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Estimating values of travel time savings for toll roads: Avoiding a common error

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A R T I C L E I N F O

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A B S T R A C T

Traditionally, the empirical valuation of travel time savings (VTTS) is obtained from a linear utility specification in a discrete choice model, which implicitly assumes a risk-neutral attitude. This paper draws on recent contributions by the authors that accommodate the attitude towards risk within a non-linear utility specification as a preferred framework within which to value travel time savings. The interest in the non-linear form is motivated by the evidence in Hensher et al. (2011) that mean estimates of VTTS in a proposed toll road context are significantly lower when account is taken of risk attitude. The percentage reduction in the estimate of mean VTTS is approximately (coincidentally) equal to the actual percentage error in traffic forecasts associated with the new tollroad two years after opening. If we could show that this evidence of a lower mean estimate under the non-linear treatment is found in other data settings, then we gain confidence in suggesting that the linear-utility assumption to valuing travel time savings might be a potential contributor to over-predicted tollroad traffic forecasts. The non-linear model is applied herein to two other tollroad choice data sets and we find that sampled car commuters tend to be risk taking when decision making is subject to risk (due to the presence of variability in travel times). The model produces lower mean VTTS estimates than the traditional (linear) model, providing additional evidence of a systematic over-prediction of VTTS under the linear assumption. This paper suggests that future empirical studies on valuing time savings (and variability) should address the attitude towards risk.

1. Introduction

Road tolling is growing in popularity as an attractive option to finance the construction and maintenance of roads, bridges and tunnels throughout the world. With the shortage of government funding and the desire of some governments to take the debt off the public balance sheet, the idea of tollroads being financed, constructed and operated by the private sector under a public-private partnership (PPP) has grown in appeal. The use of PPPs for new roads is growing, particularly in Europe (e.g., Spain and the UK), Latin America (e.g., Chile) and Australia. Spain has involved the private sector in toll road concessions since 1967, while the UK embraced PPPs for delivering roads in the late 1980s. Most of currently operating toll roads in Australia are under a range of PPPs with concessions, and some strictly public, over a typical period of 30 years. In Sydney, seven out of eight currently operating toll roads were delivered by PPPs, with the exception of the Sydney Harbour Bridge.[1]

The toll road PPP concessions in place are typically operated by the private sector from a consortia bidding process (with three bidders in most situations), with the key players in each consortium being a construction company and a financial institution. The number of toll transactions is critical to the feasibility of toll road projects. Whether or not a privately operated toll road is able to generate sufficient revenues over the concession period determines its financial capability to recover its costs, including operations, maintenance, debt and equity. Should actual traffic be lower than forecast, the toll road will incur difficulties in delivering the expected returns to its shareholders. Hence, traffic demand forecasting is a crucial input into the financial and economic appraisal of toll road projects.

In most traffic forecasting packages, the value of travel time savings (VTTS) is a critical input. In traditional four-step models, trip assignment (or route choice) is at the lowest level, which is determined by evaluating and comparing the generalised cost (i.e., the sum of time and money costs) among a number of alternative routes, where the time cost is the product of travel time and the estimated VTTS. If the generalised cost of using the toll road is lower than the generalised cost of using a free road, the traveller will be assigned to use the toll road. This concept lies at the heart of most toll road traffic forecasting models.

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[1] Sydney's M4 Western Motorway was also delivered by PPP; however the NSW Government removed the M4 Western Motorway toll on 16 February 2010.

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Table 1
A Summary of two tollroad studies.

Study	Number of sampled car commuters[a]	Year of data	Country	Recent toll used in reference trip (proportion of sample) (%)	Age	Gender (proportion female)[b]	Annual Personal Income (thousands)	Hours worked per week
1	243	2004	Australia	75.3	41.70 (11.26)	0.36	Au $87.46 (33.41)	41.91 (11.60)
2	115	2007	New Zealand	0	48.02 (12.26)	0.63	NZ $[c]48.10 (24.57)	41.92 (13.83)

The standard deviation is given in parenthesis.

[a] Model estimation has a multiple of 16 times the number of observations.

[b] For both locations, the gender proportions are not exactly 50/50. We could not source statistics for the year when each survey was conducted (2007 for New Zealand; 2004 for Australian; noting these are not census years), and the closest year that we were able to find is the 2006 census year for both locations. For the New Zealand location (source: Census of Population and Dwellings 2006, New Zealand), females outnumbered males when Age > 19. Given that this paper focuses on car commuters (with Age > 19), a higher proportion of sampled female car commuters (i.e., 0.63) is in line with the population distribution. For the Australian location, at the population level, the female proportion was 0.47 (source: Australian Bureau of Statistics, Population by Age and Sex, Australia, 2006), lower than the male proportion. Based on the Australian sample, the female proportion was 0.36, which is also lower. The difference between the gender proportions at the population and sample levels may be attributed to a low response rate of 3.5 per cent for the Australian study. Given the geographical areas sampled for the two studies were a subset of the metropolitan areas where the population profile differs from the entire metropolitan area, we have been unable to source population data that is relevant to the specific locations and the age range above 19 years old.

