The Effects of Inflation and Its Volatility on the Choice of Construction Alternatives

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INTRODUCTION

Life Cycle Cost Analysis (LCCA) is the standard method for costing long-lived construction projects. The LCCA process determines the full costs of mutually exclusive construction options, finding the project design with the lowest total lifetime cost. LCCAs have traditionally ignored the possibility of future changes in relative prices by assuming that the real prices of all construction inputs remain fixed.   This study examines historical data on real prices and finds that the assumption of constant real costs is seriously inconsistent with historical experience. Ignoring that experience can lead to serious cost overruns. We provide a method for calculating likely real costs paths and escalation rates, as well as an easy to use Microsoft Excel© - based calculator.

This study reviews the data on real price changes of four basic construction materials: concrete, asphalt, steel, and lumber and uses those data to perform Monte Carlo analysis. The study identifies a recommended set of data references and a computational structure for performing LCCAs while making use of historic data on changes in relative commodity prices. This allows policymakers to re-compute appropriate LCCAs on a monthly, quarterly, or annual basis, as inputs to their own analysis protocols.

The paper is organized as follows. In Section 1 we consider a representative road construction project and find that ignoring real price changes leads the standard LCCA analysis to under-estimate the real cost of a plausible option by economically meaningful amounts. In Section 2 we describe material-specific real price change data for asphalt, concrete, lumber, and steel. In Section 3 we detail our methodology for stochastic simulation and present the results of the stochastic simulation, namely the distribution of real costs and escalation rates for our four construction materials. In Appendix A we describe how to use our Excel © model to perform a stochastic LCCA. In Appendix B we describe how to obtain from public sources updated versions of inflation data. Appendix C gives alternative calculation methods for analysts whose software allows for variable discount rates but not escalation rates.

SECTION 1: MAGNITUDE AND DISTRIBUTION OF COST SURPRISES IN A REPRESENTATIVE PROJECT

Most Life Cycle Cost Analyses (LCCAs) assume all construction materials have constant real prices. This assumption, often not explicitly considered, is the same as assuming that all inputs' prices go up with general inflation. If prices rise more (or less) than expected, than projects with larger future costs will be unfairly advantaged (or penalized). In this section, we consider how large an effect changing real prices can plausibly have on a representative project.

Our representative project is a ten mile, four lane highway project. We assume that it can be built with either asphalt or concrete. Though the highway will have similar functionality either way, the two approaches have substantially different cost profiles, as shown in Table 1[1]. Concrete is more durable, with the majority of lifetime project cost in initial construction. Asphalt is cheaper to install but requires more maintenance, so costs are more spread throughout the life of a project.

Table 1: Cost Profile for Representative Project Assuming Constant Real Costs				
	Asphalt Alternative		Concrete Alternative	
Year	Work Item	Real Cost	Work Item	Real Cost
0	Initial Construction	27,041,644	Initial Construction	30,367,244
10	Mill/3" ACOL Mix	3,513,722	Joint Saw and Seal	553,766
10	Liquid Binder	1,844,829		
20	Mill/3" ACOL Mix	3,513,722	Joint Saw and Seal	553,766
20	Liquid Binder	1,844,829		
30	Mill/3" ACOL Mix	3,513,722	3% Patch & DG Concrete	911,017
30	Liquid Binder	1,844,829	3% Patch & DG Labor	1,748,349
40	Mill/3" ACOL Mix	3,513,722	5% Patch & DG Concrete	1,518,362
40	Liquid Binder	1,844,829	5% Patch & DG Labor	1,887,671

We performed a stochastic simulation of one thousand different outcomes. Under this technique, known as a Monte-Carlo simulation, the past distribution of inflation rates is used to generate a variety of different random possible outcomes. The technical details of the simulation are described in section 3.

The simulations found that it is likely that the actual costs for concrete maintenance would be lower than those assuming constant real costs (as in a typical LCCA). More specifically, in 86% of the simulations the real price of concrete fell over the maintenance period, meaning that scheduled maintenance would be cheaper than expected.

Conversely, asphalt inflation is likely to outstrip overall inflation, meaning that an LCCA assuming constant real costs will exaggerate asphalt's price competitiveness. In

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[1] Expenditures by Pavement Type for 10 Miles in North Carolina, rehab schedule based on modified NCDOT Interim Pavement Design Procedure

85% of simulations asphalt's real price rose over the course of forty years, leading a fixed cost LCCA to understate the actual cost of asphalt.

The cost surprise was quantitatively important, exceeding 4% of the initial projected cost (on a NPV basis) in half of cases, usually because the asphalt construction turned out relatively more expensive than concrete construction. The chart below ranks the possible outcomes of the simulation by favorability toward asphalt. In 5% percent of simulations the asphalt project's cost compared to the concrete one's improved by 0.7% or more. In 90% of simulations concrete's relative cost declined. In 70 percent of the cases, the disadvantage to using asphalt is understated by at least 2% and in half the cases the disadvantage of asphalt is understated by 4.1% or more.

Table 2: Added Cost Over-run Due to Variable Inflation for Asphalt Construction Relative to Current Practice (Percent of Intital Expected Project Cost)*	
Percentile	Cost Increase
5	-0.7%
10	0.0%
20	1.1%
30	2.0%
40	3.0%
50	4.1%
60	5.4%
70	6.5%
80	8.1%
90	11.5%
95	15.2%

*(Asphalt-Concrete Project Cost Differences Due to Real Price Changes)/(Project Cost Estimate With Constant Real Prices)

SECTION 2: CONSTRUCTION MATERIAL PRICES

We examined the real price behavior of four materials: asphalt, steel, concrete, and lumber and incorporated them into our stochastic simulator. All nominal price indices were taken from the Bureau of Labor Statistics (BLS) Producer Price Index program. Nominal prices were deflated by the overall Consumer Price Index, also from the BLS, to arrive at real costs. We examined annual data from 1977, the first year of data availability for all series, to the present (2010). Appendix B describes how to download the relevant data from the BLS website.

According to the BLS: "The Producer Price Index (PPI) . . . is a family of indexes that measure the average change over time in the prices received by domestic producers of goods and services. PPIs measure price change from the perspective of the seller . . .

PPIs are based on selling prices reported by establishments of all sizes selected by probability sampling, with the probability of selection proportionate to size. Individual items and transaction terms from these firms also are chosen by probability proportionate to size. BLS strongly encourages cooperating companies to supply actual transaction prices at the time of shipment to minimize the use of list prices. Prices submitted by survey respondents are effective on the Tuesday of the week containing the 13th day of the month. This survey is conducted primarily through the mail."

Our four materials have different characteristics, evident from their sample means and standard deviations in table 3:

Table 3: Means and Standard Devitations of Annual Percentage Real Price Changes				
	Concrete	Asphalt	Lumber	Steel
Average	-0.17%	1.25%	-1.20%	-0.16%
Standard Deviation	2.9%	6.3%	8.9%	8.9%

Lumber has had the lowest average real price change, declining 1.2% per year while asphalt has risen 1.25% per year on average. Concrete and steel have both declined slightly in real terms. Concrete's real price volatility, at 2.9%, has been substantially less than that of the other materials. The correlations between the materials' annual real price changes is fairly low, uniformly below 0.5 in absolute value and generally below 0.3, presumably because the mixes of inputs used to produce them differ substantially.

Table 4: Construction Material Real Price Correlations				
	Concrete	Asphalt	Lumber	Steel
Concrete	1.00	0.48	-0.09	0.11
Asphalt	0.48	1.00	-0.40	0.27
Lumber	-0.09	-0.40	1.00	0.26
Steel	0.11	0.27	0.26	1.00

We examined the distributions of annual real price change of the four materials and found them to be distinctly non-normal. By Chi-Square goodness of fit we found concrete and steel best represented by the logistic distribution. Asphalt and lumber were best represented by the log logistic distribution. Table 5 shows the parameters for the best-fitting distributions. The Excel-based software, selected in order to create an interface easily usable by others, did not allow estimation of serial correlations.

Table 5: Best Fitting Statistical Distribution for Materials				
	Distribution	Location	Scale	Shape
Concrete	Logistic	-0.005	0.015	NA
Asphalt	Log Logistic	-0.095	0.093	3.373
Lumber	Log Logistic	-0.304	0.279	5.856
Steel	Logistic	-0.007	0.041	NA

SECTION 3: STOCHASTIC SIMULATION

Our stochastic simulation involved one-thousand real cost paths for the four materials. Each simulation was for fifty years. The material-specific statistical distributions in Table 5 above were used, along with the correlations between the materials in Table 4.

Table 6 below shows the mean real price by commodity in the simulations. Over the long term, different real cost paths can have substantial effects. If the real prices of lumber, steel, and concrete continue to decline as they have historically, their real prices could fall to 56%, 72% and 80% of their current costs, respectively, after 50 years. In contrast, asphalt's real cost would rise by nearly 95%.

