Material-Specific Price Projections: Implementation

PROBLEM

Developing an effective life-cycle cost analysis (LCCA) model, similar to sound engineering practice, requires (a) accurate estimates of input parameters and (b) consideration of uncertainty and variation. One would expect that an LCCA would take into consideration the potential dissimilar growth of pavement materials. Yet current practice assumes all commodities will (a) grow at the same rate and (b) increase at the rate of inflation. This is partly because of the difficulty in developing effective forecasting models. Researchers at the CSHub have developed probabilistic price projections that outperform current practice and account for the volatility in paving prices (Figure 1). The purpose of this brief is to demonstrate how such models can be implemented within the scope of current LCCA models.

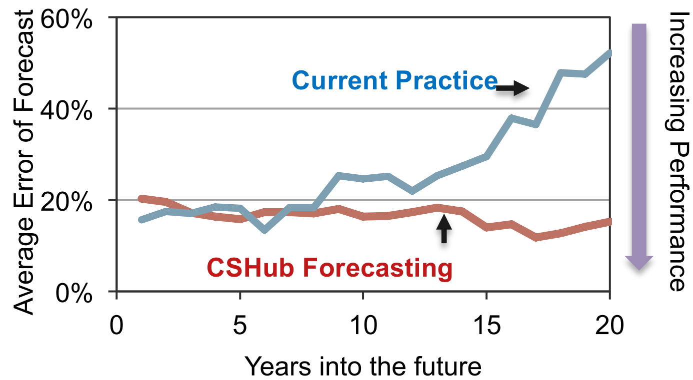

Figure 1 Average error of forecast asphalt prices using CSHub model versus current practice for one state DOT

APPROACH

The price projections developed by the CSHub can be implemented either by integrating the forecasting models into a probabilistic LCCA software tool such as FHWA's RealCost or utilizing the price projection tables provided at the end of this brief. The former approach is the preferred method, but given its complexity, the methodology to develop the latter is demonstrated via a case study the CSHub conducted with a state DOT.

Step 1: Estimate costs and years of rehabilitation - Key inputs, listed in Table 1, have all been estimated via an LCCA model integrated with Pavement-ME software. Note that material costs are broken out in order to incorporate material price projections (labeled as "adjusted cost portion").

Table 1 Description of information and calculation for each step (cost in millions of $'s)

Step 1 - Estimate costs and years of rehabilitation	Initial Construction		Rehabilitation 1		Rehabilitation 2	
	Rigid	Flexible	Rigid	Flexible	Rigid	Flexible
Year	0	0	27	15	N/A	29
Non-Adjusted Cost Portion	$1.28	$1.16	$0.69	$0.14	N/A	$0.23
Adjusted Cost Portion (e.g., material costs)	N/A	N/A	$0.07	$0.30	N/A	$0.30
Step 2 - Select index values from table for years of rehabilitation and calculate future costs						
Adjustment Index @ 5th percentile	N/A	N/A	0.890	0.810	N/A	0.964
Adjustment Index @ 95th percentile	N/A	N/A	1.151	1.349	N/A	1.501
$Cost\ Adjusted\ Portion\ at\ X\% = Cost\ Adjusted\ Portion * Adjustement\ Index\ @\ X\%$						
Adjusted Cost Portion @ 5th percentile	N/A	N/A	$0.06	$0.24	N/A	$0.29
Adjusted Cost Portion @ 95th percentile	N/A	N/A	$0.08	$0.40	N/A	$0.45

Step 3 – Calculate adjusted LCC values for different confidence levels

$$Cost\ Adjusted\ LCCA = Initial + \Sigma Discounted\ (Ajdjusted\ Cost\ + Non - Adjusted\ Costs)$$

(i.e. 5th Percentile LCC for Rigid Pavement $= \$1.28 + \frac{\$0.69+\$0.06}{(1.019)^{27}} = \$1.73$

	Rigid	Flexible
5th Percentile LCC for Pavement	$1.73	$1.75
95th Percentile LCC for Pavement	$1.74	$1.96
LCC for Pavement without Adj. Index (represents current practice estimate)	$1.74	$1.80

Step 2: Select index values from table for years of rehabilitation and calculate future costs – The table at the end of this brief provides estimates of future material price projections for concrete and asphalt for different probabilities based upon the CSHub model. For example, the 95th percentile column at year 15 for asphalt tells us that it is 95% likely future prices of asphalt will be less than 1.349 times their prices relative to the present (year 0). Escalation of future rehabilitation costs should be in accordance with how confident a decision maker wants to be about future prices. The more confident one wants to be, the higher the percentile one should utilize. This analysis has utilized the 5th and 95th percentiles to demonstrate outcomes under extreme conditions, as shown in Figure 2.

