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Short communication

Selection bias in build-operate-transfer transportation project appraisals

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ABSTRACT

Recent empirical studies have found widespread inaccuracies in traffic forecasts despite the fact that travel demand forecasting models have been significantly improved over the past few decades. We suspect that an intrinsic *selection bias* may exist in the competitive project appraisal process, in addition to the many other factors that contribute to inaccurate traffic forecasts. In this paper, we examine the potential for selection bias in the governmental process of Build-Operate-Transfer (BOT) transportation project appraisals. Although the simultaneous consideration of multiple criteria is typically used in practice, traffic flow estimate is usually a key criterion in these appraisals. For the purposes of this paper, we focus on the selection bias associated with the highest flow estimate criterion. We develop two approaches to quantify the level and chance of inaccuracy caused by selection bias: the expected value approach and the probability approach. The expected value approach addresses the question "*to what **extent** is inaccuracy caused by selection bias?*". The probability approach addresses the question "*what is the **chance** of inaccuracy due to selection bias?*". The results of this analysis confirm the existence of selection bias when a government uses the highest traffic forecast estimate as the priority criterion for BOT project selection. In addition, we offer some insights into the relationship between the extent/chance of inaccuracy and other related factors. We do not argue that selection bias is the only reason for inaccurate traffic forecasts in BOT projects; however, it does appear that it could be an intrinsic factor worthy of further attention and investigation.

1. Introduction

The Build-Operate-Transfer (BOT) scheme is increasingly used as an innovative way to finance the construction of major public transportation infrastructure projects in many developing countries, and even in some developed countries. In a BOT project bidding process, each consultant (or consortium) develops a proposed plan that includes factors related to highway pricing and capacity (Yang and Meng, 2000; Subprasom and Chen, 2007). Bidding consortiums design their pricing and capacity plans to maximize the profit from the project and the government then evaluates the social welfare benefits of the proposed plans. Generally, both the investor's profits and the social welfare benefits of the project are dependent on

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the estimated forecast of the traffic demand of the project in the target year and the estimate of the construction and operation costs of the project. Therefore, the accuracy of the traffic forecasts directly affects the efficacy of the BOT decision-making process (e.g., the ranking of project tenderers and the selection of a successful tenderer).

Beyond the significance of the forecast accuracy in the BOT project bidding process, traffic (or travel demand) forecasting is also a fundamental step in the planning and management of transportation systems. The resulting estimates of traffic flows in the network can be used to evaluate the performance of existing systems, to assess the results of the proposed planning and management strategies (e.g., new road construction, road pricing, and traffic rationing), and to study the financial feasibility of candidate projects (Chen and Subprasom, 2007). The accuracy of a traffic forecast substantially affects the quality of the system performance assessment and the resulting decision.

It is well recognized that travel demand forecasting models have significantly improved in the past few decades. However, many recent empirical studies have demonstrated the inaccuracy of the traffic forecasts of various transportation projects. In other words, the traffic forecast estimate at the project design stage may be significantly different from the true value at the operating stage. These recent empirical and statistical studies include those of Flyvbjerg et al. (2005), who used data from 183 road projects and 27 rail projects in 14 nations; Bain (2009), who used data from 104 international and privately financed toll road projects; Li and Hensher (2010), who used data from 14 toll roads in the three largest Australian cities; Parthasarathi and Levinson (2010), who used data from 108 projects in Minnesota, USA; Roxas and Chalermpong (2010), who used data from 89 road and 40 bridge projects in Thailand and Philippines; and Nicolaisen and Næss (2015), who used data from 35 road projects in Denmark and England to evaluate the accuracy of travel demand forecasts for do-nothing alternatives.

Given the inaccuracy of many traffic forecasts, we suspect that ***an intrinsic selection bias may exist in the government's competitive transportation project appraisal process***, in addition to the many factors contributing to inaccurate traffic forecasts identified by previous empirical studies. This selection bias may occur because the observable traffic forecasts are generated by non-randomly selected samples in the transportation system, given that only winning projects will be built and observed and losing projects are never built or appear in the system (Heckman, 1979). Therefore, we hypothesize that the selection bias associated with the appraisal criterion is one of the factors contributing to the inaccuracy of traffic forecasts. This can be analytically derived by quantifying the level and chance of inaccuracy caused by selection bias. In particular, a BOT project bidding and appraisal process may involve a selection bias when some particular criterion (e.g., the highest flow estimate, the lowest cost estimate, or the highest financial benefit estimate) is set as the primary criterion for selecting the successful bid. Recently, Eliasson and Fosgerau (2013) also considered selection bias as a possible source of systematic cost overruns and demand shortfalls. However, these authors focused on a project selection scenario in which a subset of projects are selected to implement within the candidate projects pool according to the relationship between the predicted payoff and the specified threshold of individual projects. Our paper complements Eliasson and Fosgerau's study in terms of both selection scenario (i.e., the selection of which project from what pool of proposals) and justification methodology. This paper deals with a bidder selection scenario in which a single bidder is selected from the multiple bidders to win a single BOT project and the bias occurs between the benefit (or cost) predicted by the successful bidder and the actual project benefit (or cost) after implementation. In reference to the justification methodology, Eliasson and Fosgerau (2013) quantified the mean relative cost (or benefit) error of selected projects using simulation, whereas this paper analytically quantifies both the extent and chance of inaccuracy caused by the selection bias.

As identified by many previous empirical studies, there are many factors and practical considerations other than selection bias that contribute to the inaccuracy of traffic forecasts. For example, Mackie and Preston (1998) identified 21 sources of error and bias in transport project appraisals. The errors they identified were related to the project objectives being unclear, incompletely specified, or inconsistent with the appraisal criteria, definitions of the study areas, and scheme options; multifarious sources of data and model errors; and evaluation errors, such as double counting, inappropriate values, and a failure to balance quantified and non-quantified items. Flyvbjerg et al. (2005) analyzed the stated causes of inaccuracies in traffic forecasts for 26 rail projects and 208 road projects. They found that the reasons for these inaccuracies are highly different for rail and road projects. For rail projects, uncertainty about trip distribution and deliberately slanted forecasts are the two most important stated causes; for road projects, uncertainties about trip generation and land-use development are the two most frequent stated causes of forecast inaccuracies. Bain (2009) used the Traffic Risk Index (TRI) to summarize the principal reasons for forecast inaccuracies and to offer investors and financial analysts a systematic way of evaluating forecasting risk. The project attributes in the TRI include tolling culture, tariff escalation, forecast horizon, toll facility details, data collection, private/commercial users, micro-economics, and traffic growth. Lemp and Kockelman (2009) reviewed the literature on the sources of risk and uncertainty in traffic forecasts and how these relate to project financing. Parthasarathi and Levinson (2010) identified errors in model inputs (such as demographic forecasts, trip making characteristics, and network differences between the assumed network and the actual in-place network) as possible sources of inaccuracy in traffic forecasts. For more discussions of demand forecast inaccuracy, interested readers can refer to a literature review by Nicolaisen and Driscoll (2014).

In this paper, we examine the potential influence of selection bias on the BOT transportation project appraisal process. Although many criteria can be considered simultaneously in a realistic BOT project appraisal process, the evaluation usually depends on the traffic flow estimate. For the purposes of this paper, we consider that the bidding consortium with the highest traffic flow estimate will have the highest chance to win the contract because, everything else being equal, it offers a lower toll and a higher benefit for the BOT project. To quantify the selection bias associated with the highest flow estimate