørensen et al., 2014; Hysing, 2015), our results as shown in Table 3 indicate that both do not necessarily guarantee a successful implementation. More importantly, congestion pricing can even be implemented without any trials or referenda due to a few other dominating factors among which the strong political will plays a decisive role.

The ALS in Singapore was implemented only after one-year public dialogue without any formal trials or referenda, though some modifications were made later based on the public's feedback. This strong political will had a predominant role over public attitudes when congestion pricing was to be implemented in Singapore. As a small city-sate country, one level of government is powerful during the decision-making process without the need to communicate and coordinate with other layers of government (Phang and Toh, 2004). As a result, the political process for implementing congestion pricing was relatively simple and efficient which largely facilitated the implementation of the ALS (as well as the ERP) (Seik, 1997). Similar to the case of Singapore, the political dominance was also observable in London's congestion pricing scheme in which no trial or referendum was involved during the implementation. As rendered by legislation, the predominant power of the mayor to introduce congestion pricing played a decisive role in forging ahead with the scheme without the need to build a political coalition (Anas and Lindsey, 2011). Nevertheless, the lack of public support did exist in a public consultation resulting in the removal of the western extension of the scheme (Santos and Fraser, 2006).

In contrast to the smooth political process in Singapore and London, the clumsy political handing of New York City's congestion pricing proposal largely contributed to its failure despite the strong support from Mayor Bloomberg. Of the 16 initiatives included in the plan (termed PlaNYC), the congestion pricing proposal was the only component that had to be approved by the New York State Legislature (Bloomberg, 2007). The remainder is within New York City's (or its regional) jurisdiction. The state approval, however, did not come for a while, but a Traffic Congestion Mitigation Commission was approved by the State legislature to investigate the plan. With several changes made to the original plan's complexity and fairness based on the public's opinions, the commission approved the plan with a vote of 13 to 2 (Neuman, 1 Feb. 2008). Nevertheless, the proposal was still subject to another two rounds of voting. Though the New York City Council approved the plan with a vote of 30 to 20 (Cardwell, 1 April 2008), the Democratic Conference of the State Assembly decided not to vote on the proposal because of the overwhelming opposition which came mainly from the elected officials and the public in the four New York City boroughs outside Manhattan (Confessore, 8 April 2008).

Unlike Singapore, London and New York City where governments spent great time and resources on investigating the applicability of congestion pricing, the government in Hong Kong made no effort to effectively sell the scheme to the public resulting in a lack of publicized information about funding, resource allocation, technical feasibility, equity, costs and benefits, etc. (Noordegraaf et al., 2014). This is one of the main reasons why congestion pricing was rejected in Hong Kong despite both a trial and a referendum. It clearly indicates that during the political process for implementing congestion pricing (or any other public policies), bilateral information sharing is another key element that allows the public to capture the potential advantages and disadvantages of the scheme.

It is noteworthy that a congestion pricing trial can guarantee such information sharing by enabling the stakeholders to experience in person the real benefits and by establishing a more concrete and tangible understanding of the effectiveness (Hensher and Li, 2013). Empirical evidence has shown that public acceptance increases after people have experienced the positive consequences. In Stockholm, for example, the support rate just before the trial was only 33% in November 2005, but it increased to 51.3% in the following referendum in September 2006 (Sørensen et al., 2014) and even reached nearly 70% in a follow-up poll in May 2011 (Börjesson et al., 2012). The variations of public acceptance toward congestion pricing in Stockholm was also confirmed by Winslott-Hiselius et al. (2009). On the other hand, in New York City, Edinburgh and the Greater Manchester where no trial was involved, simply a referendum was unable to lead the scheme to a final field implementation.

In general, a government-oriented political process for implementing congestion pricing as in the case of Singapore or London is case-specific and hence, should not be perceived as a widely applicable policy template. Instead, this political process should be seen as a close-loop interaction between the government and the public whereby information is shared between both parties. In Hong Kong, New York City, Edinburgh and the Greater Manchester, though a referendum (or multiple public hearings) was held during which the public's opinions were conveyed to the government, inadequate knowledge or feedback was provided in turn by the government with respect to the potential consequences after the implementation of the scheme, either through a trial or by means of theoretical modelling. As a result, the closed-loop interaction degrades into a unilateral political process which violates the previously discussed rule of bilateral information sharing. A real-world example that adopts the interaction-oriented political process is Stockholm's congestion pricing scheme in which both a trial and a referendum were held.