Table 6: Mean Real Price in 1000 Simulations				
Year	Concrete	Asphalt	Lumber	Steel
1	99.5%	101.3%	98.8%	99.3%
5	97.7%	107.0%	94.2%	96.6%
10	95.5%	114.3%	88.9%	93.4%
20	91.2%	130.8%	79.0%	87.3%
25	89.2%	139.9%	74.1%	84.6%
30	87.2%	149.7%	70.1%	81.9%
40	83.3%	171.0%	63.1%	76.7%
50	79.6%	194.4%	56.3%	71.7%

An analyst could use the above real prices (or the more detailed year-by-year tables below) to modify costs in an LCCA. For example, say an LCCA calls for $1 million in steel twenty years in the future. Since steel is expected to have a real cost of only 87% of its current level, the analyst would use $873,000 instead of $1,000,000 (87.3% of $1,000,000) and then discount that figure back using a real discount rate.

Using material-specific escalation rates is an equivalent, and often easier to implement, method for adjusting for real price differentials. The table below shows the mean annual escalation rate from the 1000 simulations.

Table 7: Mean Annual Real Escalation Rate in 1000 Simulations			
Concrete	Asphalt	Lumber	Steel
-0.5%	1.1%	-1.6%	-1.0%

Stochastic simulation is particularly useful for quantifying the risks associated with a cost estimate. Tables 8 provide, for each material, estimated deciles in the year-by-year probability distributions of future real costs. Thus, for instance, the historical data indicate that the real price of concrete 20 years hence will be less than or equal to 105.7%, the number highlighted in Table 8c, with probability 0.90. To compute real costs estimated likely to be exceeded only 10% of the time, one would multiply all future material costs based on current prices by the corresponding figures in the 90% columns in these tables (converted to fractions, so 105.7% would become 1.057) before

discounting. Conversely, to compute optimistic estimates, those likely to be exceeded 90% of the time, one would use the adjustments indicated in the 10% columns in these tables. The stochastic simulator described in Appendix A performs these calculations automatically.

Table 8c: Real Price Mean and Distribution for Concrete										
Year	Mean	Percentiles								
		10	20	30	40	50	60	70	80	90
1	99.5%	96.2%	97.4%	98.2%	98.9%	99.5%	100.2%	100.8%	101.6%	102.9%
2	99.1%	94.2%	96.1%	97.1%	98.2%	99.2%	100.0%	100.9%	102.1%	103.8%
3	98.6%	92.8%	94.9%	96.3%	97.5%	98.6%	99.8%	101.0%	102.4%	104.8%
4	98.2%	91.0%	93.4%	95.2%	96.7%	98.3%	99.5%	101.0%	102.6%	105.2%
5	97.7%	89.9%	92.5%	94.3%	95.8%	97.5%	99.1%	100.8%	102.7%	105.6%
6	97.3%	89.4%	91.7%	93.5%	95.3%	96.8%	98.6%	100.6%	102.9%	105.8%
7	96.8%	88.6%	90.8%	93.0%	94.8%	96.4%	98.3%	100.4%	102.8%	105.8%
8	96.4%	87.6%	90.1%	92.1%	94.1%	96.2%	97.9%	100.2%	102.8%	106.0%
9	95.9%	86.2%	89.4%	91.8%	93.8%	95.6%	97.5%	99.8%	102.5%	105.7%
10	95.5%	85.2%	88.6%	91.1%	93.1%	95.3%	97.1%	99.4%	102.0%	105.8%
11	95.1%	84.1%	87.8%	90.2%	92.5%	94.8%	96.9%	99.3%	102.3%	106.3%
12	94.6%	83.3%	87.4%	89.7%	91.9%	94.3%	96.6%	99.1%	101.9%	105.4%
13	94.2%	82.8%	86.5%	89.1%	91.4%	93.8%	96.3%	98.5%	101.7%	106.1%
14	93.8%	82.2%	85.6%	88.8%	91.2%	93.3%	95.6%	98.1%	101.4%	106.0%
15	93.3%	81.3%	85.4%	88.2%	90.5%	92.8%	95.2%	97.7%	101.5%	106.2%
16	92.9%	80.7%	84.9%	87.6%	90.1%	92.5%	94.8%	97.2%	100.9%	105.9%
17	92.5%	79.9%	83.9%	87.0%	89.7%	92.1%	94.6%	96.9%	100.4%	105.5%
18	92.0%	79.1%	83.3%	86.6%	89.2%	91.6%	93.8%	97.0%	100.2%	104.9%
19	91.6%	78.0%	83.0%	85.9%	88.4%	91.0%	93.4%	96.7%	100.2%	105.1%
20	91.2%	77.6%	81.8%	84.9%	87.8%	90.9%	93.6%	96.4%	99.9%	105.7%
21	90.8%	77.2%	81.2%	84.5%	87.6%	89.9%	93.0%	95.9%	99.6%	105.5%
22	90.4%	76.3%	80.5%	83.9%	86.8%	89.7%	92.6%	95.9%	99.8%	105.7%
23	90.0%	75.6%	80.1%	83.2%	86.2%	89.2%	92.4%	95.4%	99.5%	105.2%
24	89.6%	75.1%	79.3%	83.0%	85.7%	88.9%	92.3%	95.3%	99.3%	105.7%
25	89.2%	74.7%	78.9%	82.1%	85.3%	88.4%	91.8%	94.5%	98.4%	105.9%
26	88.8%	74.2%	78.3%	81.5%	85.1%	88.3%	91.1%	94.5%	98.4%	105.9%
27	88.4%	72.9%	77.7%	81.0%	84.7%	87.6%	91.1%	93.8%	98.2%	105.6%
28	88.0%	72.8%	77.0%	80.4%	84.2%	87.1%	89.9%	93.8%	97.9%	105.7%
29	87.6%	71.9%	76.3%	79.8%	83.9%	86.6%	89.5%	93.2%	98.1%	105.3%
30	87.2%	71.6%	75.6%	79.6%	83.1%	86.3%	89.4%	93.0%	98.5%	104.7%
31	86.8%	70.6%	75.2%	79.2%	82.3%	85.7%	89.3%	93.3%	98.1%	104.5%
32	86.4%	69.7%	74.7%	78.7%	81.9%	85.7%	89.0%	93.2%	98.1%	104.3%
33	86.0%	69.1%	74.0%	77.9%	81.3%	85.1%	88.8%	92.8%	97.4%	104.2%
34	85.6%	68.2%	73.6%	77.5%	81.2%	84.8%	88.4%	92.6%	97.3%	103.6%
35	85.2%	67.6%	72.9%	77.0%	80.9%	84.3%	88.1%	92.1%	96.9%	103.7%
36	84.9%	66.8%	72.5%	76.8%	80.3%	83.8%	87.5%	92.1%	96.4%	102.6%
37	84.5%	66.2%	72.0%	76.4%	79.9%	83.6%	87.5%	91.8%	95.9%	103.4%
38	84.1%	65.7%	71.0%	75.8%	79.9%	83.6%	87.3%	91.3%	96.0%	103.1%
39	83.7%	65.3%	71.0%	75.1%	79.0%	83.1%	87.2%	91.0%	95.3%	102.5%
40	83.3%	64.5%	69.9%	75.0%	78.9%	82.4%	87.1%	90.5%	94.9%	102.4%
41	82.9%	64.2%	69.5%	74.4%	79.0%	82.2%	85.9%	90.0%	94.3%	102.2%
42	82.6%	64.0%	69.2%	73.9%	78.2%	81.8%	85.5%	89.7%	93.8%	101.9%
43	82.2%	63.6%	68.9%	73.7%	78.0%	81.6%	85.3%	89.4%	93.8%	101.9%
44	81.8%	62.9%	68.3%	73.3%	77.1%	81.1%	84.6%	88.7%	94.0%	101.4%
45	81.5%	62.2%	67.5%	72.8%	77.1%	80.5%	84.3%	88.4%	93.7%	101.1%
46	81.1%	61.7%	67.3%	72.0%	76.7%	80.1%	84.1%	88.5%	93.1%	101.2%
47	80.7%	61.2%	66.8%	71.7%	75.9%	79.9%	83.6%	87.7%	92.7%	100.6%
48	80.4%	60.5%	66.2%	71.1%	75.9%	79.6%	83.0%	87.5%	92.7%	100.6%
49	80.0%	60.3%	66.1%	70.9%	75.3%	79.2%	82.7%	87.1%	92.7%	99.4%
50	79.6%	59.9%	65.5%	70.2%	74.3%	78.9%	82.8%	86.4%	92.4%	99.2%