[c] One New Zealand dollar (NZ$) was equivalent to 0.88 Australian dollar (Au$) in 2007.

Given the importance of VTTS to toll roads, Hensher and Goodwin (2004) claimed that the VTTS values must be properly used; otherwise "incorrect use of VTTS may cause serious distortion of investment priorities, and potentially financial stress serious enough to call the viability of a company, or the sustainability of a risk-sharing agreement, into question" (p.172). They also identified some common errors in using VTTS for toll roads, and suggested approaches to avoiding those errors.

This paper is a follow-up of Hensher and Goodwin (2004). The aim of this paper is to reveal a further common error in the form of risk attitude associated with the estimation of VTTS. The paper is motivated by the evidence in Hensher et al. (2011) that mean estimates of VTTS in a proposed toll road context are significantly lower when account is taken of risk attitude. Evidence from a number of countries shows that traffic demand for toll roads tends to be over-predicted (see TRB, 2006 for American evidence; Vassallo, 2007 for Spanish evidence; Li and Hensher, 2010a for Australian evidence; Welde, 2011 for Norwegian evidence Bain, 2009 for evidence throughout the world). The World Bank (2008) emphasised that most tollroad failures[2] are attributed to over-estimated forecasts, often referred to as 'optimism bias' (see also Bain, 2009). The contribution of this paper to transport policy is to identify whether the traditional modelling framework to estimating VTTS might contribute to this over-prediction, and to suggest an improvement in the modelling framework that might contribute to closing the gap in forecast errors of traffic.

The remaining sections are organised as follows. The next section introduces two stated choice (SC) data sets, as the empirical setting for incorporating risk attitude in order to test for VTTS over-estimates. This is followed by a discussion on the traditional modelling framework for valuing travel time savings and time variability, highlighting its major behavioural limitation, and then using an improved model that addresses both preferences and risk attitudes (two important components of decision making). We then present the empirical evidence which shows systematically higher mean VTTS estimates from the traditional (risk neutral) model, compared to the values from a model that estimates risk attitude. The paper concludes with key findings and recommendation.

[2] The Mexican PPP toll roads might be the best well known examples. Between 1987 and 1995, 52 toll roads were awarded under PPPs in Mexico, where 23 toll road projects failed, mainly due to overestimated traffic forecasts and cost overruns, and were rescued by the Mexican government's bailout programme (about US$5 billion was paid to the banks and about US$ 2.6 billion was paid to the construction companies).

2. Data sources

Two stated choice data sets from Australian and New Zealand tollroad studies conducted in 2004 and 2007 are used in this paper. The choice experiments involved each sampled commuter[3] answering 16 choice scenario questions. In each choice question, the respondent was required to make a choice among three alternatives, one described by a recent trip and two alternatives defined by attribute levels pivoted off of the recent (or reference) trip profile. Pivoting offers more realism in the stated choice experiment since hypothetical alternatives are defined relative to the reference alternative (status quo), giving better specificity in the context of the choice task (Train and Wilson, 2008). The two surveys (summarised in Table 1) were conducted as computer aided personal interviews (CAPI), where a D-efficient choice experiment design was used.

In these two studies, the trip time variability attribute was defined as *plus* or *minus* a level of time (see Fig. 1 for an example). In addition to trip time variability, free flow time (described to respondents as 'can change lanes without restriction and drive freely at the speed limit') and slowed down time (described as 'changing lanes is noticeably restricted and your freedom to travel at the speed limit is periodically inhibited. Queues will form behind any lane blockage such as a broken down car') are also provided in the choice tasks. The reported travel times are explained as typical times. For both studies, the trip cost is disaggregated into the running cost and the toll cost. The sample size for car commuters is 115[4] in Study 2 and 243 in Study 1.

[3] In both data sets, both car commuters and non-commuters were sampled. This paper focuses on car commuters.

[4] A potential limitation of the New Zealand data set in particular is that the sample may not be representative; however one referee commented that: "The advantage of disaggregate models is that they can explain behaviour at an individual level, [and] so as far as we have sufficient heterogeneity in the data to explain these differences, they would account for different behaviour of different individuals". Although the sample size in this data set seems to preclude identification of statistically significant differences in respect of socioeconomic influences, a behavioural strength of the mixed multinomial logit model used in this paper, is that the random parameters attached to the attributes of the alternatives enables us to reveal sufficient (randomly distributed) heterogeneity in the data to explain differences in the behaviour of individuals.