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Transport safety and traffic forecasting: An economist's perspective

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ABSTRACT

This paper is concerned with forecasting traffic accidents at a relatively aggregate level and over a long time period; the sort of information that is required as part of a comprehensive cost-benefit analysis of a major transportation investment or policy change. It is not so focused on appraising the social value of specific safety measures, although some of the points made seem germane. Whereas there has been much *ex ante* analysis at the meso- and macro-levels looking at the causes of accidents and ways of reducing both their number and severity, much less *ex post* has been done considering the accuracy of predictions of accident rates after an investment or policy initiative. Given the evidence that exists on the accuracy of traffic forecasts, especially involving oft over-optimistic predictions of public transit and rail use, there is at least a *prima facie* case for arguing that many investment and policy decisions are being based, in part, on over favorable assumptions with regard to their aggregate safety impacts.

1. Introduction

Safety is a major concern of transportation planners and engineers in their design of transportation infrastructure and its use. It is also, both out of self-interest and also the result of public policy, central to the behavior of those that make use of the transportation system, and in some cases those that live or work adjacent to transportation infrastructure. Having relatively good forecasts of the safety associated with a transportation system, or parts of it are thus important. Added to this, because decisions often involve a long-term perspective, is a need to have relatively good forecasts of future accident levels; and it is this latter subject that concerns us in this essay.

In terms of content, this is essentially an economics paper, with the major, although not only, interest being in the costs of accidents, and *ipso facto* of preventing them. In the sense that many transportation investments are partially justified as having an implicit positive impact on accident levels, it also have an inherent policy undertone. In particular, we are concerned with the types of distortion that can occur in calculating the full economic benefits of a transportation investment or policy change, and especially any of the safety effects, when traffic forecasts are poor.[1] While the technical safety aspects of such things as road design and its associated architecture, and traffic management approaches have been quite intensively studied, and are essential for evaluating local initiatives, such detailed analysis is of limited use when assessing large projects unless the traffic forecasts used are reasonable.

In considering the links between the need for reasonably accurate estimates of individual accident costs and traffic forecasting, the paper has its boundaries. We focus almost exclusively with matters of road safety and surface public transportation. There are important issues regarding the poor forecasting records of demand for other modes, and these undoubtedly have implications for safety policy, but space constraints preclude discussion extending into the air or to water modes. Additionally, we are only concerned with safety in terms of traffic accidents; it does not look at issues of security. While there is a perturbing trend for deliberate attacks on vehicles or using them for delivering an attack, including car and bus bombings, the issue of poor traffic forecasting, as far as one can tell, is not a major factor in trying to predict where they will occur.

2. The cost-benefit analysis calculation

Transportation investments involving the public sector generally involve considerations of both positive economic efficiency and

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[1] This usually involves meso-level projects such as major new freeways or public transportation system investments but may include significant policy changes such as modifications to speed limits. It may also include macro-level studies that forecast future national accident levels of the type done by Broughton [1] for the U.K. and Ulf Brüde [2] regarding Sweden.

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normative ideas of equity, and are assessed using some form of cost-benefit (or 'benefit-cost' to use the U.S. terminology) analysis [3]. Although practical limitations often mean that the analysis is partial, strictly, in a formal sense cost-benefit analysis involves estimating the monetary value of the widest range of effects of a project or policy over the long-term, taking into account such things as non-traded costs and benefits, and the implications of actions on future, as well as current generations. This can be expressed formally as;

$$NPV_{SW} = \sum_{G=1}^{G=x} \sum_{t=1}^{T=K} \left(\frac{aP(B_{GT}) - bP(L_{GT})}{(1-i)^T} \right) \tag{1}$$

where: NPV_{SW} is the social net present value; $aP(B_{GT})$ is the probable social benefit to be enjoyed by individual a in year T as a result of the investment's completion; B_{GT} *is* given a weighting a, to reflect society's welfare preference; $bP(L_{GT})$ is the probable social cost imposed on individual in b year T as a result of the investment's completion. L_{GT} is given a weighting b, to reflect society's welfare preference; i is the relative social weight attached to a cost or benefit occurring in a given year (the social discount rate); K is the anticipated life of the investment; and G is the number of individuals affected.

Because most transportation investments involve superior design and traffic control systems than their predecessors, safety normally enters the calculus as a benefit (an element in B). The monetary value of reduced accidents on the transportation system embraces mortality and morbidity considerations along with material damage to vehicles, road architecture, and adjacent buildings.[2] It covers not only the immediate transportation infrastructure under consideration, but also, because of normal route and mode diversions, embraces a significantly larger network than that immediately impacted.