Year	Mean	Percentiles								
		10	20	30	40	50	60	70	80	90
1	99.3%	90.3%	93.6%	95.8%	97.6%	99.3%	101.0%	102.8%	105.0%	108.3%
2	98.6%	85.6%	90.2%	93.3%	96.1%	98.4%	100.8%	103.6%	107.5%	112.1%
3	98.0%	82.1%	87.5%	91.6%	94.7%	97.2%	100.2%	103.8%	108.7%	114.8%
4	97.3%	79.7%	84.9%	89.0%	92.9%	96.3%	100.6%	104.0%	108.6%	116.3%
5	96.6%	76.6%	82.6%	87.4%	91.8%	96.1%	99.8%	103.9%	109.7%	117.3%
6	96.0%	74.9%	80.4%	85.9%	90.6%	94.1%	98.7%	103.7%	109.1%	120.7%
7	95.3%	72.6%	78.7%	84.5%	88.5%	94.0%	98.7%	104.0%	109.5%	121.3%
8	94.7%	70.4%	76.9%	82.1%	87.5%	92.9%	98.0%	104.2%	111.3%	121.5%
9	94.0%	69.2%	75.6%	80.8%	86.8%	92.3%	97.7%	103.7%	111.2%	121.7%
10	93.4%	66.6%	73.7%	79.4%	85.9%	91.5%	97.1%	103.4%	110.9%	124.8%
11	92.7%	64.6%	72.5%	78.1%	84.6%	89.9%	96.1%	102.3%	110.6%	123.1%
12	92.0%	63.2%	72.0%	77.9%	83.4%	88.9%	95.7%	101.8%	110.3%	123.2%
13	91.4%	61.1%	69.8%	76.9%	82.8%	88.8%	94.3%	101.5%	110.2%	123.7%
14	90.8%	60.6%	68.4%	74.7%	82.1%	87.8%	93.5%	101.5%	109.4%	124.2%
15	90.2%	59.3%	67.1%	74.0%	80.6%	87.0%	93.3%	99.8%	108.5%	124.7%
16	89.4%	58.3%	66.4%	73.9%	79.8%	85.8%	92.7%	99.2%	108.4%	124.6%
17	88.8%	57.3%	65.1%	72.0%	79.4%	85.3%	92.0%	99.4%	109.0%	124.6%
18	88.3%	56.0%	64.4%	71.1%	77.7%	85.1%	92.0%	99.2%	109.4%	123.8%
19	87.7%	55.6%	63.8%	70.7%	77.1%	84.1%	90.3%	98.5%	109.9%	123.6%
20	87.3%	54.4%	62.7%	69.7%	75.6%	82.5%	89.2%	97.8%	108.9%	125.3%
21	86.8%	52.5%	61.5%	68.2%	75.0%	81.1%	88.2%	97.1%	109.2%	125.5%
22	86.0%	51.8%	60.0%	67.8%	73.4%	80.5%	87.5%	96.9%	109.3%	125.8%
23	85.6%	50.3%	59.0%	66.3%	73.1%	80.1%	86.8%	96.5%	108.4%	126.2%
24	85.0%	49.5%	57.3%	64.5%	72.7%	79.6%	87.1%	96.3%	109.2%	126.9%
25	84.6%	48.8%	57.5%	63.5%	70.8%	78.3%	85.8%	95.8%	109.2%	128.0%
26	84.2%	47.3%	55.7%	62.6%	69.5%	77.1%	86.4%	95.8%	110.2%	128.2%
27	83.5%	46.8%	55.1%	61.8%	69.7%	76.2%	85.2%	94.6%	108.3%	128.2%
28	83.0%	45.7%	54.8%	60.7%	68.9%	75.4%	84.1%	94.2%	108.1%	128.1%
29	82.4%	45.4%	53.4%	60.0%	67.1%	75.7%	83.4%	94.2%	107.9%	127.3%
30	81.9%	43.0%	52.8%	59.5%	67.4%	73.8%	82.2%	93.8%	107.2%	128.8%
31	81.3%	42.9%	51.6%	58.8%	66.0%	72.6%	81.1%	93.6%	106.7%	131.3%
32	80.9%	41.8%	50.4%	58.6%	65.3%	72.6%	81.1%	91.8%	108.1%	131.7%
33	80.2%	41.1%	49.8%	58.4%	64.9%	72.0%	80.5%	90.7%	105.6%	128.2%
34	79.7%	40.7%	49.3%	57.1%	63.9%	71.4%	79.6%	90.1%	106.3%	128.1%
35	79.2%	40.3%	47.6%	56.8%	64.1%	70.5%	79.2%	90.0%	104.5%	129.4%
36	78.7%	39.2%	48.0%	56.3%	63.6%	70.3%	78.9%	89.2%	102.5%	126.8%
37	78.1%	38.6%	47.1%	55.4%	62.6%	69.7%	77.5%	87.8%	103.1%	127.8%
38	77.7%	38.4%	46.5%	54.3%	61.5%	69.2%	76.8%	88.3%	101.8%	127.0%
39	77.3%	37.2%	46.2%	53.2%	61.8%	68.8%	75.8%	86.5%	102.0%	126.4%
40	76.7%	37.2%	45.7%	52.8%	61.0%	68.1%	75.6%	86.1%	101.8%	124.9%
41	76.2%	36.3%	44.3%	52.1%	59.6%	67.2%	74.9%	85.8%	100.9%	124.6%
42	75.8%	36.1%	44.2%	51.1%	58.4%	66.5%	74.3%	85.9%	100.8%	126.0%
43	75.1%	35.6%	43.9%	50.6%	57.4%	64.4%	74.2%	85.3%	100.9%	124.5%
44	74.7%	34.5%	43.2%	49.8%	56.7%	64.7%	74.4%	86.5%	101.1%	122.6%
45	74.2%	33.8%	42.9%	49.4%	55.9%	64.1%	72.9%	85.5%	99.7%	121.2%
46	73.7%	33.3%	42.4%	48.5%	55.7%	64.2%	73.2%	84.3%	98.2%	121.9%
47	73.2%	32.0%	41.4%	48.0%	55.1%	62.8%	73.8%	84.4%	97.9%	121.7%
48	72.8%	31.7%	40.9%	47.4%	54.4%	62.2%	72.1%	83.1%	96.9%	124.8%
49	72.2%	30.9%	40.1%	47.2%	53.8%	61.0%	72.7%	83.3%	96.2%	124.6%
50	71.7%	30.6%	39.9%	46.0%	53.6%	61.2%	71.1%	82.6%	95.6%	125.8%

Table 8s: Real Price Mean and Distribution for Steel

| Year | Mean | Table 8a: Real Price Mean and Distribution for Asphalt — Percentiles |

