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Benefit-Cost methodology for highway-railway grade crossing safety protocols as applied to transportation infrastructure project prioritization processes

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Abstract

This paper summarizes efforts in assisting the North Carolina Department of Transportation (Rail Division) in developing a methodology for identifying and prioritizing safety projects at highway-rail at-grade crossings (grade crossings). This approach leverages recent developments in data management to improve the identification, prioritization and selection of safety projects through the calculation of all the costs and benefits associated to a safety project. This approach will also provide policymakers with the kind of information they need to communicate with the public and other government agencies about the benefits of investing in safety.

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1. Introduction

Over the last century, the United States has built a substantial amount of infrastructure for all modes of transportation, but in the last few decades has failed to allocate sufficient funding to the maintenance of this infrastructure. Fuel excise taxes are supposed to be accumulated in the Highway Maintenance Trust Fund that is

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supposed to fund highway maintenance and improvements. However, as fuel prices rose starting in 2003, vehicle miles traveled and fuel tax revenues declined. The HMT has been consistently under-funded for most of the last 20 years. Other trends such as the public sector's large debt and worsening pension fund burden due to the aging population indicate funding infrastructure expenditures by government agencies will continue to be challenged. Funding for safety improvements has not been immune from these trends' impacts. Safety projects have had to compete for an allocation of funds hampered by the lack of visibility of secondary costs from insufficient investment as discussed in this paper.

Over the last five years the US Department of Transportation (USDOT) has been leading a significant change in the process of allocating grants for infrastructure projects, embedded in the Transportation Infrastructure Generating Economic Recovery (TIGER) program established by Congress in 2009. Since then it has dedicated $4.1 billion for six rounds to fund projects that have a significant impact on the nation, a region or a metropolitan area. A variety of project types have been awarded including ports, rail, roads, transit, bicycle paths and pedestrian walkways. The TIGER program has a well-defined benefit-cost framework which has been identified as a primary decision driver in the most recent transportation authorization program, Moving Ahead for Progress in the 21st Century Act (MAP-21) signed into law in July, 2012.

The TIGER program and MAP-21 follow the longer term efforts by the USDOT to bring infrastructure funding into a common capital budget allocation framework. This would also include Section 130 funding. This refers to the 130th section of the 23rd United States code which outlines the Federal-Aid funding program for grade crossings. Therefore a contribution of this paper is to apply developments in the literature regarding estimation of at-grade crash costs and their probabilities within the USDOT benefit-cost framework in order to support Rail Division's efforts to obtain funding from both the state and federal governments based on safety and economic merits.

Most of the frameworks/models currently used for safety fund allocation have been developed under different circumstances for funding availability. However more recent research, as discussed in the next section, has shown how to identify and quantify the secondary impacts of safety improvements. By applying this to well established benefit cost analyses such as the Federal Rail Administration's (FRA) with modifications to bring that in line with overall USDOT's efforts, it is possible to quantify these impacts with the occasional conclusion that closing a rail crossing for safety may have a much lower benefit cost ratio than would otherwise be the case. Furthermore at the time of their development, conventional frameworks/models where challenged by the availability/accessibility of data and computing power. The recent developments in data management have provided an opportunity to leverage data-driven approaches, such as those described in this paper to improve the identification, prioritization and selection of safety projects. These developments should also provide policymakers with the kind of information they need to communicate with the public and other government agencies about the benefits of investing in safety.

1.1. State of the practice

1.1.1. Identifying potentially hazardous crossings

Rail Division has been using variations of the Investigative Index formula since the early 1970s to identify and rank potentially hazardous crossings. The present version of the Investigative Index, Equation (1), NCDOT (2003), incorporates many variables and is divided into three parts; exposure, crash history, and sight distance. Variables used are level of crossing protection (Pf), highway traffic volume (ADTmodified), train volume (TV), train speed (TSF), number and type of tracks (TF), crash history (C crashes over Y years), and sight distance (SDF).

$$H = \frac{Pf \times ADTmodified \times TV \times TSF \times TF}{160} + \left(70 \times \frac{C}{Y}\right)^2 + SDF \tag{1}$$

where $ADTmodified$ = Average Daily Traffic (vehicles per day) with the following modifications:

- Add (number of school bus occupants)/1.2 to ADT when school buses use the crossing
- Multiply ADT by 1.2 when hazardous materials exist
- Multiply ADT by 1.2 when passenger trains use the crossing

The FRA Prediction Model, Ogden (2007), is the most commonly used method for identifying, selecting and programming rail safety crossing projects in the US. This formula was developed in the mid-1980s and was designed