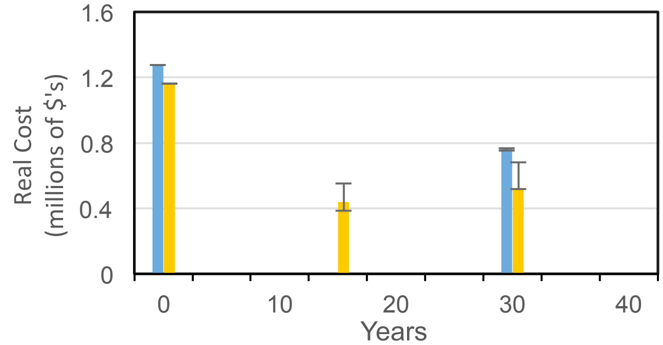

Figure 2. Cash flow diagram for flexible and rigid pavement designs using the 5th and 95th percentile price projections

Step 3: Calculate adjusted LCC values for different confidence levels – The estimated cash flow can be converted into an NPV by using an appropriate discount rate as determined by a decision maker. Figure 3 presents the NPV using a discount rate of 1.9% (consistent wiith OMB A-94 30-year treasury rates) (a) when material-price projections are excluded (represented by the blue and yellow bars) and (b) discounting all future rehabilitations by the 5th/95th percentile estimates. Note that making use of the 95th percentile projections drastically alters the cost competitiveness of the two designs, demonstrating the potential importance of incorporating price projections and, more importantly, uncertainty in these analyses.

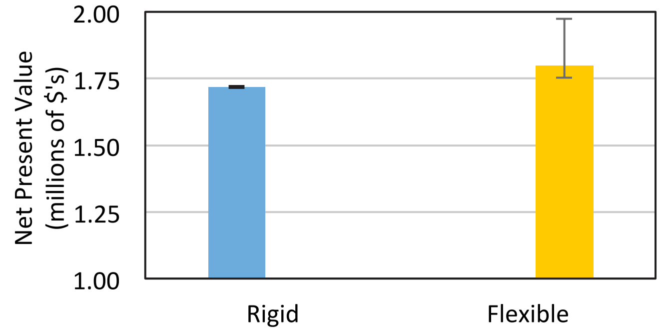

Figure 3. NPV for flexible and rigid pavement designs using the 5th and 95th percentile price projections

FINDINGS

This research brief has detailed a simplified approach to incorporate probabilistic price forecasts in an LCCA framework. Accounting for uncertainty in LCCA allows decision makers to feel more confident in their decisions by understanding the range of possible outcomes. Although this analysis is a good first step in considering uncertainty, a more complex probabilistic model (such as RealCost) can enhance the effectiveness of the model in several ways. For example, referencing the previous case study, the joint likelihood the two rehabilitations would exceed the 95th percentile is lower than 5%, meaning the presented methodology may overestimate actual uncertainty. A simulation model, on the other hand, can overcome this. Similarly, a more elaborate approach can easily consider (a) many sources of variation and (b) develop a target curve, as shown in Figure 4, which presents the probabilistic LCC for each alternative. Such a target curve provides a more robust, visual representation of results so that decision makers can make decisions based upon different levels of confidence.

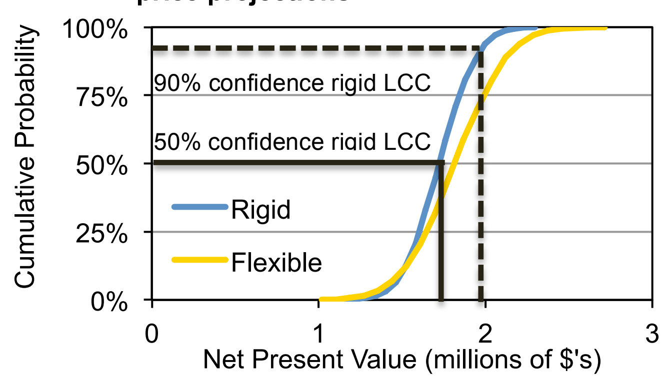

Figure 4. NPV for flexible and rigid pavement designs when using complex model

IMPACT

The CSHub has developed probabilistic price projections for paving materials that can fit within the framework of existing software tools (e.g., RealCost). The approach described in this brief allows for uncertainty regarding future material prices to be considered in a simplified manner.