Year	Mean	10	20	30	40	50	60	70	80	90
1	101.3%	95.4%	96.7%	97.8%	98.8%	99.8%	101.0%	102.5%	104.6%	108.3%
2	102.7%	93.8%	95.4%	97.1%	98.8%	100.9%	102.8%	104.9%	107.6%	113.7%
3	104.1%	92.2%	94.8%	97.3%	99.5%	101.7%	103.9%	107.2%	111.3%	117.9%
4	105.5%	91.0%	94.4%	97.2%	99.8%	102.6%	106.2%	109.4%	114.0%	121.9%
5	107.0%	90.4%	94.6%	98.0%	100.6%	103.5%	107.4%	110.9%	116.6%	124.7%
6	108.5%	89.9%	94.9%	97.8%	101.0%	104.5%	108.2%	112.5%	119.4%	131.2%
7	109.9%	89.3%	95.3%	98.5%	102.0%	106.0%	110.3%	115.1%	121.8%	134.5%
8	111.3%	89.2%	94.8%	98.7%	102.8%	107.2%	111.7%	117.2%	124.8%	136.0%
9	112.8%	88.9%	94.3%	99.2%	103.6%	108.6%	113.7%	119.4%	127.8%	139.5%
10	114.3%	89.2%	94.9%	99.5%	103.8%	109.1%	114.2%	121.3%	129.7%	145.7%
11	115.9%	88.9%	94.7%	100.1%	104.6%	110.3%	115.8%	122.5%	133.7%	148.0%
12	117.5%	88.3%	94.8%	100.5%	105.5%	112.3%	117.6%	125.1%	134.9%	151.8%
13	119.1%	88.0%	95.1%	101.1%	107.2%	112.8%	120.0%	127.7%	138.2%	153.3%
14	120.8%	87.9%	95.2%	101.6%	107.9%	113.8%	121.5%	130.2%	141.5%	157.1%
15	122.4%	88.7%	96.3%	102.2%	108.5%	115.6%	123.3%	132.3%	142.4%	160.7%
16	124.0%	88.5%	96.3%	103.2%	109.3%	116.4%	125.5%	133.1%	144.6%	163.6%
17	125.6%	88.9%	96.2%	104.6%	110.3%	117.6%	126.9%	136.4%	147.6%	169.9%
18	127.3%	88.8%	97.7%	104.6%	111.4%	119.1%	127.5%	137.5%	150.0%	171.6%
19	129.1%	88.9%	98.2%	105.3%	112.2%	119.4%	129.1%	139.8%	152.3%	176.3%
20	130.8%	89.2%	98.5%	106.2%	112.6%	121.0%	131.6%	141.9%	155.2%	178.2%
21	132.5%	90.1%	99.8%	106.7%	114.4%	122.4%	133.1%	143.9%	157.4%	181.2%
22	134.3%	90.5%	100.2%	107.4%	114.3%	125.6%	134.9%	145.7%	160.5%	187.6%
23	136.2%	91.4%	100.2%	108.6%	116.4%	126.5%	136.3%	145.7%	164.4%	189.3%
24	138.1%	90.9%	100.3%	109.0%	117.2%	127.2%	138.3%	149.7%	168.5%	193.2%
25	139.9%	91.0%	101.3%	110.0%	119.1%	129.3%	139.6%	151.6%	169.6%	200.5%
26	141.9%	91.3%	102.4%	111.3%	119.9%	129.6%	141.5%	154.2%	171.1%	202.5%
27	144.0%	91.1%	101.9%	110.9%	120.9%	131.8%	142.9%	158.3%	174.3%	212.7%
28	146.0%	90.9%	102.8%	111.1%	122.3%	132.6%	144.0%	160.5%	178.8%	215.6%
29	148.0%	91.1%	103.2%	112.7%	124.6%	134.3%	146.8%	162.3%	180.5%	220.0%
30	149.7%	91.0%	104.0%	113.3%	125.1%	135.7%	149.1%	165.0%	183.9%	222.0%
31	151.6%	92.2%	104.5%	115.3%	126.0%	138.3%	150.1%	165.9%	186.0%	228.6%
32	153.7%	92.4%	106.7%	115.3%	127.8%	140.0%	152.1%	168.2%	188.9%	230.3%
33	155.8%	92.9%	106.2%	117.7%	127.3%	140.4%	154.1%	170.5%	192.9%	233.3%
34	158.0%	93.1%	106.7%	117.2%	128.9%	141.3%	156.6%	173.2%	196.3%	239.4%
35	160.1%	93.5%	107.6%	117.5%	130.7%	144.3%	158.7%	178.2%	199.9%	244.1%
36	162.4%	93.4%	107.7%	119.3%	131.8%	146.1%	160.4%	178.2%	203.2%	248.7%
37	164.3%	95.3%	108.7%	121.7%	132.5%	147.9%	162.8%	181.5%	203.3%	251.8%
38	166.3%	96.0%	109.5%	121.2%	133.8%	148.0%	164.0%	184.1%	209.7%	257.7%
39	168.7%	96.2%	110.1%	122.8%	135.2%	148.9%	167.7%	186.9%	212.9%	262.1%
40	171.0%	96.6%	110.9%	123.2%	136.8%	150.1%	170.0%	188.9%	219.6%	262.8%
41	173.2%	96.8%	111.5%	123.6%	138.8%	152.0%	171.5%	191.5%	222.6%	269.2%
42	175.2%	97.0%	112.0%	125.8%	140.3%	154.2%	174.1%	195.1%	227.0%	278.8%
43	177.3%	96.7%	114.4%	127.5%	141.4%	156.9%	174.7%	197.8%	228.3%	282.0%
44	179.7%	97.6%	115.0%	128.7%	142.0%	158.6%	177.5%	198.1%	234.2%	282.0%
45	182.2%	99.2%	115.9%	131.0%	143.6%	161.3%	178.4%	202.8%	233.7%	289.1%
46	184.8%	99.4%	116.0%	132.3%	145.6%	162.6%	180.8%	204.0%	236.4%	290.5%
47	187.3%	99.6%	116.9%	133.3%	146.3%	163.7%	183.4%	208.6%	237.8%	294.6%
48	189.3%	100.5%	118.3%	133.7%	148.5%	165.7%	187.6%	213.9%	240.7%	294.0%
49	191.8%	101.6%	121.1%	135.2%	150.1%	166.5%	187.3%	213.1%	246.2%	303.9%
50	194.4%	102.8%	121.0%	135.5%	150.9%	168.8%	189.6%	216.5%	250.3%	307.6%

Table 8L: Real Price Mean and Distribution for Lumber										
		Percentiles								
Year	Mean	10	20	30	40	50	60	70	80	90
1	98.8%	88.7%	91.6%	93.7%	95.6%	97.4%	99.4%	101.8%	104.9%	110.1%
2	97.7%	83.3%	87.3%	90.3%	93.1%	95.5%	98.3%	102.0%	106.4%	114.7%
3	96.5%	78.9%	84.0%	87.5%	91.0%	94.2%	97.5%	101.7%	107.7%	117.0%
4	95.3%	74.8%	80.7%	85.1%	88.9%	93.2%	97.0%	101.0%	107.4%	118.1%
5	94.2%	72.2%	77.9%	83.0%	86.8%	91.1%	95.8%	101.0%	107.6%	119.7%
6	93.1%	68.7%	75.0%	80.5%	85.0%	90.5%	94.8%	100.3%	108.1%	120.0%
7	92.1%	65.7%	73.1%	78.4%	83.3%	88.6%	93.9%	99.7%	108.3%	122.8%
8	91.1%	64.0%	70.9%	76.2%	81.9%	87.1%	92.1%	99.3%	107.0%	124.0%
9	90.0%	61.1%	68.7%	74.2%	79.7%	86.0%	92.0%	98.3%	107.4%	123.4%
10	88.9%	58.5%	67.0%	72.3%	79.7%	84.9%	90.8%	97.5%	106.2%	123.3%
11	87.7%	57.3%	64.7%	71.4%	77.7%	83.0%	90.0%	96.4%	105.5%	123.4%
12	86.7%	55.5%	63.2%	68.8%	75.8%	81.9%	88.2%	96.0%	106.8%	123.9%
13	85.6%	53.5%	61.8%	67.6%	73.7%	80.1%	86.8%	96.3%	106.0%	122.6%
14	84.5%	52.0%	60.3%	66.3%	72.2%	78.4%	85.5%	93.9%	107.4%	123.2%
15	83.5%	50.8%	58.8%	64.6%	70.3%	77.8%	85.5%	93.6%	103.7%	123.4%
16	82.6%	48.9%	56.9%	62.9%	69.8%	75.7%	82.8%	92.5%	103.0%	124.3%
17	81.7%	47.6%	54.9%	61.5%	68.2%	74.9%	81.9%	91.6%	102.4%	123.0%
18	80.9%	46.2%	53.5%	60.3%	67.1%	73.6%	81.2%	89.4%	102.5%	124.4%
19	79.9%	45.5%	52.5%	58.8%	65.7%	72.3%	79.9%	87.8%	101.8%	122.5%
20	79.0%	43.1%	51.2%	57.2%	64.4%	71.7%	78.8%	87.6%	102.8%	123.7%
21	77.9%	41.5%	49.9%	56.3%	64.1%	71.0%	77.3%	87.0%	101.8%	123.4%
22	76.9%	41.6%	47.8%	55.5%	61.8%	69.2%	76.8%	87.2%	101.5%	123.9%
23	76.0%	39.9%	47.0%	54.1%	61.1%	68.1%	75.0%	86.2%	101.1%	120.7%
24	75.1%	38.6%	45.5%	52.2%	59.7%	66.5%	75.0%	85.6%	100.8%	122.6%
25	74.1%	37.1%	44.9%	51.4%	58.3%	66.0%	75.2%	84.8%	99.1%	119.7%
26	73.4%	36.2%	43.1%	51.0%	57.7%	65.2%	73.5%	83.6%	98.4%	121.6%
27	72.5%	35.4%	43.1%	50.3%	57.0%	63.8%	72.0%	82.4%	98.1%	123.2%
28	71.7%	34.0%	42.0%	49.2%	55.4%	62.7%	71.3%	81.3%	97.5%	123.6%
29	70.8%	33.5%	41.2%	48.0%	54.9%	62.1%	70.3%	80.5%	96.4%	121.9%
30	70.1%	32.4%	39.5%	46.7%	54.5%	60.8%	69.0%	79.8%	95.1%	124.6%
31	69.4%	31.6%	38.5%	45.1%	52.7%	60.2%	68.1%	78.9%	94.8%	123.5%
32	68.6%	30.9%	37.6%	44.7%	52.1%	58.9%	67.3%	77.9%	94.8%	122.3%
33	67.7%	30.2%	37.0%	43.6%	50.8%	57.5%	65.9%	77.0%	94.3%	124.3%
34	67.1%	29.2%	35.5%	42.2%	49.9%	56.6%	64.8%	76.4%	93.1%	124.7%
35	66.5%	28.1%	34.6%	41.3%	48.7%	56.3%	64.6%	76.0%	92.7%	122.4%
36	65.8%	27.2%	34.2%	40.0%	47.7%	55.0%	64.0%	74.7%	93.5%	122.1%
37	65.2%	26.2%	33.1%	40.2%	46.9%	53.8%	63.9%	73.3%	92.1%	118.0%
38	64.3%	26.0%	33.0%	39.3%	45.3%	53.3%	62.2%	73.4%	91.8%	117.0%
39	63.6%	24.9%	32.2%	38.6%	44.9%	52.6%	61.1%	73.5%	90.9%	116.0%
40	63.1%	24.3%	31.0%	36.7%	44.1%	51.6%	60.3%	73.1%	89.1%	114.8%
41	62.4%	23.6%	30.3%	36.9%	43.1%	49.9%	59.2%	71.7%	88.0%	113.9%
42	61.6%	23.2%	30.0%	36.3%	42.8%	49.6%	58.4%	70.9%	87.1%	112.7%
43	60.7%	23.3%	29.3%	36.0%	42.1%	49.8%	57.3%	70.0%	85.4%	109.7%
44	60.0%	22.6%	28.5%	34.7%	41.2%	49.1%	56.9%	68.5%	85.1%	109.3%
45	59.3%	21.4%	28.7%	33.9%	40.4%	48.2%	56.5%	67.5%	82.6%	108.5%
46	58.6%	20.6%	27.6%	33.2%	39.5%	46.3%	56.8%	66.1%	84.1%	107.8%
47	58.1%	20.8%	26.9%	32.4%	38.9%	45.9%	55.3%	65.5%	83.3%	106.7%
48	57.6%	19.9%	26.1%	31.9%	38.2%	45.8%	54.0%	65.6%	82.5%	106.0%
49	57.0%	19.6%	25.6%	31.2%	38.0%	45.3%	52.4%	63.9%	81.4%	107.1%
50	56.3%	18.8%	25.4%	30.7%	37.3%	44.6%	51.9%	62.8%	80.9%	108.8%

The tables below give the real escalation rates equivalent to the real prices above. An analyst should select the approximate average date of future expenditures. For example, if future concrete maintenance costs will occur 15 years in the future, then the analyst should use the 90th percentile escalation rate in year 15 (0.4%) to escalate concrete costs.