It follows from the above discussions that a trial and a referendum are generally advisable which help build an interaction-oriented political process for the implementation of congestion pricing. Since a referendum imposes considerable informational demands on voters despite direct application of democracy, a trial becomes essential which renders the real benefits from pricing to the public, and which addresses the limited understanding and misconceptions that might lead to greater opposition (Gaunt et al., 2007; Hensher and Li, 2013). As argued by Santos and Fraser (2006), decision making on congestion pricing should not be subject to a referendum only. This further indicates, for implementing public policies including congestion pricing, the significance of the interaction-oriented political process during which bilateral information sharing is pursued.

4. Influencing factors of public acceptance

4.1. Privacy

The issue of privacy first came up in the congestion pricing trial in Hong Kong which led to the rejection of the proposal in the subsequent referendum (Hau, 1990). Concerns about the invasion of road users' privacy were common among various groups of stakeholders (Borins, 1988; Ison and Rye, 2005). Therefore, the issue of privacy was

addressed both when the ERP was introduced in Singapore and when congestion pricing was implemented in London (Noordegraaf et al., 2014). For example, the smartcard used in Singapore's ERP carries no personal information about drivers or vehicles. The itineraries of travelers are thus not recorded by the charging facilities at different locations. To promote public acceptance, the transport authority should take responsibility to protect the privacy of smartcard users. When smartcard data are used for either research or industrial purposes, personal information should be kept secure.

4.2. Equity

The distribution of tolls among different sociodemographic groups may lead to the issue of equity. In the context of congestion pricing, low-income drivers and people with mobility impairments are faced with more severe traveling burden and further limitations on the travel options (Weinstein and Sciara, 2006). The out-of-pocket charges hamper the poor from using road facilities, making the road resources a privilege of the rich. For a particular congestion pricing scheme, residents living either inside or outside the charging area may have concerns about its fairness. Hence it is important for the public to know that congestion pricing represents a step toward more equitable use of transportation systems (Poole, 1992).

The congestion pricing implemented in London, Stockholm and Milan has taken measures to address the issue of equity. In London, full exemption is granted for vehicles used by disabled people, in conjunction with a 90% discount and 10 GBP registration fee per year for vehicles registered to residents of the central zone (Santos and Fraser, 2006). Similarly in Milan, exemption applies for vehicles used by handicapped people, and a discount is available for frequent users (Rotaris et al., 2010). In Stockholm, congestion pricing is generally progressive as "high-income groups paid more than low-income groups, men paid more than women, employed more than unemployed etc." (Börjesson et al., 2012). This argument was supported by a quantitative case study in Stockholm where further numerical details can be found (Eliasson and Mattsson, 2006). In contrary, the issue of equity was not adequately addressed in New York City, Edinburgh and Hong Kong where the proposed schemes were rejected. Though several changes were made to the original plan's complexity and fairness based on public opinions, the Democratic Conference of the State Assembly decided not to vote on New York City's congestion pricing proposal because of the overwhelming opposition (Confessore, 8 April 2008). Opposition came mainly from the elected officials and the public in the four New York City boroughs outside Manhattan. The strongest came from eastern Queens and southern Brooklyn, areas that were not only more vehicle-dependent but also had the least public transit access. As Schaller (2010) argued, "pricing proposals need to be perceived as benefiting drivers individually and not simply society at large". In Edinburgh, though people with mobility impairments were to be exempt from the charge, politicians from the neighboring areas still considered the exemption for Edinburgh residents unfair which largely contributed to the abandonment (Ryley and Gjersoe, 2006). During the congestion pricing trial in Hong Kong, taxi drivers and commercial vehicle owners were exempt from the charge due to political pressure, which, however, "would increase the burden on other road users, with private car drivers feeling singled out and discriminated against" (Ison and Rye, 2005).

