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From theory to practice in road safety policy: Understanding risk versus mobility

Robert B. Noland*

Alan M. Voorhees Transportation Center, Edward J. Bloustein School of Planning and Public Policy, Rutgers University, 33 Livingston Ave., New Brunswick, NJ 08901, USA

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ABSTRACT

This paper reviews theoretical issues surrounding transport safety modeling and the implications for road safety policy. The behavioral mechanisms that affect transport safety are typically not considered in safety modeling. These issues are discussed in the context of trade-offs between risk-taking, as perceived by travelers, and other mobility objectives and the attributes associated with them. This is an extension of other theoretical frameworks, such as risk compensation, and attempts to integrate some of the previous frameworks developed over the years. Various examples of behavioral adaptation to specific policies are discussed and linked to the framework. These issues are then discussed in the context of improvements to empirical work in this area and the linkage of theoretical frameworks to crash modeling, in particular the estimation and use of Crash Modification Factors. Conclusions suggest that there are many deficiencies in practice, from estimation of models to choice of effective policies. Progress is being made on the former, while the publication of practical guidance seems to have substantial lags in knowledge.

1. Introduction

The primary objective of road safety policy is to make travel safer. Over the last 40 years major effort has been devoted to achieving reductions in vehicle crashes and their severity in all developed countries, with mixed results. For example, Sweden and the United Kingdom, have seen dramatic reductions in both fatal and injury outcomes over the last 40 years, whether measured per capita or per vehicle-kilometer traveled (VKT), both having the best overall safety records of any country. The US, on the other hand, has seen smaller reductions. For many years the total number of fatalities stagnated at about 42,000 per year, only recently dropping in 2008 with the global financial crisis.[1]

Road safety policy is typically the domain of many different disciplines. This includes traffic engineers, economists, psychologists, statisticians, public health professionals, and more recently urban planners. Frequently these different disciplines approach road safety policy from different perspectives. Placement of road safety policy within the broader framework of transport behavior, choice, and economic decision making tends to be lacking. For example, the choice of mode can have a major impact on overall levels of safety and understanding how relative modal risk affects these decisions is often not considered, even for non-motorized modes.[2] Transport policy that affects the choice of mode may have implications for overall road safety.

A good example of this is how increases in the use of non-motorized modes can affect overall safety. Jacobsen (2003), in a widely cited paper, suggests that there is 'safety in numbers' providing a protective effect for bicyclists and pedestrians. Theoretically this might occur due to the presence of non-motorized modes leading to reductions in speed; that is motorists take greater care when they interact with more non-motorized modes. The increase in the visibility of non-motorized modes may also lead to greater awareness and more careful driving. Alternatively, the analysis in Jacobsen could be spurious; that is, there is another underlying mechanism (such as improved bicycle and pedestrian infrastructure) that both attracts more non-motorized activity and also makes it safer. Thus, a fuller understanding of behavioral responses can lead to better policy decisions.

Another important issue for a better understanding of how to improve road safety is how the results of research studies are

* Tel.: +1 848 932 2859.
E-mail address: rnoland@rutgers.edu.

[1] See http://www-fars.nhtsa.dot.gov/Main/index.aspx for total fatalities and other aggregate data for the US.

[2] Noland and Kunreuther (1995) examined how perceptions of risk affect the use of bicycles as a commute mode.

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applied in practice. As many of the debates over policy are politically controversial the actual implementation of policies and interpretation of research results is not simply achieved. Examples include the repeal of motorcycle helmet laws in the US, which are proven to be effective at reducing fatalities, and debates over speed cameras in the UK (Delaney, Ward, Cameron, & Williams, 2005), also shown to reduce fatalities (Gains, Nordstrom, Heydecker, & Shrewsbury, 2005). Speed limit policies in particular have proven difficult to implement for safety; the US repealed a nationwide 55 mph speed limit that accounted for large reductions in traffic fatalities when initially implemented in the mid-1970s with subsequent increases in fatalities and crashes on repeal (Friedman, Hedeker, & Richter, 2009). Much of the debate over speed control now centers on urban areas where efforts to implement traffic-calming features are often met with controversy by vocal minorities (Taylor & Tight, 1997).

The measurement of traffic safety and how this influences policies is also dependent on the choice of metric. The scale of measurement, whether by mode, road type, or area can influence policy. For example a focus on only motorized modes may ignore the consequences for pedestrians. The actual metric chosen to measure casualties may also have an impact on policy choice (Johnston, 2010). These may include total deaths and injuries or be measured based on total travel (per VKT) or per capita. Per capita measures allow one to compare road casualties with other public health problems. VKT based measures presume that casualties are an unfortunate consequence of mobility, which is seen as beneficial. This leads to perverse effects, such as in the US, increased mobility (measured by VKT) will tend to lower the rate of casualties per VKT, suggesting to policy makers that there is progress in reducing casualties, even when totals are increasing. Defined targets for total casualties, and especially fatalities, can lead to changing "…the institutional mindset from one of managing a by-product to one of viewing safety as a fundamental outcome…" (Johnston, 2010, p. 1177).