Table 9c: Escalation Rate for Concrete

Year	Mean	Percentiles								
		10	20	30	40	50	60	70	80	90
1	-0.46%	-3.81%	-2.58%	-1.75%	-1.08%	-0.46%	0.16%	0.83%	1.65%	2.88%
2	-0.48%	-2.92%	-1.99%	-1.46%	-0.89%	-0.41%	0.00%	0.42%	1.06%	1.88%
3	-0.48%	-2.47%	-1.74%	-1.26%	-0.84%	-0.47%	-0.08%	0.32%	0.79%	1.58%
4	-0.49%	-2.32%	-1.69%	-1.22%	-0.83%	-0.44%	-0.11%	0.24%	0.65%	1.26%
5	-0.49%	-2.11%	-1.54%	-1.18%	-0.85%	-0.51%	-0.17%	0.15%	0.54%	1.10%
6	-0.49%	-1.86%	-1.43%	-1.11%	-0.80%	-0.53%	-0.23%	0.10%	0.47%	0.95%
7	-0.49%	-1.72%	-1.37%	-1.04%	-0.76%	-0.52%	-0.24%	0.06%	0.39%	0.81%
8	-0.49%	-1.64%	-1.29%	-1.02%	-0.76%	-0.49%	-0.27%	0.03%	0.34%	0.73%
9	-0.49%	-1.64%	-1.24%	-0.94%	-0.70%	-0.50%	-0.28%	-0.03%	0.27%	0.62%
10	-0.49%	-1.59%	-1.21%	-0.93%	-0.71%	-0.48%	-0.30%	-0.06%	0.20%	0.57%
11	-0.49%	-1.57%	-1.18%	-0.93%	-0.70%	-0.48%	-0.29%	-0.06%	0.21%	0.55%
12	-0.49%	-1.51%	-1.12%	-0.90%	-0.70%	-0.49%	-0.29%	-0.08%	0.16%	0.44%
13	-0.49%	-1.44%	-1.11%	-0.88%	-0.69%	-0.49%	-0.29%	-0.12%	0.13%	0.46%
14	-0.49%	-1.39%	-1.10%	-0.85%	-0.66%	-0.50%	-0.32%	-0.13%	0.10%	0.42%
15	-0.49%	-1.37%	-1.05%	-0.83%	-0.66%	-0.50%	-0.33%	-0.16%	0.10%	0.40%
16	-0.49%	-1.33%	-1.02%	-0.82%	-0.65%	-0.48%	-0.33%	-0.18%	0.05%	0.36%
17	-0.49%	-1.31%	-1.03%	-0.81%	-0.63%	-0.48%	-0.33%	-0.18%	0.02%	0.32%
18	-0.49%	-1.30%	-1.01%	-0.80%	-0.63%	-0.49%	-0.35%	-0.17%	0.01%	0.27%
19	-0.49%	-1.30%	-0.98%	-0.80%	-0.64%	-0.50%	-0.36%	-0.17%	0.01%	0.26%
20	-0.49%	-1.26%	-1.00%	-0.81%	-0.65%	-0.47%	-0.33%	-0.18%	-0.01%	0.28%
21	-0.49%	-1.22%	-0.99%	-0.80%	-0.63%	-0.51%	-0.35%	-0.20%	-0.02%	0.25%
22	-0.49%	-1.22%	-0.98%	-0.80%	-0.64%	-0.49%	-0.35%	-0.19%	-0.01%	0.25%
23	-0.49%	-1.21%	-0.96%	-0.79%	-0.64%	-0.50%	-0.34%	-0.21%	-0.02%	0.22%
24	-0.49%	-1.19%	-0.96%	-0.78%	-0.64%	-0.49%	-0.33%	-0.20%	-0.03%	0.23%
25	-0.49%	-1.16%	-0.95%	-0.79%	-0.63%	-0.49%	-0.34%	-0.22%	-0.07%	0.23%
26	-0.49%	-1.14%	-0.94%	-0.78%	-0.62%	-0.48%	-0.36%	-0.22%	-0.06%	0.22%
27	-0.49%	-1.16%	-0.93%	-0.78%	-0.61%	-0.49%	-0.35%	-0.24%	-0.07%	0.20%
28	-0.49%	-1.13%	-0.93%	-0.78%	-0.61%	-0.49%	-0.38%	-0.23%	-0.08%	0.20%
29	-0.49%	-1.13%	-0.93%	-0.77%	-0.60%	-0.49%	-0.38%	-0.24%	-0.07%	0.18%
30	-0.49%	-1.11%	-0.93%	-0.76%	-0.62%	-0.49%	-0.37%	-0.24%	-0.05%	0.15%
31	-0.49%	-1.12%	-0.92%	-0.75%	-0.62%	-0.50%	-0.36%	-0.22%	-0.06%	0.14%
32	-0.49%	-1.12%	-0.91%	-0.75%	-0.62%	-0.48%	-0.36%	-0.22%	-0.06%	0.13%
33	-0.49%	-1.12%	-0.91%	-0.75%	-0.63%	-0.49%	-0.36%	-0.23%	-0.08%	0.12%
34	-0.49%	-1.12%	-0.90%	-0.75%	-0.61%	-0.48%	-0.36%	-0.23%	-0.08%	0.10%
35	-0.49%	-1.11%	-0.90%	-0.74%	-0.60%	-0.49%	-0.36%	-0.24%	-0.09%	0.10%
36	-0.49%	-1.12%	-0.89%	-0.73%	-0.61%	-0.49%	-0.37%	-0.23%	-0.10%	0.07%
37	-0.49%	-1.11%	-0.88%	-0.73%	-0.61%	-0.48%	-0.36%	-0.23%	-0.11%	0.09%
38	-0.49%	-1.10%	-0.90%	-0.73%	-0.59%	-0.47%	-0.36%	-0.24%	-0.11%	0.08%
39	-0.49%	-1.09%	-0.87%	-0.73%	-0.60%	-0.47%	-0.35%	-0.24%	-0.12%	0.06%
40	-0.49%	-1.09%	-0.89%	-0.72%	-0.59%	-0.48%	-0.35%	-0.25%	-0.13%	0.06%
41	-0.49%	-1.07%	-0.88%	-0.72%	-0.57%	-0.48%	-0.37%	-0.26%	-0.14%	0.05%
42	-0.49%	-1.06%	-0.87%	-0.72%	-0.58%	-0.48%	-0.37%	-0.26%	-0.15%	0.04%
43	-0.49%	-1.05%	-0.86%	-0.71%	-0.58%	-0.47%	-0.37%	-0.26%	-0.15%	0.04%
44	-0.49%	-1.05%	-0.86%	-0.70%	-0.59%	-0.47%	-0.38%	-0.27%	-0.14%	0.03%
45	-0.49%	-1.05%	-0.87%	-0.70%	-0.58%	-0.48%	-0.38%	-0.27%	-0.14%	0.03%
46	-0.49%	-1.04%	-0.86%	-0.71%	-0.57%	-0.48%	-0.38%	-0.27%	-0.16%	0.02%
47	-0.49%	-1.04%	-0.85%	-0.70%	-0.59%	-0.48%	-0.38%	-0.28%	-0.16%	0.01%
48	-0.49%	-1.04%	-0.85%	-0.71%	-0.57%	-0.47%	-0.39%	-0.28%	-0.16%	0.01%
49	-0.49%	-1.03%	-0.84%	-0.70%	-0.58%	-0.48%	-0.39%	-0.28%	-0.16%	-0.01%
50	-0.49%	-1.02%	-0.84%	-0.71%	-0.59%	-0.47%	-0.38%	-0.29%	-0.16%	-0.02%

