# Modeling Uncertainty in LCCA

## Problem

The difficulty of projecting the life-cycle of a pavement project has led the Federal Highway Administration (FHWA) to promote the use of a probabilistic Life Cycle Cost Assessment (LCCA). There is little guidance, however, in the selection of probabilistic input values to quantify uncertainty, which can be derived from various sources, including limited data sets, conflicting evidence, measurement uncertainty, and trends related to time and economies of scale. The goal of this work is to move probabilistic LCCA into practice by creating a model structure that recognizes, characterizes, and statistically models uncertainty related to input values, in order to understand the risk of alternative designs.

## Approach

Our research focuses on statistically analyzing three types of uncertainty and trends related to cost: time, economies of scale, and basic variation in the data. First, based on historical price data, the nominal price of pavement materials have increased at a non-linear rate. A best-fit distribution of the real-price change over time is currently implemented to capture the volatility for different commodities. Secondly, regression analysis has been utilized to model the relationship between quantity of materials for a project and the unit-price cost. Although regression analysis shows a strong correlation between certain parameters related to cost, no process has a perfect one-to-one relationship. Finally, by using the standard errors of the regression coefficients, the model is able to capture the variation in the data. Incorporating these three components, a probabilistic LCCA model has been developed and applied to different roadway alternatives for different projects.

## Findings

Initial results indicate that a large contributor to variance is the limited available data for some life-cycle processes. In particular, the material price-evolution over time for asphalt has a larger variance than concrete (Figure 1), and economies of scale influence life-cycle costs considerably (Figure 2). Future work will focus on further data collection to reduce uncertainty, analyze the appropriateness of different types of distributions for cost related inputs, and investigate the use of material-specific inflation rates.

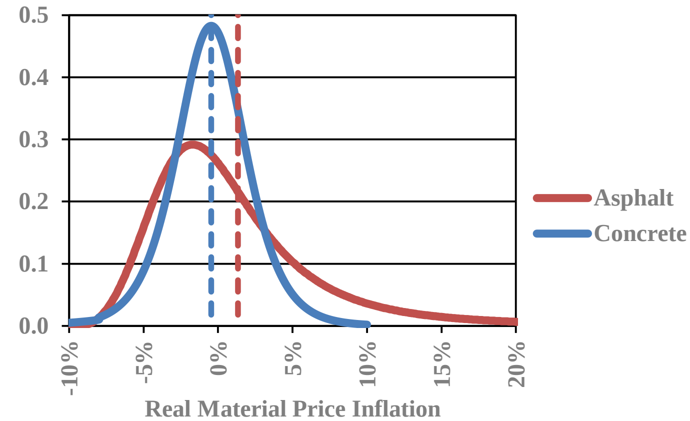


**Figure 1: Best-fit probability density function for material-price inflation of concrete (logistic) and asphalt (log-logistic) using 35-years of historical data, with the dashed lines representing the mean value of each distribution. It should be noted that for a log-logistic distribution, the peak does not correspond with the mean.**

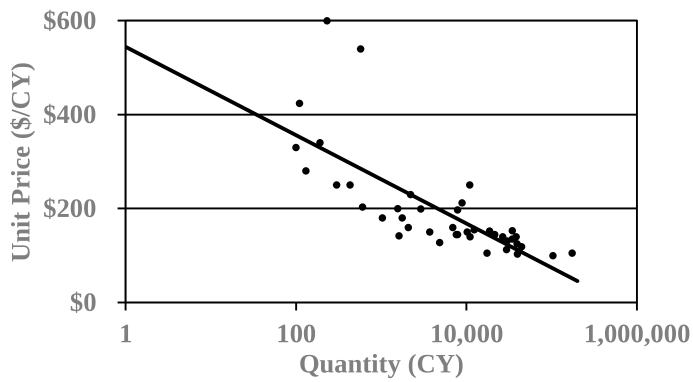


**Figure 2: The above figure shows the correlation between price and quantity of materials, using 12-months of project bid data from CalTrans, for one life-cycle process. Through regression analysis, a best-fit curve can be fitted to the data, modeling this correlation, and the standard error of the regression coefficients can be used to capture the basic variation in the data set.**

## Impact

Interfacing this model with the recently developed MEPDG will allow decision makers to fully understand the probabilistic life-cycle cost of alternative designs for a given project. This will allow a decision maker to choose a pavement alternative based on the risk they are willing to accept.

## More

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