The tolling mechanism may also result in the issue of equity. The ALS in Singapore allowed an unlimited number of passages which led to concerns about its equity (Santos, 2005). Hence this issue was fully considered and addressed when the ERP was introduced as an improvement. Unlike New York City and Edinburgh where a flat toll was used, a time-of-day toll rate was applied in Singapore, Stockholm and Hong Kong. This type of time-dependent charge helps relieving the equity concerns raised by the tolling mechanism. A recent study by Francke and Kaniok (2013) found that distance-based congestion pricing with fixed kilometer charge was, on average, most preferred over the other conceivable alternatives. In the UK, however, a fixed cordon charge was preferred over a variable one (Jaensirisak et al., 2005). Though a fixed charge is easily understood, the lack of equity and efficiency is a major drawback (Hensher and Li, 2013).

4.3. Complexity

In Edinburgh and the Greater Manchester, part of the argument for the rejection of congestion pricing was that the proposed cordon-based schemes were more complicated as compared with the others (Hensher and Li, 2013). Two pricing cordons were designed in both schemes in contrast with only one in Stockholm. The ease of understanding was a major concern in the design of Stockholm's congestion pricing (Eliasson, 2008). Similarly in Milan, the Area C is much simpler than its predecessor Ecopass. The charging rate under the Area C is fixed whereas a variable charging structure was used in the Ecopass based on the vehicle type, the Euro emissions class, and the fuel type. The switch from complexity to simplicity for easy calculation turns out to be effective in gaining public acceptance for further development (Decorla-Souza and Kane, 1992; Hensher and Li, 2013). Though the congestion pricing proposal in New York City did not eventually enter an open vote of the full Assembly, the issue of complexity was considered during the previous discussion period. Based on public opinions, several changes were made to the original plan's complexity and fairness by the Traffic Congestion Mitigation Commission approved by the State legislature (Schaller, 2010). The inbound, outbound and intra-zonal trips, for example, were to be charged in the original plan, but only inbound trips were kept after the revision.

The failures in Edinburgh and the Greater Manchester and the successes in Stockholm and Milan suggest that congestion pricing should start with a simple and well-understood proposal to create a clear picture for the residents. The experience in Singapore's congestion pricing progress further indicates that improvements may be considered and made at later stages. Specifically, when the ALS was introduced in Singapore, drivers entering the restricted zone were charged with a fixed price of about 1.3 USD (i.e. flat toll). With a few modifications and expansions along the years, the biggest improvement came when the ERP was introduced. The original flat toll was updated to a more complex step toll where the rate varies by the time of day, the location and the vehicle type. Since drivers had already been familiar with the basics of the scheme, the upgrade did not add much to the complexity issue. On the contrary, the equity and efficiency aspects were improved. Further numerical details about the comparison can be found in Phang and Toh (2004).

4.4. Uncertainty

When introducing new policies including congestion pricing, uncertainty is a major reason for the lack of support since voters are familiar with the status quo but uncertain about the new schemes particularly in the absence of trials (Ingberman, 1985; Samuelson and Zeckhauser, 1988). Two types of uncertainty were identified by De Borger and Proost (2012): (i) uncertainty with respect to the effectiveness of the proposed scheme, and (ii) uncertainty in terms of revenue allocation.

A major reason for resistance to congestion pricing is the uncertainty about its effectiveness which is closely related to the modal substitution costs or willingness to pay (Giuliano, 1992; Jones, 2003). To address this concern, Poole (1992) did a demonstration project to show the public how effective congestion pricing may be. Based on an interview with 368 Edinburgh residents in May 2005, Gaunt et al. (2007) found that a key reason for the rejection of congestion pricing in Edinburgh was the lack of understanding, a finding that was also confirmed by Allen et al. (2006). For congestion pricing in Hong Kong, the government made no effort to effectively sell the scheme to the general

public, which resulted in a lack of publicized information about the potential effects particularly the benefits that might be experienced (Noordegraaf et al., 2014). With less information, voters are more likely to vote against the new policies, termed risk-averse behavior (Christin et al., 2002). Based on an analysis of the survey data, Odeck and Kjerkreit (2010) showed that people with inadequate information about road pricing would be 2.14 times more negative than those who were well-informed, holding all other factors constant. Therefore, uncertainty over the effectiveness of congestion pricing may exert a negative impact on the future development. This indicates that more information and education is needed for the successful implementation of congestion pricing which is exactly what trials can provide.