Table 9s: Escalation Rate for Steel										
		Percentiles								
Year	Mean	10	20	30	40	50	60	70	80	90
1	-0.69%	-9.73%	-6.40%	-4.17%	-2.36%	-0.69%	0.98%	2.80%	5.01%	8.34%
2	-0.83%	-7.47%	-5.04%	-3.42%	-1.98%	-0.82%	0.39%	1.78%	3.68%	5.90%
3	-0.88%	-6.36%	-4.35%	-2.88%	-1.78%	-0.94%	0.06%	1.25%	2.83%	4.70%
4	-0.90%	-5.53%	-4.02%	-2.88%	-1.81%	-0.93%	0.15%	0.97%	2.09%	3.84%
5	-0.91%	-5.18%	-3.74%	-2.65%	-1.69%	-0.80%	-0.04%	0.76%	1.86%	3.25%
6	-0.92%	-4.70%	-3.58%	-2.49%	-1.62%	-1.00%	-0.22%	0.60%	1.46%	3.18%
7	-0.93%	-4.47%	-3.36%	-2.38%	-1.73%	-0.88%	-0.19%	0.56%	1.31%	2.80%
8	-0.93%	-4.29%	-3.22%	-2.43%	-1.65%	-0.91%	-0.25%	0.52%	1.35%	2.46%
9	-0.94%	-4.00%	-3.06%	-2.33%	-1.56%	-0.88%	-0.25%	0.41%	1.19%	2.20%
10	-0.94%	-3.99%	-3.00%	-2.28%	-1.50%	-0.89%	-0.29%	0.33%	1.04%	2.24%
11	-0.94%	-3.89%	-2.88%	-2.23%	-1.51%	-0.97%	-0.36%	0.20%	0.92%	1.91%
12	-0.95%	-3.75%	-2.70%	-2.05%	-1.50%	-0.97%	-0.36%	0.15%	0.82%	1.75%
13	-0.95%	-3.71%	-2.73%	-2.00%	-1.44%	-0.91%	-0.45%	0.12%	0.75%	1.65%
14	-0.95%	-3.51%	-2.67%	-2.06%	-1.40%	-0.93%	-0.48%	0.10%	0.64%	1.56%
15	-0.95%	-3.42%	-2.62%	-1.98%	-1.43%	-0.92%	-0.46%	-0.01%	0.55%	1.48%
16	-0.95%	-3.32%	-2.53%	-1.87%	-1.40%	-0.96%	-0.47%	-0.05%	0.50%	1.39%
17	-0.95%	-3.22%	-2.50%	-1.92%	-1.35%	-0.93%	-0.49%	-0.04%	0.51%	1.30%
18	-0.95%	-3.17%	-2.42%	-1.88%	-1.39%	-0.89%	-0.46%	-0.05%	0.50%	1.20%
19	-0.95%	-3.04%	-2.34%	-1.81%	-1.36%	-0.91%	-0.54%	-0.08%	0.50%	1.12%
20	-0.95%	-3.00%	-2.31%	-1.79%	-1.39%	-0.96%	-0.57%	-0.11%	0.43%	1.14%
21	-0.95%	-3.02%	-2.29%	-1.81%	-1.36%	-0.99%	-0.60%	-0.14%	0.42%	1.09%
22	-0.95%	-2.95%	-2.30%	-1.75%	-1.40%	-0.98%	-0.60%	-0.14%	0.40%	1.05%
23	-0.95%	-2.95%	-2.27%	-1.77%	-1.35%	-0.96%	-0.61%	-0.16%	0.35%	1.02%
24	-0.95%	-2.89%	-2.29%	-1.81%	-1.32%	-0.94%	-0.57%	-0.16%	0.37%	1.00%
25	-0.95%	-2.83%	-2.19%	-1.80%	-1.37%	-0.97%	-0.61%	-0.17%	0.35%	0.99%
26	-0.95%	-2.84%	-2.23%	-1.78%	-1.39%	-0.99%	-0.56%	-0.16%	0.38%	0.96%
27	-0.95%	-2.77%	-2.18%	-1.77%	-1.33%	-1.00%	-0.59%	-0.21%	0.29%	0.92%
28	-0.95%	-2.76%	-2.13%	-1.76%	-1.32%	-1.01%	-0.62%	-0.21%	0.28%	0.89%
29	-0.95%	-2.69%	-2.14%	-1.74%	-1.37%	-0.96%	-0.62%	-0.21%	0.26%	0.84%
30	-0.96%	-2.77%	-2.11%	-1.72%	-1.30%	-1.01%	-0.65%	-0.21%	0.23%	0.85%
31	-0.96%	-2.69%	-2.11%	-1.70%	-1.33%	-1.03%	-0.67%	-0.21%	0.21%	0.88%
32	-0.96%	-2.69%	-2.12%	-1.66%	-1.32%	-1.00%	-0.65%	-0.27%	0.24%	0.86%
33	-0.96%	-2.66%	-2.09%	-1.62%	-1.30%	-0.99%	-0.65%	-0.30%	0.16%	0.76%
34	-0.96%	-2.61%	-2.06%	-1.64%	-1.31%	-0.99%	-0.67%	-0.31%	0.18%	0.73%
35	-0.96%	-2.56%	-2.10%	-1.60%	-1.26%	-0.99%	-0.66%	-0.30%	0.13%	0.74%
36	-0.96%	-2.57%	-2.02%	-1.58%	-1.25%	-0.97%	-0.66%	-0.32%	0.07%	0.66%
37	-0.96%	-2.54%	-2.01%	-1.58%	-1.26%	-0.97%	-0.69%	-0.35%	0.08%	0.66%
38	-0.96%	-2.49%	-2.00%	-1.60%	-1.27%	-0.96%	-0.69%	-0.33%	0.05%	0.63%
39	-0.96%	-2.50%	-1.96%	-1.61%	-1.23%	-0.95%	-0.71%	-0.37%	0.05%	0.60%
40	-0.96%	-2.44%	-1.94%	-1.58%	-1.23%	-0.96%	-0.70%	-0.37%	0.04%	0.56%
41	-0.96%	-2.44%	-1.96%	-1.58%	-1.25%	-0.96%	-0.70%	-0.37%	0.02%	0.54%
42	-0.96%	-2.40%	-1.93%	-1.58%	-1.27%	-0.97%	-0.71%	-0.36%	0.02%	0.55%
43	-0.96%	-2.37%	-1.89%	-1.57%	-1.28%	-1.02%	-0.69%	-0.37%	0.02%	0.51%
44	-0.96%	-2.39%	-1.89%	-1.57%	-1.28%	-0.99%	-0.67%	-0.33%	0.02%	0.46%
45	-0.96%	-2.38%	-1.86%	-1.56%	-1.29%	-0.98%	-0.70%	-0.35%	-0.01%	0.43%
46	-0.96%	-2.36%	-1.85%	-1.56%	-1.26%	-0.96%	-0.68%	-0.37%	-0.04%	0.43%
47	-0.96%	-2.39%	-1.86%	-1.55%	-1.26%	-0.99%	-0.64%	-0.36%	-0.05%	0.42%
48	-0.96%	-2.37%	-1.85%	-1.54%	-1.26%	-0.98%	-0.68%	-0.38%	-0.06%	0.46%
49	-0.96%	-2.37%	-1.85%	-1.52%	-1.26%	-1.00%	-0.65%	-0.37%	-0.08%	0.45%
50	-0.96%	-2.34%	-1.82%	-1.54%	-1.24%	-0.98%	-0.68%	-0.38%	-0.09%	0.46%

