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Optimal bus transit route packaging in a privatized contracting regime

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ABSTRACT

This study presents an optimization model as a methodology for the transit regulator (or a government authority) to design bus transit route packages to be tendered out to contesting operators through competitive tendering (CT). The optimal route packaging takes into account the perspectives of all stakeholders in a bus transit system- the commuters, operators and the regulator. The problem is formulated as a Mixed Integer Nonlinear Programming (MINLP) problem. To solve the formulated MINLP, we transform it into a Mixed Integer Linear Program (MILP) by using linearization techniques so that global optimality of the solution could be guaranteed. A numerical study is then performed on a real-life transit network to evaluate the model validity. The proposed methodology provides a comprehensive decision making framework for the regulator contemplating to contract out bus transit route packages through CT so as to achieve the objectives of encouraging competition, ensuring the attractiveness of the bus transit market to contesting operators and meeting commuters' expected service levels.

1. Introduction

Bus transit is, by far, the most flexible, accessible and favored mode of public transportation across the globe. Since the advent of organized public transportation regulatory authorities dedicated towards the systematic provision of transit facilities, such as the U.S. Department of Transportation for the USA or the Land Transport Authority (LTA) for Singapore, several operative models have been conceptualized and implemented to make the bus transit system more financially and socially sustainable. Public transportation infrastructure improvisation, wherein the government interacts with the public in a direct way on a daily basis so as to make it more convenient, remains a paramount concern.

In the past, the post-world wars' period in the latter half of the 20th century saw huge financial losses for the public transport industry and the concurrent surge in private vehicle ownership which led to a major downsizing of the public transportation infrastructure. With motorization causing environmental degradation and posing a threat to sustainability, a few nations adopted to nationalize the facilities so that the system could operate with minimum government subsidies. Although it was not very beneficial, it still helped keep the industry afloat.

The first major breakthrough in public transportation policy came in the form of the Transport Act of 1985 passed by the Parliament of the United Kingdom which aimed at the deregulation of public transportation facilities and introducing competition in the transit market through privatization. This was a major development in the public transportation industry with

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a strong intention to structure public transportation policy towards social welfare (Gómez-Ibáñez and Meyer, 1997; van de Velde and Wallis, 2013). It also revolutionized the nature of public transport from a mere service to a competitive market calling for innovation and high levels of service. Many other countries tried to introduce competition through deregulation subsequently. Along with the initiatives on the operational side, there have been research studies in the literature that further suggest strategies to improve the state of bus transit mainly by two methods: (a) bus transit network and service design (b) optimal contracting of bus transit. In particular, transit network and service design has attracted much research attention (Ceder and Wilson, 1986; Cortés et al., 2011; Meng and Qu, 2013; Wang and Lo, 2008; Szeto and Jiang, 2014; Szeto and Wu, 2011; Farahani et al., 2013; Wu et al., 2015; Wang and Du, 2013). But unfortunately, there have been only few research studies that focus on optimal strategies for bus transit contracting and policy making.

From the contractual point of view, there exist different regimes under which privatization or deregulation might operate and it has long been a debate on what is the most financially feasible contracting methodology for a particular transit system. A detailed analysis on the policy background and the implications of different forms of bus contracting for various stakeholders can be found in Walters and Cloete (2008). There have been many studies investigating this topic; however, as transit facilities are greatly affected by local politics, economy and financial institutions, it is difficult to draw a consensus on a preferred regime. Hensher and Stanley (2003) elaborates on the performance based contracts where the operations are based on trust and relationship building. Such a contract is generally negotiated with the incumbent operators. A few other studies (Hensher, 2010; Gordon et al., 2013, etc.) discussed the intricacies of the contracting process in terms of completeness and clarity in contractual terms between the transit regulator and the transit players for projects relating to public transport infrastructure expansion. The Australian bus transit industry presents an illustrative case study on the preferred contracting regime for a particular transit market. Bray and Wallis (2008) gave a detailed account of the experience in Adelaide where the bus contracting regime transitioned from a monopoly operation to a competitively tendered system as in Singapore. Wallis and Bray (2014) discussed the benefits that were observed when the transition occurred in Adelaide. Hensher et al. (2016) referred to a choice experiment to study public transport operators' preferences for different contractual regimes where multinomial logit was used to study the preferred contracting regime based on various parameters. Besides, in the literature, there are certain comparative studies between the two different types of operative regimes mentioned above: performance based contracts and CT. Hensher and Stanley (2010) reviewed the themes that are crucial in choosing a particular contractual regime and suggested that performance based contracts would deliver a better value for money. Further, Hensher and Wallis (2005) discussed the success and failures of the CT model in pursuit of a better value for money objective and promotes performance based contracts to contain government spending through subsidies. On the contrary, Wallis and Bray (2014) provided evidence that CT has significantly reduced the cost of transit provision and improved quality of service in some of the major Australian cities such as Adelaide and Perth, as compared to prior regimes such as the performance based negotiated contracts. Funding remains a pertinent issue while contemplating a transition in the contracting regime in public transit services. Walters (2010) examined the benefits accrued from adopting a CT regime in terms of transparency in funding, competitiveness, improved service levels and the overall financial relationships (Stanley and Hensher, 2008) between the regulator and the operators. Also, to present a contrary view, Kavanagh (2016) discussed why CT cannot be considered as the most appropriate method of transit contracting in each and every instance. Hence, choice of an operative model is subjective in nature and largely depends on the local conditions and the financial objectives of all involved stakeholders.

The existing research works mentioned above only provide descriptive discussions using statistical/data-driven approaches on the qualitative nature of the different kinds of contractual regimes while never addressing analytical frameworks for contracting. Also, analytical studies on CT are only restricted to strategies that could help attain cost efficiency without presenting any mathematical paradigm for decision making in the tendering process. For instance, the work by Iseki (2010) computed the cost efficiency on the basis of degree of contracting i.e. how much of the transit service is contracted out through CT. Another work by Iseki (2008) examined the cost efficiency in transit provision through CT by categorizing agencies into different size groups depending on their degree of contracting in contrast to past studies in which the entire transit industry was assumed to be a set of agencies with similar cost structure. An interesting study that investigates the relationship between operating cost and number of bidders for local bus contracts was presented in Amaral et al. (2013). Evidently, these studies mostly demonstrate how contracting under the CT model could be made cost efficient through the optimal degree of contracting. However, they failed to propose any decision making framework for the regulatory authority to contract out transit routes through the CT model.

Hence, to avoid a costlier financial model with higher operating costs, lower levels of service, lower revenues, and thus higher subsidy requirement, many major transit friendly cities, such as London, opted for the government contracting regime where the government owns all the assets and the transit routes are tendered out to operators only for the routine operation through CT. While contracting out transit routes in a government contracting model through CT, the regulatory authority needs to make decisions on various elements of the contract such as the transit route packages, number of private players to be allowed to operate in the transit market and the methodology of allocating transit route packages to the eligible players. The resulting design of the contracting process should be financially and socially sustainable such that it is favorable and equitable for all the involved entities i.e. the regulator, operators and the commuters in the long run. In this study, we address the design of optimal transit route packages involved in the contracting process under the CT model. An explicit analytical framework for the regulators' decision making on the optimal transit route packaging for a deregulated transit market involving both private and public players is presented. Considering the fact that more countries are now willing to adopt an