Uncertainty in terms of revenue allocation can also result in rejection of congestion pricing (May, 1992). Dedicating revenues for roadway improvements and providing subsidies for alternative modes can both increase public acceptance and help congestion pricing become a reality (Decorla-Souza and Kane, 1992). To demonstrate how revenues should be allocated, a package of revenue uses was proposed by Small (1992) for compensating highway users. Using stated preference, Farrell and Saleh (2005) found that revenues generated from congestion pricing should be used to improve public transport through lower fares, greater frequency, and increased reliability. It was also found through surveys, however, that greater public acceptance of congestion pricing could be guaranteed if the collected revenues were used to either replace car taxes or lower fuel taxes (Ubbels and Verhoef, 2006). Hence the two alternatives for allocating revenues were further studied and compared (De Borger and Proost, 2012). The results showed that the public is more supportive if the generated revenues are used to improve public transport. Note that the proposed schemes in London, Stockholm, Milan and the Greater Manchester were all part of a package of wider transport policies that included public transport improvements using the generated revenues. Such a wider transport strategy appears a key determinant of public acceptability (May, 1992).

5. An approach to improving public acceptance

Given the identified influencing factors, we propose an extended three-step approach to promote public acceptance of congestion pricing based on Hensher and Li (2013):

i During the design stage, privacy, equity and complexity should be considered with public education. To raise the public's confidence in congestion pricing, the government needs to ensure that personal information is kept secure for all the stakeholders. Equity analysis may be further incorporated into the project planning. The "tradable credit method" as in Liu et al. (2014a,2014b), for example, can be applied. To improve acceptability, ease of understanding should be the initial focus for practical implementation rather than theoretical complexity. We suggest that forecasting models be developed for prediction of the potential changes that may arise as a result of congestion pricing, and that the results be clearly conveyed to the public. Meanwhile, the government should make effort to sell the proposal to the media and ensure that the generated revenues will be used for public transport improvements.

ii We suggest that a congestion pricing trial be implemented prior to any referendum, the results of which are conveyed regularly to the public for a better understanding of the proposal. Note that trials can provide knowledge needed to address the issue of uncertainty particularly with respect to the effectiveness of congestion pricing. Based on public attitudes and opinions throughout the trial, improvements can be considered and made later to the original plan.

iii During the implementation stage, the most critical task for the government is to maintain the practice implemented at the design and trial stages to build up social trust. To smooth the public's anxiety over the issue of uncertainty in terms of revenue allocation, policy makers or practitioners should keep the promise that the generated revenues are used to improve public transport and that practical actions are made visible to the public. Overall the scheme should not be perceived by the public simply as a "cash cow" (Attard and Ison, 2010).

Public acceptance plays a major role at all stages of congestion pricing. In developing countries, public acceptance may even become a decisive factor in implementation mainly due to the large populations with different levels of socio-demographic groups. Note that the proposed three-step approach can be further extended to a four-step procedure, taking into account the right of way as the preparation stage. As an integral part of the public welfare benefits, the right of way is a type of execution of public rights. In this context, investigation into the "legality" of congestion pricing may be necessary prior to the introduction and publicity. As argued by May (1992), "in most countries, legislation is not currently available to permit road pricing". Also note that the design stage plays a more major role than the other two where the issues of privacy, equity and complexity need to be well-addressed. Learning from the experience of New York City, the government should not focus on the societal benefits for a particular group of people. Giuliano (1992) argued that equity remains a major barrier but is not particularly important with respect to public acceptance because congestion pricing never leads to Pareto improvement. It is true that certain groups of people will lose in this redistributive policy while others gain. Hence complementary measures may be needed to ensure that all levels of society benefit from the congestion pricing strategy.

From a practical point of view, a well-designed congestion pricing scheme can largely facilitate the enforcement of the trial and implementation stages. To demonstrate the effectiveness of congestion pricing and to achieve stronger public support, the government should follow two principle rules: (i) information about the real effects of congestion pricing is publicized, and (ii) the generated revenues are used to improve public transport.

