ABSTRACT

Issariyanukula, Apichai. Ph.D., Purdue University, December, 2011. A Probabilistic Analysis of Highway Maintenance Treatment Cost Using Bayesian Statistical Techniques. Major Professor: Samuel Labi.

The purpose of this study is to enhance the estimation of aggregate planning-phase costs of transportation facilities. At the planning phase of transportation facility development, cost-related data are often limited and project scope is often not well defined. As such, the general practice of cost estimation of transportation projects at this phase has been largely deterministic and based on data from historical similar projects. However, the variability associated with project conditions leads to significant uncertainty and error in project cost estimates that are developed in this manner. Thus, actual project costs often end up very different from what was predicted at the planning phase, thus posing a serious finance-related risk in highway management. Unfortunately, current existing risk assessment and analysis tools that are intended to address such problems, are impractical and hardly used in the industry because they also rely on historical data, require input of detailed project information that are often unavailable during planning, and fail to exploit the available expert knowledge of cost factors that often explain for cost deviations.

To address this issue, this dissertation shows how agencies could carry out a risk-based probabilistic analysis of highway project costs using Bayesian statistical techniques with limited data. The dissertation introduces four stochastic cost models on the basis of Bayesian statistics: the One-State Bayesian Cost Model, Hierarchical Bayes Cost Model, General Bayesian Regression and the Random-Effects Bayesian Regression. Each of these models are applicable at different levels of data availability, and can estimate the point estimate, range estimate and full probability distribution of project cost. Unlike the classical Frequentist modeling structures, the Bayesian cost models can amalgamate simultaneously, information from historical data and expert opinion into the analysis using probability theory, thus helping to reap the benefits associated with each of these two information

sources, particularly where each source alone is inadequate to develop a reliable cost estimate. The dissertation demonstrates the application of the new cost estimation approach using a case study involving functional hot-mix asphaltic concrete overlay data from Indiana. The Bayesian models are used to fit and predict the cost of this highway maintenance treatment. In contrast to classical (Frequentist) cost estimation that yields a fixed value for each of cost parameter, the Bayesian describes all such parameters using probability distributions thus allowing the assignment of probabilities, rather than fixed values, to model parameters, confidence intervals, cost elasticities and other model outputs. The dissertation also studied the effect of incorporating expert opinion into cost estimation analysis using data from the case study and showed that expert opinion can and does help improve the precision of model estimation and prediction. The application of the developed framework for Bayesian cost estimation is not only limited to the highway maintenance planning but can also be used for cost estimation of planned actions at other phases of highway development and also in other modes of transportation.