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Authors: O. Swei, in collaboration with Dr. J. Gregory, and Dr. R. Kirchain.

Table 2 Probabilistic forecast indices developed by the CSHub by making use of developed forecasting models. The percentiles indicate that one can be X% confident future prices will not exceed a particular value. Indices should be applied to the material-specific component.

	Asphalt								Concrete							
Year	**Mean**	**5th**	**10th**	**25th**	**50th**	**75th**	**90th**	**95th**	**Mean**	**5th**	**10th**	**25th**	**50th**	**75th**	**90th**	**95th**
0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1	99.2	84.8	87.9	93.2	98.9	104.8	110.7	114.4	100.1	95.7	96.8	98.3	100.0	101.8	103.4	104.6
2	99.0	81.0	84.9	91.4	98.6	106.1	113.9	118.6	100.2	94.1	95.3	97.7	100.1	102.9	105.3	106.5
3	99.2	79.1	83.6	90.2	98.9	107.5	115.5	120.9	100.4	93.2	94.6	97.4	100.2	103.2	106.1	107.6
4	99.6	77.6	82.8	90.7	99.3	108.1	116.5	122.6	100.4	92.3	93.9	97.0	100.4	103.8	106.8	108.7
5	99.9	78.0	83.1	90.3	99.5	108.8	117.8	123.6	100.6	91.7	93.8	97.1	100.7	104.4	107.5	109.0
6	100.0	77.1	82.3	90.5	99.3	108.5	118.4	124.9	100.7	91.1	93.3	96.7	100.8	104.6	108.3	110.2
7	100.7	77.1	81.5	90.4	100.1	110.1	120.7	126.9	100.8	90.7	92.8	96.8	100.9	105.1	108.7	110.7
8	100.8	76.8	81.3	89.9	100.4	110.7	120.8	126.3	100.9	90.4	92.7	96.6	100.8	105.4	109.1	111.1
9	101.4	76.9	82.6	90.7	100.3	111.8	121.3	128.3	100.8	90.3	92.9	96.4	100.9	105.3	109.2	111.2
10	102.3	78.7	82.9	91.6	101.2	112.6	122.5	129.7	101.0	90.5	92.8	96.5	101.0	105.5	109.5	112.0
11	103.0	78.0	82.9	91.9	102.4	112.8	123.8	130.5	101.1	90.0	92.5	96.5	101.1	105.7	110.0	112.2
12	103.8	79.2	83.7	92.5	102.6	114.6	124.8	131.1	101.2	89.8	92.6	96.6	101.3	105.9	109.9	112.1
13	104.4	79.9	83.9	92.8	103.7	114.9	125.0	132.8	101.3	89.7	92.3	96.8	101.3	106.1	110.4	112.9
14	105.3	79.9	83.9	93.8	104.4	116.0	127.8	133.9	101.4	89.9	92.4	96.7	101.4	106.0	110.4	113.4
15	106.7	81.0	85.9	95.1	105.8	117.9	128.6	134.9	101.4	89.8	92.4	96.6	101.2	106.2	110.9	113.5
16	107.7	82.0	87.1	95.8	106.5	118.8	130.1	137.8	101.4	89.4	92.1	96.5	101.3	106.2	110.9	113.6
17	108.7	82.1	87.3	97.2	107.9	119.6	130.5	138.4	101.5	89.3	92.0	96.5	101.6	106.5	110.8	113.6
18	110.0	83.1	88.7	97.6	109.4	121.3	133.3	140.2	101.5	89.4	92.3	96.3	101.8	106.3	111.2	114.1
19	111.3	83.7	89.7	99.1	110.8	122.4	134.3	141.5	101.6	89.1	91.9	96.6	101.8	106.5	111.1	113.8
20	112.4	85.5	91.5	100.2	112.0	123.8	135.1	140.9	101.7	89.5	91.8	96.7	101.8	106.7	111.1	114.3
21	114.1	86.4	92.0	101.7	113.6	126.4	136.9	142.7	101.7	89.5	92.2	96.3	101.8	106.6	111.3	114.3
22	115.0	86.1	92.8	103.1	115.1	127.0	137.1	143.1	101.8	89.7	92.1	96.4	101.9	106.9	111.4	114.8