6. Conclusion

To build the gap between congestion pricing theory and practice, this paper reviews nine area-based congestion pricing schemes and provides an in-depth analysis of public acceptance using a qualitative case study approach. Despite technical and financial challenges, the most significant barrier to the implementation of congestion pricing remains the low public acceptance. Since more information including the real benefits is made available at the trial stage, a congestion pricing trial is critical in establishing strong public support and in obtaining positive referendum outcomes. Initially, people may tend to be reserved or even negative toward a new policy particularly congestion pricing that involves out-of-pocket costs. Hence without experiencing the real effects and potential benefits, people are more in favor of the status quo. It is understandable that the public generally opposes a policy that is benefit-uncertain and that even increases the financial burden. This phenomenon shows that a lack of publicized information about the effectiveness of congestion pricing is a major reason for rejection, and that practitioners should be aware of the significance of a congestion pricing trial. To help promote congestion pricing among the public, an interaction-oriented political process is more advisable during which information about every aspect of the scheme is shared between the government and the public through a trial and a referendum (or multiple).

Four influencing factors are identified that may have significant impacts on public acceptance toward congestion pricing. The public's concerns about privacy mainly come from the fact that the charging facilities may record personal information. Travelers are typically averse to the disclosure of personal information which may lead to safety concerns. The issue of equity also remains a criticism of congestion pricing where different levels of socio-demographic groups are involved. If not properly addressed, practical implementation may fail,

as has been the case in New York City. To increase the willingness to pay, the government should seek alternative ways toward equitable congestion pricing, e.g. distance-based tolling or the "tradable credit method". Complexity is another major obstacle to congestion pricing. From the experience of Stockholm, ease of understanding should be the initial focus rather than an efficient but complex theoretical tolling structure. Empirical evidence has confirmed that a higher degree of complexity leads to a lower public acceptability. Finally, people are more supportive of congestion pricing if the issue of uncertainty is well-addressed, i.e. if provided with knowledge about the effectiveness and revenue allocation. An extended three-step approach is proposed to promote the practical implementation of congestion pricing. Though decision making is also subject to other implementation factors such as strong political will, the main obstacle remains the low public acceptance.

Since the area-based congestion pricing schemes are the major focus of this paper, more investigation on facility- and distance-based schemes can be a direction for future research. Public acceptance toward different types of schemes can be jointly analyzed and compared. Also note that a few other area-based schemes are not considered in the current analysis and hence, further extension can be made toward this direction.

Acknowledgements

This study is supported by the Projects of International Cooperation and Exchange (No. 51561135003), Key Projects (No. 51638004) and Youth Projects (No. 71501038) of the National Natural Science Foundation of China.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.cstp.2018.01.004.