This paper examines several of the issues surrounding road safety policy from a behavioral perspective, explicitly considering how safety policy influences mobility. This begins with a discussion of theoretical frameworks for understanding road safety behavior and the formulation of a proposed theoretical framework that unifies many of the previous theories. Various examples of behavioral adaptation are discussed. This is followed by a discussion of modeling and data issues associated with empirical estimations. Interpretation and use of model results is then discussed. Conclusions examine how to improve the process of analyzing road safety policies with the hope that improvements in knowledge and actual reductions in crash and severity outcomes can be achieved.

2. A review of theoretical frameworks

Road safety policy has generally been pursued using the tools of enforcement, education, and engineering. Enforcement is assumed to lead to reduced risk taking among motorists, education provides a means of improving driving skills and increasing awareness of potential risks, while engineering is aimed at improving both the crash integrity of the vehicle, survivability of crashes, and changes to the road infrastructure to reduce crashes and their severity (i.e., making the road itself more "forgiving"). The theoretical constructs surrounding the formulation of policy in these areas, especially in the engineering realm, has generally assumed a deterministic and fixed response to any intervention that is estimated to reduce crashes. In essence, this assumes that individuals do not change their behavior in response to an engineering improvement or policy.

Devising a theoretical framework for how effective various policies are requires the inclusion of a behavioral element into the theory, and this could substantively modify conclusions about the effectiveness of various interventions. The effect of behavioral responses has long been a controversial topic and was originally noted in the seminal work of Smeed (1949), who stated:

> "It is frequently argued that it is a waste of energy to take many of these steps to reduce accidents. There is a body of opinion that holds that the provision of better roads, for example, or the increase in sight lines merely enables the motorist to drive faster, and the result is the same number of accidents as previously. I think there will nearly always be a tendency of this sort, but I see no reason why this regressive tendency should always result in exactly the same number of accidents as would have occurred in the absence of active measures for accident reduction." (Smeed, 1949, p. 13)

Smeed thus recognized the issue as early as 1949, and recognized that any response would not fully off-set the increased risk from faster driving. Probably the first formal analysis of this idea dates to Taylor (1964) who studied the galvanic skin response[3] of test drivers and determined that there was a measurable change when drivers encountered riskier situations. Taylor posited that driving behavior is regulated in such a manner as to control risk by maintaining a given level of anxiety, and this can be controlled by speed choice. He also suggested that "Driver behaviour could be more directly manipulated by deliberate introduction of 'artificial hazards'…" (Taylor, 1964, p. 450).[4]

2.1. Cognitive models

Following the work of Taylor (1964), the first psychological theory was originally proposed by Näätänen and Summala (1974). This was the "Zero-Risk theory" and the implication for road safety is discussed in Summala (1988). The main hypothesis proposed is that drivers adjust to road risks and therefore do not subjectively experience it under normal driving conditions. This theory recognizes an implicit trade-off of risk with mobility, although this is expressed as the driver's motivation. That motivation can include other objectives, such as conservation of effort, or the excitement of speed. The rarity of drivers actually experiencing risk thus motivates them to increase their speed to satisfy other motivations for driving. Summala (1988) states that "the key to effective safety countermeasures is…to prevent [drivers] from satisfying their motives" (p. 500) and this implies some form of speed control.

Wilde (1982) formulated the risk homeostasis theory to explain risks in road safety. Wilde's research developed from psychological theories of human behavior and posited that individuals seek stimulus from achieving a specified target level of risk in their lives. Thus, any reduction in transport risk might increase risk-taking behavior to achieve the same target level of risk. Expanding this beyond just transport behavioral reactions, Wilde suggested that other risky behaviors for which individuals derive pleasure might also increase (e.g. rock climbing, sky diving, or other thrill-seeking activities). The homeostatic mechanism described by Wilde was that target risk would remain constant and that effective policies must be aimed at reducing the desired target risk. One assumption behind this theory is that individuals can accurately perceive their

[3] Galvanic skin response is a measure of how the skin conducts electricity and varies with the moisture content of the skin. In short, when one sweats it is a measure of psychological and physiological arousal (e.g. increased heart rate and alertness).

[4] This is of course, what is accomplished by some traffic calming techniques.