23	116.8	88.6	94.1	104.6	116.5	129.3	140.1	145.2	101.9	89.6	92.0	96.5	101.9	107.1	111.6	114.4
24	118.2	89.0	95.8	105.8	118.5	130.9	140.8	146.5	101.9	89.5	92.1	96.7	101.8	107.2	111.7	114.5
25	120.0	90.8	96.5	107.9	120.4	132.6	142.1	147.0	101.9	88.8	91.7	96.5	101.8	107.2	111.6	114.5
26	121.7	93.0	99.8	110.1	122.5	133.2	143.2	148.6	101.8	89.4	91.9	96.5	101.6	107.4	111.8	114.2
27	123.1	95.5	101.3	112.0	124.2	134.6	144.0	149.0	101.8	89.0	91.9	96.5	101.6	107.2	111.8	115.1
28	124.2	95.7	101.1	112.7	125.4	136.2	144.9	149.6	101.9	89.1	92.0	96.7	101.8	107.1	111.9	114.9
29	125.3	96.4	103.9	114.5	126.4	137.2	145.2	150.1	101.9	89.1	92.1	96.6	101.6	107.2	111.9	114.7
30	126.7	97.4	105.1	116.5	127.8	138.4	146.0	150.9	101.9	89.5	92.0	96.3	101.7	107.3	112.1	115.5
31	127.8	100.5	107.7	118.1	129.0	138.7	146.4	151.1	101.9	89.7	92.1	96.3	101.7	107.1	112.4	115.0
32	128.3	100.9	108.2	118.7	129.0	138.9	147.2	151.8	101.8	89.3	91.9	96.4	101.8	106.9	112.2	115.2
33	129.2	103.6	109.8	120.2	130.1	139.4	147.4	151.6	101.8	89.2	91.9	96.3	101.7	107.0	112.0	115.2
34	129.8	104.6	110.6	120.8	130.8	139.6	147.2	152.1	101.9	89.3	91.8	96.4	101.9	107.2	112.1	115.2
35	130.9	107.3	113.5	122.2	131.4	140.4	148.2	152.3	102.0	89.7	91.8	96.5	101.9	107.4	112.2	115.2
36	131.2	108.6	113.8	123.0	131.7	140.7	147.7	152.0	102.1	89.2	92.2	96.5	101.9	107.3	112.4	115.4
37	131.9	108.3	114.7	123.7	132.4	141.1	148.4	152.2	102.1	89.2	91.9	96.7	102.2	107.3	112.3	115.5
38	132.5	111.2	116.3	124.5	133.0	140.8	148.8	153.3	102.1	88.9	91.8	96.7	102.1	107.5	112.2	115.2
39	132.9	111.5	116.5	124.5	133.3	141.6	148.4	153.3	102.2	88.9	91.5	96.6	102.1	107.6	112.5	115.2
40	133.5	112.7	117.7	125.5	133.4	142.1	149.1	154.3	102.2	89.0	91.8	96.7	102.2	107.4	112.5	115.2
41	133.5	113.1	117.5	125.6	134.0	141.9	149.1	152.8	102.2	89.4	91.9	96.8	102.1	107.6	112.4	115.5
42	133.9	113.1	117.7	125.9	134.1	142.2	149.6	154.2	102.2	89.1	92.0	96.9	102.1	107.7	112.4	115.3
43	134.1	114.3	118.3	126.2	134.3	141.8	149.9	154.5	102.3	89.5	92.2	97.0	102.3	107.7	112.5	115.6
44	133.9	114.6	118.7	125.7	133.9	141.9	149.4	154.6	102.3	89.6	92.2	96.9	102.4	107.7	112.3	115.2
45	133.9	115.1	119.2	125.7	134.2	141.5	149.0	153.2	102.4	89.4	92.7	97.1	102.5	107.6	112.4	115.5
46	133.9	114.9	118.4	125.4	134.0	142.2	149.2	153.4	102.5	89.3	92.3	97.2	102.3	107.8	112.6	115.6
47	134.1	114.1	118.8	126.1	133.9	142.4	149.8	154.2	102.4	89.3	92.4	97.2	102.4	107.7	112.4	115.2
48	134.1	113.1	117.9	126.1	134.5	142.5	150.2	154.2	102.4	89.1	92.2	97.2	102.6	107.6	112.4	115.1
49	134.2	113.7	118.8	126.1	134.2	142.2	149.7	154.6	102.4	88.8	92.2	97.1	102.5	107.8	112.5	115.4
50	134.0	114.2	118.2	125.9	133.9	142.1	149.1	153.5	102.4	89.0	92.1	96.8	102.6	107.7	112.4	115.3