References

Ahmed, B., 2011. Manchester congestion charge scheme: a review. J. Civil. Eng. Constr. Technol. 2 (11), 236–241.
Allen, S., Gaunt, M., Rye, T., 2006. An investigation into the reasons for the rejection of congestion charging by the citizens of Edinburgh. Eur. Transp.\Trasporti Europei 32, 95–113.
Altshuler, A., 2010. Equity, pricing, and surface transportation politics. Urban Affairs Rev. 46, 155–179.
Anas, A., Lindsey, R., 2011. Reducing urban road transportation externalities: road pricing in theory and in practice. Rev. Environ. Econ. Policy 5 (1), 66–88.
Attard, M., Ison, S.G., 2010. The implementation of road user charging and the lessons learnt: the case of Valletta, Malta. J . Transp. Geogr. 18 (1), 14–22.
Börjesson, M., Eliasson, J., Hugosson, M.B., Brundell-Freij, K., 2012. The Stockholm congestion charges—5 years on effects: acceptability and lessons learnt. Transp. Policy 20, 1–12.
Banister, D., 2003. Critical pragmatism and congestion charging in London. Int. Soc. Sci. J. 55 (176), 249–264.
Beevers, S.D., Carslaw, D.C., 2005. The impact of congestion charging on vehicle emissions in London. Atmos. Environ. 39 (1), 1–5.
Bloomberg, M., 2007. New York City Mobility Needs Assessment, 2007–2030. PlaNYC, The City of New York, NYC, US (Accessible through.).
Bonsall, P., Shires, J., Maule, J., Matthews, B., Beale, J., 2007. Responses to complex pricing signals: theory, evidence and implications for road pricing. Transp. Res. Part A 41 (7), 672–683.
Borins, S.F., 1988. Electronic road pricing: an idea whose time may never come. Transp. Res. Part A 22 (1), 37–44.
Cardwell, D., 2008. City Council Approves Fee to Drive Below 60th. The New York Times (Retrieved from 1 April). http://www.nytimes.com/2008/04/01/nyregion/01congestion.html?ref=nyregion.
Christin, T., Hug, S., Sciarini, P., 2002. Interests and information in referendum voting: an analysis of Swiss voters. Eur. J. Political Res. 41 (6), 759–776.
Confessore, N., 2008. $8 Traffic Fee for Manhattan Gets Nowhere. The New York Times (Retrieved from 8 April). http://www.nytimes.com/2008/04/08/nyregion/08congest.html?pagewanted=1&ei=5088&en=6327902f9d5026b0&ex=1365393600&partner=rssnyt&emc=rss.
Dawson, J.A., Catling, I., 1986. Electronic road pricing in Hong Kong. Transp. Res. Part A 20 (2), 129–134.
De Borger, B., Proost, S., 2012. A political economy model of road pricing. J. Urban Econ. 71 (1), 79–92.
De Palma, A., Lindsey, R., 2011. Traffic congestion pricing methodologies and technologies. Transp. Res. Part C 19 (6), 1377–1399.
Decorla-Souza, P., Kane, A.R., 1992. Peak period tolls: precepts and prospects. Transportation 19 (4), 293–311.
Eliasson, J., Jonsson, L., 2011. The unexpected yes: explanatory factors behind the positive attitudes to congestion charges in Stockholm. Transp. Policy 18 (4), 636–647.
Eliasson, J., Mattsson, L.-G., 2006. Equity effects of congestion pricing: quantitative methodology and a case study for Stockholm. Transp. Res. Part A 40 (7), 602–620.
Eliasson, J., Hultkrantz, L., Nerhagen, L., Rosqvist, L.S., 2009. The Stockholm congestion–charging trial 2006: overview of effects. Transp. Res. Part A 43 (3), 240–250.
Eliasson, J., 2008. Lessons from the Stockholm congestion charging trial. Transp. Policy 15 (6), 395–404.
Farrell, S., Saleh, W., 2005. Road-user charging and the modelling of revenue allocation. Transp. Policy 12 (5), 431–442.
Francke, A., Kaniok, D., 2013. Responses to differentiated road pricing schemes. Transp. Res. Part A 48, 25–30.
Gaunt, M., Rye, T., Allen, S., 2007. Public acceptability of road user charging: the case of Edinburgh and the 2005 referendum. Transp. Rev. 27 (1), 85–102.
Giuliano, G., 1992. An assessment of the political acceptability of congestion pricing. Transportation 19 (4), 335–358.
Goh, M., 2002. Congestion management and electronic road pricing in Singapore. J. Transp. Geogr. 10 (1), 29–38.
Gorman, D., Higgins, M., Muirie, J., 2008. The Edinburgh congestion charging proposals: the devil in the detail. Public Health 122 (11), 1188–1190.
Harrison, B., 1986. Electronic road pricing in Hong Kong. III: estimating and evaluating the effects. Traffic Eng. Control 27 (1), 13–18.