The economic contribution of changes in safety for this type of exercise has come in the form of placing a financial value on accident reductions. The methodologies for doing this have evolved over the years, and are well rehearsed in academic and professional writings.[3] A comprehensive study essentially involves estimates of the costs of repairing/replacing the physical equipment and infrastructure that are damaged in accidents, the costs of any medical and other public services that may be required to deal with the accident and handle traffic congestion, the time costs imposed on delayed drivers as a result of the accident, and the "costs" to the individuals involved and their kith and kin; this latter element being by far the most problematic to evaluate.

There is an inherent social aversion to valuing the loss of a life and, to a lesser extent, an injury. The earliest approach to valuation of life focused on the welfare loss of the individual killed with an almost arbitrary addition of an indirect effect to reflect the costs felt to those close to the individual; lost output or consumption being an oft used measure of the direct cost. This calculation, given knowledge of such things as income and average life expectancies offered a crude revealed preference accountancy framework to operate under. The more recent analysis makes use of market theories and in particular the willingness-to-pay of individuals to avoid death or injury; basically a quasi-actuarial estimation procedure. The methodology has now move from the revealed-preference approach of the *ex-anti* and *ex-post* evaluations, to a revealed preference framework. Individuals are asked, albeit in a very controlled environment, how much they would be willing to pay to reduce the chance of a major accident. This amount, when combined with the actual probability of an accident and the number of travelers, offers an estimate of the value of enhancing safety.[4]

There are clearly technical challenges with the willingness-to-pay approach, such as defining the appropriate sampling fame and couching apposite questions, but it is now widely used for assessing the value to individuals of reducing the probability of having an accident. We stay away from the issue of the appropriateness of the methodology, and whether it can be applied with any degree of accuracy, and consider the implications of applying the wrong multiplicand to individuals' values of safety enhancement. In other words, what are the implications of poor traffic forecasts on the overall value of safety improvements even if economists get individuals' monetary values of safety changes broadly correct?

From a forecasting perspective, a major input into appraising the accident benefits and costs transportation initiatives are, therefore, predictions of future traffic levels; having good estimates of the costs of each accident are of limited use in a cost-benefit analysis without good predictions of the numbers of accidents.[5] There is an abundance of analysis of what factors cause accidents – road design, alcohol and drug consumption, driver training, and so on – but the volume of traffic, when it occurs, the routes being used, and its composition are perhaps the main factors when assessing major investments and policy changes.[6]

The fact that traffic forecasts are themselves historical and often been poor is a given fact, but bygones-are-bygones and the issues here are with regard to improving future cost-benefit analysis assessments. The on-going concern about sustainable development, and in particular the influential *Stern Report* [7], has been changing the way that discounting rates are determined in cost-benefit calculations (the i in Eq. (1)). Basically, if we adopt the underlying notions of sustainability set out in the *Brundtland Report*, and especially that the overall resource base on Earth should be maintained for future generations, the discount rate in cost-benefit analysis should be near zero. From a practical perspective this means that long-term traffic predictions and accident costs play a very much larger role in estimating net present values of investments; *e.g.* with an 8% social discount rate cost-benefit analyses are dominated by considerations twelve years or so into the future, but with a 1% rate accident rates 80 years or more ahead still heavily influence the calculations. Even if the value of a life saved is accurate in both cases, a small error in traffic forecasts will affect the associate aggregate number of accidents and their costs.

3. Record of transportation forecasters

3.1. The numbers

The traffic forecasts used in cost-benefit analysis, despite the numerous years of engagement of traffic engineers, the marketing of "sophisticated" software by transportation consultants, and the development of better data collection procedures, remain generally poor.[7] But before moving to consider just how inaccurate forecasts often are, there is a need to consider what level of accuracy is needed in the safety component of a cost-benefit analysis, which, after all is a somewhat different calculation with regard to the physical engineering maintenance or financing of a facility.

[2] In some rate cases the expected overall safety record may be forecast to be worse after a change to the transportation system, in which case accidents become a cost item in the calculation.

[3] For a survey, see Michael Jones-Lee and Graham Loomes [4].

[4] For an account of parallel calculation methods regarding the safety of freight being transported see, Ian Savage [5].

[5] This point was made by Brüde [2] in the context of forecasting traffic accidents in Sweden, "Making forecasts entails extrapolating the regression model outside the area where the observations were made. Making forecasts differ considerably from taking a random sample from a well-defined population and performing statistical interference, i.e. point and intervals estimates of expected values within the range of observations. This requires calculated confidence intervals for forecast and the prediction intervals for observed outcomes to be regarded with some caution."

[6] Hakim et al. [6] provide a useful if now a little dated survey of the macro factors that have been found important in determining surface transportation accidents. These are obviously important for considering specific safety initiatives, but here the focus is in the accident implications of more general transportation changes.

[7] Mackinder and Evans [8] provided an early critique of U.K. forecasts.