Table 9a: Escalation Rate for Asphalt										
Year	Mean	Percentiles								
		10	20	30	40	50	60	70	80	90
1	1.33%	-4.62%	-3.30%	-2.22%	-1.22%	-0.17%	1.02%	2.48%	4.57%	8.33%
2	1.23%	-3.14%	-2.33%	-1.45%	-0.59%	0.46%	1.38%	2.41%	3.74%	6.65%
3	1.19%	-2.69%	-1.77%	-0.90%	-0.16%	0.56%	1.30%	2.36%	3.63%	5.66%
4	1.18%	-2.34%	-1.43%	-0.70%	-0.05%	0.65%	1.51%	2.26%	3.33%	5.08%
5	1.18%	-1.99%	-1.11%	-0.39%	0.11%	0.69%	1.44%	2.10%	3.12%	4.52%
6	1.17%	-1.76%	-0.86%	-0.36%	0.17%	0.73%	1.33%	1.99%	3.00%	4.64%
7	1.16%	-1.61%	-0.69%	-0.22%	0.29%	0.83%	1.40%	2.03%	2.86%	4.33%
8	1.16%	-1.42%	-0.66%	-0.16%	0.34%	0.88%	1.39%	2.01%	2.81%	3.92%
9	1.16%	-1.29%	-0.65%	-0.09%	0.39%	0.92%	1.44%	1.99%	2.77%	3.77%
10	1.15%	-1.14%	-0.53%	-0.05%	0.37%	0.87%	1.34%	1.95%	2.63%	3.84%
11	1.15%	-1.07%	-0.49%	0.01%	0.41%	0.89%	1.34%	1.86%	2.67%	3.63%
12	1.15%	-1.03%	-0.45%	0.04%	0.45%	0.97%	1.36%	1.88%	2.52%	3.54%
13	1.15%	-0.98%	-0.39%	0.08%	0.53%	0.93%	1.41%	1.90%	2.52%	3.34%
14	1.15%	-0.92%	-0.35%	0.11%	0.55%	0.93%	1.40%	1.91%	2.51%	3.28%
15	1.15%	-0.80%	-0.25%	0.14%	0.55%	0.97%	1.40%	1.88%	2.39%	3.21%
16	1.15%	-0.76%	-0.23%	0.20%	0.56%	0.96%	1.43%	1.81%	2.33%	3.12%
17	1.15%	-0.69%	-0.23%	0.26%	0.58%	0.96%	1.41%	1.84%	2.32%	3.17%
18	1.14%	-0.66%	-0.13%	0.25%	0.60%	0.98%	1.36%	1.78%	2.28%	3.04%
19	1.14%	-0.62%	-0.09%	0.27%	0.61%	0.94%	1.35%	1.78%	2.24%	3.03%
20	1.14%	-0.57%	-0.07%	0.30%	0.60%	0.96%	1.38%	1.77%	2.22%	2.93%
21	1.14%	-0.50%	-0.01%	0.31%	0.64%	0.97%	1.37%	1.75%	2.18%	2.87%
22	1.14%	-0.45%	0.01%	0.33%	0.61%	1.04%	1.37%	1.72%	2.17%	2.90%
23	1.14%	-0.39%	0.01%	0.36%	0.66%	1.03%	1.36%	1.65%	2.18%	2.81%
24	1.14%	-0.40%	0.01%	0.36%	0.66%	1.01%	1.36%	1.70%	2.20%	2.78%
25	1.14%	-0.37%	0.05%	0.38%	0.70%	1.03%	1.34%	1.68%	2.13%	2.82%
26	1.14%	-0.35%	0.09%	0.41%	0.70%	1.00%	1.34%	1.68%	2.09%	2.75%
27	1.14%	-0.35%	0.07%	0.39%	0.70%	1.03%	1.33%	1.71%	2.08%	2.83%
28	1.14%	-0.34%	0.10%	0.38%	0.72%	1.01%	1.31%	1.70%	2.10%	2.78%
29	1.14%	-0.32%	0.11%	0.41%	0.76%	1.02%	1.33%	1.68%	2.06%	2.76%
30	1.14%	-0.32%	0.13%	0.42%	0.75%	1.02%	1.34%	1.68%	2.05%	2.69%
31	1.14%	-0.26%	0.14%	0.46%	0.75%	1.05%	1.32%	1.65%	2.02%	2.70%
32	1.13%	-0.25%	0.20%	0.45%	0.77%	1.06%	1.32%	1.64%	2.01%	2.64%
33	1.13%	-0.22%	0.18%	0.49%	0.73%	1.03%	1.32%	1.63%	2.01%	2.60%
34	1.13%	-0.21%	0.19%	0.47%	0.75%	1.02%	1.33%	1.63%	2.00%	2.60%
35	1.13%	-0.19%	0.21%	0.46%	0.77%	1.05%	1.33%	1.66%	2.00%	2.58%
36	1.13%	-0.19%	0.21%	0.49%	0.77%	1.06%	1.32%	1.62%	1.99%	2.56%
37	1.13%	-0.13%	0.23%	0.53%	0.76%	1.06%	1.33%	1.62%	1.94%	2.53%
38	1.13%	-0.11%	0.24%	0.51%	0.77%	1.04%	1.31%	1.62%	1.97%	2.52%
39	1.13%	-0.10%	0.25%	0.53%	0.78%	1.03%	1.34%	1.62%	1.96%	2.50%
40	1.13%	-0.09%	0.26%	0.52%	0.79%	1.02%	1.34%	1.60%	1.99%	2.44%
41	1.13%	-0.08%	0.27%	0.52%	0.80%	1.03%	1.32%	1.60%	1.97%	2.44%
42	1.13%	-0.07%	0.27%	0.55%	0.81%	1.04%	1.33%	1.60%	1.97%	2.47%
43	1.13%	-0.08%	0.31%	0.57%	0.81%	1.05%	1.31%	1.60%	1.94%	2.44%
44	1.13%	-0.06%	0.32%	0.57%	0.80%	1.05%	1.31%	1.57%	1.95%	2.38%
45	1.13%	-0.02%	0.33%	0.60%	0.81%	1.07%	1.29%	1.58%	1.90%	2.39%
46	1.13%	-0.01%	0.32%	0.61%	0.82%	1.06%	1.30%	1.56%	1.89%	2.35%
47	1.13%	-0.01%	0.33%	0.61%	0.81%	1.05%	1.30%	1.58%	1.86%	2.33%
48	1.13%	0.01%	0.35%	0.61%	0.83%	1.06%	1.32%	1.60%	1.85%	2.27%
49	1.13%	0.03%	0.39%	0.62%	0.83%	1.05%	1.29%	1.56%	1.86%	2.29%
50	1.13%	0.06%	0.38%	0.61%	0.83%	1.05%	1.29%	1.56%	1.85%	2.27%

Table 9L: Escalation Rate for Lumber										
Year	Mean	Percentiles								
		10	20	30	40	50	60	70	80	90
1	-1.18%	-11.30%	-8.44%	-6.31%	-4.42%	-2.56%	-0.56%	1.78%	4.88%	10.07%
2	-1.39%	-8.74%	-6.55%	-4.99%	-3.50%	-2.29%	-0.84%	0.99%	3.16%	7.10%
3	-1.47%	-7.61%	-5.66%	-4.36%	-3.09%	-1.97%	-0.85%	0.57%	2.51%	5.38%
4	-1.50%	-7.01%	-5.22%	-3.94%	-2.89%	-1.74%	-0.75%	0.25%	1.81%	4.25%
5	-1.52%	-6.31%	-4.86%	-3.65%	-2.79%	-1.85%	-0.85%	0.20%	1.48%	3.67%
6	-1.53%	-6.07%	-4.67%	-3.55%	-2.67%	-1.66%	-0.88%	0.05%	1.30%	3.09%
7	-1.53%	-5.82%	-4.38%	-3.42%	-2.57%	-1.71%	-0.89%	-0.04%	1.14%	2.98%
8	-1.54%	-5.42%	-4.21%	-3.33%	-2.46%	-1.71%	-1.03%	-0.08%	0.85%	2.72%
9	-1.55%	-5.33%	-4.08%	-3.26%	-2.48%	-1.66%	-0.92%	-0.19%	0.79%	2.37%
10	-1.55%	-5.21%	-3.93%	-3.19%	-2.25%	-1.63%	-0.96%	-0.26%	0.61%	2.12%
11	-1.56%	-4.94%	-3.88%	-3.01%	-2.26%	-1.68%	-0.96%	-0.33%	0.49%	1.93%
12	-1.56%	-4.79%	-3.75%	-3.07%	-2.29%	-1.65%	-1.04%	-0.34%	0.55%	1.80%
13	-1.57%	-4.69%	-3.63%	-2.97%	-2.32%	-1.69%	-1.09%	-0.29%	0.45%	1.58%
14	-1.57%	-4.56%	-3.55%	-2.89%	-2.30%	-1.72%	-1.11%	-0.45%	0.51%	1.50%
15	-1.57%	-4.41%	-3.48%	-2.87%	-2.32%	-1.66%	-1.04%	-0.44%	0.24%	1.41%
16	-1.57%	-4.37%	-3.46%	-2.86%	-2.22%	-1.72%	-1.17%	-0.49%	0.19%	1.37%
17	-1.57%	-4.27%	-3.47%	-2.82%	-2.23%	-1.68%	-1.17%	-0.51%	0.14%	1.23%
18	-1.57%	-4.20%	-3.42%	-2.77%	-2.19%	-1.69%	-1.15%	-0.62%	0.14%	1.22%
19	-1.57%	-4.06%	-3.33%	-2.76%	-2.19%	-1.69%	-1.17%	-0.68%	0.09%	1.07%
20	-1.58%	-4.12%	-3.29%	-2.76%	-2.17%	-1.65%	-1.18%	-0.66%	0.14%	1.07%
21	-1.58%	-4.10%	-3.25%	-2.70%	-2.10%	-1.62%	-1.22%	-0.66%	0.09%	1.01%
22	-1.58%	-3.91%	-3.30%	-2.64%	-2.16%	-1.66%	-1.19%	-0.62%	0.07%	0.98%
23	-1.58%	-3.92%	-3.23%	-2.63%	-2.12%	-1.66%	-1.24%	-0.64%	0.05%	0.82%
24	-1.58%	-3.89%	-3.22%	-2.67%	-2.13%	-1.69%	-1.19%	-0.64%	0.03%	0.85%
25	-1.58%	-3.89%	-3.15%	-2.62%	-2.14%	-1.65%	-1.13%	-0.66%	-0.04%	0.72%
26	-1.58%	-3.83%	-3.18%	-2.56%	-2.09%	-1.63%	-1.17%	-0.68%	-0.06%	0.75%
27	-1.58%	-3.77%	-3.07%	-2.51%	-2.06%	-1.65%	-1.21%	-0.71%	-0.07%	0.78%
28	-1.58%	-3.78%	-3.05%	-2.50%	-2.09%	-1.65%	-1.20%	-0.74%	-0.09%	0.76%
29	-1.58%	-3.70%	-3.01%	-2.50%	-2.05%	-1.63%	-1.21%	-0.74%	-0.13%	0.68%
30	-1.58%	-3.68%	-3.05%	-2.50%	-2.00%	-1.64%	-1.23%	-0.75%	-0.17%	0.74%
31	-1.58%	-3.65%	-3.03%	-2.53%	-2.05%	-1.63%	-1.23%	-0.76%	-0.17%	0.68%
32	-1.58%	-3.60%	-3.01%	-2.48%	-2.02%	-1.64%	-1.23%	-0.78%	-0.17%	0.63%
33	-1.58%	-3.56%	-2.97%	-2.48%	-2.03%	-1.66%	-1.26%	-0.79%	-0.18%	0.66%
34	-1.58%	-3.56%	-3.00%	-2.50%	-2.02%	-1.66%	-1.27%	-0.79%	-0.21%	0.65%
35	-1.58%	-3.57%	-2.99%	-2.49%	-2.04%	-1.63%	-1.24%	-0.78%	-0.22%	0.58%
36	-1.58%	-3.55%	-2.94%	-2.51%	-2.03%	-1.65%	-1.23%	-0.81%	-0.19%	0.56%
37	-1.58%	-3.55%	-2.94%	-2.44%	-2.03%	-1.66%	-1.20%	-0.84%	-0.22%	0.45%
38	-1.58%	-3.49%	-2.87%	-2.43%	-2.06%	-1.64%	-1.24%	-0.81%	-0.22%	0.41%
39	-1.58%	-3.50%	-2.86%	-2.41%	-2.03%	-1.63%	-1.26%	-0.79%	-0.24%	0.38%
40	-1.59%	-3.48%	-2.89%	-2.47%	-2.02%	-1.64%	-1.26%	-0.78%	-0.29%	0.34%
41	-1.58%	-3.46%	-2.87%	-2.40%	-2.03%	-1.68%	-1.27%	-0.81%	-0.31%	0.32%
42	-1.59%	-3.42%	-2.82%	-2.38%	-2.00%	-1.66%	-1.27%	-0.81%	-0.33%	0.29%
43	-1.59%	-3.34%	-2.82%	-2.35%	-1.99%	-1.61%	-1.29%	-0.83%	-0.37%	0.22%
44	-1.59%	-3.33%	-2.81%	-2.38%	-2.00%	-1.60%	-1.28%	-0.86%	-0.37%	0.20%
45	-1.59%	-3.37%	-2.74%	-2.38%	-1.99%	-1.61%	-1.26%	-0.87%	-0.42%	0.18%
46	-1.59%	-3.37%	-2.76%	-2.37%	-2.00%	-1.66%	-1.22%	-0.90%	-0.38%	0.16%
47	-1.59%	-3.29%	-2.76%	-2.37%	-1.99%	-1.65%	-1.25%	-0.90%	-0.39%	0.14%
48	-1.59%	-3.30%	-2.76%	-2.35%	-1.99%	-1.61%	-1.27%	-0.87%	-0.40%	0.12%
49	-1.59%	-3.27%	-2.74%	-2.35%	-1.96%	-1.60%	-1.31%	-0.91%	-0.42%	0.14%
50	-1.59%	-3.29%	-2.70%	-2.33%	-1.96%	-1.60%	-1.30%	-0.93%	-0.42%	0.17%