Hau, T.D., 1990. Electronic road pricing: developments in Hong Kong 1983–1989. J. Transp. Econ. Policy 203–214.
Hensher, D.A., Li, Z., 2013. Referendum voting in road pricing reform: a review of the evidence. Transp. Policy 25, 186–197.
Hepburn, P., 2014. Local democracy in a digital age: lessons for local government from the manchester congestion charge referendum. Local Gov. Stud. 40 (1), 82–101.
Hysing, E., 2015. Citizen participation or representative government–building legitimacy for the Gothenburg congestion tax. Transp. Policy 39, 1–8.
Ingberman, D.E., 1985. Running against the status quo: institutions for direct democracy referenda and allocations over time. Public Choice 46 (1), 19–43.
Isaksson, K., Richardson, T., 2009. Building legitimacy for risky policies: the cost of avoiding conflict in Stockholm. Transp. Res. Part A 43 (3), 251–257.
Ison, S., Rye, T., 2005. Implementing road user charging: the lessons learnt from Hong Kong, Cambridge and Central London. Transp. Rev. 25 (4), 451–465.
Jaensirisak, S., Wardman, M., May, A., 2005. Explaining variations in public acceptability of road pricing schemes. J. Transp. Econ. Policy 127–153.
Jones, P., Hervik, A., 1992. Restraining car traffic in European cities: an emerging role for road pricing. Transp. Res. Part A 26 (2), 133–145.
Jones, P., 1998. Urban road pricing: public acceptability and barriers to implementation. In: Button, K.J., Verhoef, E. (Eds.), Road Pricing, Traffic Congestion and the Environment. Edward Elgar Publishing, pp. 263–284.
Jones, P., 2003. Acceptability of road user charging: meeting the challenge. In: Schade, J., Schlag, B. (Eds.), Acceptability of Transport Pricing Strategies. Elsevier, pp. 27–62.
Knight, F.H., 1924. Some fallacies in the interpretation of social cost. Q. J. Econ. 582–606.
Langmyhr, T., 1999. Understanding innovation: the case of road pricing. Transp. Rev. 19 (3), 255–271.
Larson, R.C., Sasanuma, K., 2010. Urban vehicle congestion pricing: a review. J. Ind. Syst. Eng. 3 (4), 227–242.
Lindsey, R., 2006. Do economists reach a conclusion on road pricing? the intellectual history of an idea. Econ J. Watch 3 (2), 292–379.
Litman, T., 2006. London Congestion Pricing: Implications for Other Cities. Victoria Transport Policy Institute, Victoria, BC, Canada (Accessible through). http://core.ac.uk/download/pdf/6630967.pdf.
Liu, Z., Meng, Q., Wang, S., 2013. Speed-based toll design for cordon-based congestion pricing scheme. Transp. Res. Part C 31, 83–98.
Liu, Z.Y., Wang, T.S., Qu, X.B., Yan, Y.D., 2014a. Urban congestion pricing: practices and future development. In: Applied Mechanics and Materials. Trans Tech Publications Switzerland. pp. 787–793.
Liu, Z., Wang, S., Meng, Q., 2014b. Optimal joint distance and time toll for cordon-based congestion pricing. Transp. Res. Part B 69, 81–97.
Liu, Z., Wang, S., Zhou, B., Cheng, Q., 2017. Robust optimization of distance-based tolls in a network considering stochastic day to day dynamics. Transp. Res. Part C 79, 58–72.
Martino, A., 2011. Milano: from Pollution Charge to Congestion Charge. TRT Trasporti e Territorio, Leuven, Belgium (Accessible through). http://www.trt.it/document/Martino%20-%20AreaC%20Milano.pdf.
May, A., 1992. Road pricing: an international perspective. Transportation 19 (4), 313–333.
McQuaid, R., Grieco, M., 2005. Edinburgh and the politics of congestion charging: negotiating road user charging with affected publics. Transp. Policy 12 (5), 475–476.
Meng, Q., Liu, Z., 2012. Impact analysis of cordon-based congestion pricing scheme on mode-split of bimodal transportation network. Transp. Res. Part C 21 (1), 134–147.
Meng, Q., Liu, Z., Wang, S., 2012. Optimal distance-based toll design for cordon-based congestion pricing scheme with continuously distributed value-of-time. Transp. Res. Part E 48 (5), 937–957.
Neuman, W., 2008. State Commission Approves a Plan for Congestion Pricing. The New York Times (Retrived from 1 Feb.). http://www.nytimes.com/2008/02/01/nyregion/01congest.html.
Noordegraaf, D.V., Annema, J.A., Van Wee, B., 2014. Policy implementation lessons from six road pricing cases. Transp. Res. Part A 59, 172–191.

Odeck, J., Kjerkreit, A., 2010. Evidence on users' attitudes towards road user charges–a cross-sectional survey of six Norwegian toll schemes. Transp. Policy 17 (6), 349–358.
Odioso, M.S., Smith, M.C., 2008. Perceptions of congestion charging: lessons for US cities from London and Stockholm. Proceedings of the 2008 Systems and Information Engineering Design Symposium (SIEDS 2008). IEEE 221–226.
Percoco, M., 2013. Is road pricing effective in abating pollution? Evidence from Milan. Transp. Res. Part D 25, 112–118.
Percoco, M., 2014. The impact of road pricing on housing prices: preliminary evidence from Milan. Transp. Res. Part A 67, 188–194.
Peters, J.R., Gordon, C., 2009. Results not guaranteed: a tale of road pricing in New York and London. J. Urban Technol. 16 (1), 113–131.
Phang, S.-Y., Toh, R.S., 2004. Road congestion pricing in Singapore: 1975 to 2003. Transp. J. 16–25.
Pigou, A.C., 1920. The Economics of Welfare. MacMillan, London.
Poole, R.W., 1992. Introducing congestion pricing on a new toll road. Transportation 19 (4), 383–396.
Rotaris, L., Danielis, R., Marcucci, E., Massiani, J., 2010. The urban road pricing scheme to curb pollution in Milan, Italy: description, impacts and preliminary cost–benefit analysis assessment. Transp. Res. Part A 44 (5), 359–375.
Rye, T., Gaunt, M., Ison, S., 2008. Edinburgh's congestion charging plans: an analysis of reasons for non-implementation. Transp. Plann. Technol. 31 (6), 641–661.
Ryley, T., Gjersoe, N., 2006. Newspaper response to the Edinburgh congestion charging proposals. Transp. Policy 13 (1), 66–73.
Sørensen, C.H., Isaksson, K., Macmillen, J., Åkerman, J., Kressler, F., 2014. Strategies to manage barriers in policy formation and implementation of road pricing packages. Transp. Res. Part A 60, 40–52.
Samuelson, W., Zeckhauser, R., 1988. Status quo bias in decision making. J. Risk Uncertain 1 (1), 7–59.
Santos, G., Fraser, G., 2006. Road pricing: lessons from London. Econ. Policy 21 (46), 264–310.
Santos, G., Behrendt, H., Maconi, L., Shirvani, T., Teytelboym, A., 2010. Part I: externalities and economic policies in road transport. Res. Transp. Econ. 28 (1), 2–45.
Santos, G., 2005. Urban congestion charging: a comparison between London and Singapore. Transp. Rev. 25 (5), 511–534.
Schaller, B., 2010. New York City's congestion pricing experience and implications for road pricing acceptance in the United States. Transp. Policy 17 (4), 266–273.
Schuitema, G., Steg, L., Forward, S., 2010. Explaining differences in acceptability before and acceptance after the implementation of a congestion charge in Stockholm. Transp. Res. Part A 44 (2), 99–109.
Seale, C., Gobo, G., Gubrium, J.F., Silverman, D., 2004. Introduction: inside qualitative research. In: Seale, C., Gobo, G., Gubrium, J.F., Silverman, D. (Eds.), Qualitative Research Practice. Sage Publications.
Seik, F.T., 1997. An effective demand management instrument in urban transport: the area licensing scheme in Singapore. Cities 14 (3), 155–164.
Seik, F.T., 2000. An advanced demand management instrument in urban transport: electronic road pricing in Singapore. Cities 17 (1), 33–45.
Sherriff, G., 2015. Voting on sustainable transport: communication and governance challenges in greater Manchester's 'congestion charge'referendum. Local Environ. 20 (12), 1507–1530.
Small, K.A., 1992. Using the revenues from congestion pricing. Transportation 19 (4), 359–381.
Ubbels, B., Verhoef, E., 2006. Behavioral responses to road pricing: empirical results from a survey of Dutch car owners. Transp. Res. Rec.: J. Transp. Res. Board 159–166.
Van Wee, B., 2009. Transport policy: what it can and what it can't do? In: The 2009 European Transport Conference. Leiden, Netherlands.
Wang, S., Meng, Q., Liu, Z., 2013. Fundamental properties of volume-capacity ratio of a private toll road in general networks. Transp. Res. Part B 47, 77–86.
Weinstein, A., Sciara, G.-C., 2006. Unraveling equity in HOT lane planning a view from practice. J. Plann. Educ. Res. 26 (2), 174–184.
Willoughby, C., 2000. Singapore's Experience in Managing Motorization and Its Relevance to Other Countries, TWU-43. World Bank, Washington, DC (Accessible through). http://www.worldbank.org/transport/publicat/twu_43.pdf.
Winslott-Hiselius, L., Brundell-Freij, K., Vagland, Å., Byström, C., 2009. The development of public attitudes towards the Stockholm congestion trial. Transp. Res. Part A 43 (3), 269–282.
Yang, H., Huang, H., 2005. Mathematical and Economic Theory of Road Pricing. Elsevier, Oxford.
Zheng, Z., Liu, Z., Liu, C., Shiwakoti, N., 2014. Understanding public response to a congestion charge: a random-effects ordered logit approach. Transp. Res. Part A 70, 117–134.