APPENDIX A: USING THE STOCHASTIC SIMULATOR

This analysis was conducted with the Risk software package from Palisade ©, available at http://www.palisade.com/risk/ . Risk is a Microsoft Excel © add-in allowing one to work in the familiar Excel environment. The Excel/Risk datafile associated with this paper allows one to verify/update this work as well as evaluate alternative construction projects.

A: Evaluating Projects

Select the "ProjectCostItems" tab. It will be populated with the data used previously in Tables 1 and 2:

Calculate Distribution   Clear

		Alternative A					Alternative B		
	Yr	Item	Grows With	Cost Today		Yr	Item	Grows With	Cost Today
	0	Initial Construction	Inflation	30,367,244		0	Initial Construction	Inflation	27,041,644
	10	Joint Saw and Seal	Inflation	553,766		10	Mill/3" ACOL Mix	Inflation	3,513,722
	20	Joint Saw and Seal	Inflation	553,766		10	Liquid Binder	Asphalt	1,844,829
	30	3% Patch & DG Concrete	Concrete	911,017		20	Mill/3" ACOL Mix	Inflation	3,513,722
	30	3% Patch & DG Labor	Inflation	1,748,349		20	Liquid Binder	Asphalt	1,844,829
	40	5% Patch & DG Concrete	Concrete	1,518,362		30	Mill/3" ACOL Mix	Inflation	3,513,722
	40	5% Patch & DG Labor	Inflation	1,887,671		30	Liquid Binder	Asphalt	1,844,829
			Inflation			40	Mill/3" ACOL Mix	Inflation	3,513,722
			Inflation			40	Liquid Binder	Asphalt	1,844,829
			Inflation					Inflation	
			Inflation					Inflation	
			Inflation					Inflation	
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			Inflation					Inflation	
			Inflation					Inflation	

ProjectCostItems / Steel / Lumber / Asphalt / Inflation / Concrete / Inputs / OMB Non-Stochastic

To clear out this sample data, click the "Clear" button, circled above in red. Then input cost items in the boxes for Alternative A and B. In the column "Yr", input how many years in the future the expense is expected to occur. In the "Grows With" column, select how the item should grow. The allowable choices (via dropdown box) are Concrete, Asphalt, Lumber, Steel along with Inflation (for all others). In the "Cost Today" column, put how much the item would cost today (*e.g. ignoring any possible future inflation*).

Once all the expected costs have been entered for both projects, click the "Calculate" button circled above in blue. This will perform 1000 stochastic simulations, comparing the total costs of Project A to Project B.

The simulator will create output like that shown below:

Output: Project A NPV and Project B NPV

	Mean	Percentiles								
		10	20	30	40	50	60	70	80	90
Project A	33,710,314	33,497,075	33,558,115	33,603,578	33,643,119	33,680,231	33,729,502	33,782,081	33,840,777	33,947,616
Project B	41,576,665	39,776,712	40,229,217	40,526,186	40,902,200	41,367,004	41,761,585	42,291,828	42,879,548	43,722,638
Relative Cost of A-B (Negative if A Cheaper)	-7,866,351	-6,102,182	-6,527,696	-6,857,871	-7,231,181	-7,659,820	-8,046,562	-8,553,730	-9,136,976	-9,960,612

The first column, "Mean" shows the average cost of the two alternatives across all simulations on a net present value (npv) basis. The next 9 columns show the distribution of outcomes across the stochastic simulation, ordered from lowest to highest cost. For example, in the table above there is a 20% chance that Project A will cost less than/equal to $33.6 million and a 10% change that it will cost more than/equal to $33.947 million.

The third row shows the distribution of the cost of project a – the cost of project b. Negative numbers occur when project A is cheaper while positive numbers occur when project B is cheaper.

APPENDIX B: DOWNLOADING UPDATED INFLATION DATA

The inflation data we used is updated monthly, generally around the 12th day of the month, and can be downloaded from http://data.bls.gov/cgi-bin/srgate. To download the correct series, one must know their "series id" to retrieve them from the bls website. These series ids are shown in table B below.

Table B: Identifiers for Construction Materials	
Product	**Series Id**
Asphalt	PCU324121324121
Concrete	PCU327320327320
Lumber	WPU081
Steel	WPU1017
Inflation (CPI)	CUUR0000SA0

The real price of a material is its nominal price divided by the overall inflation level. The means that to get the real price of steel, divide the number retrieved from the steel series above by the same-period number for inflation.

To download, enter the "series id" shown above and then click the "next" button.

Screenshot of Webpage:

Series Report

Series ID Formats
Enter series id(s) below:

```
PCU324121324121
PCU327320327320
WPU081
WPU1017
CUUR0000SA0
```

Next ->

Clear Form

Real interest rates appropriate for federal projects are published annually by the Office of Management and budget in their appendix C to OMB Circular No. A-94. The current version (for use throughout 2011) can be found at http://www.whitehouse.gov/sites/default/files/omb/memoranda/2011/m11-12.pdf.

APPENDIX C: USING MATERIAL SPECIFIC DISCOUNT RATES WHEN SOFTWARE REQUIRES IT

As discussed above, LCCAs should generally be conducted in real terms with an escalation rate for materials whose real cost is likely to change. However, if an analyst is working with LCCA software that does not allow for an escalation rate, the same calculation can be made by varying the discount rate applied to each material. Varying the discount rate by <u>product is only recommended as a computational workaround</u>.

The Mathematical Equivalence of Escalation Rates with Variable Discount Rates

Under the preferred escalation rate based approach to determining a cash-flows present value (PV), future real cash flows are first escalated at a material (m) specific escalation rate (e) and then discounted back at the fixed discount rate (d):

$$PV = e^m/d$$

The same present value result can be calculated by ignoring the escalation rate but setting each material's discount rate to the overall discount rate divided by the material's escalation rate:

$$d^m = d/e^m$$

since $e^m/d = 1/(d/e^m)$