

# **Impact of the Discount Rate on Long Life Pavement Capital Improvements: A Discussion of the Financial Inputs**

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One of the most influential characteristics of a life cycle cost analysis (LCCA) is the discount rate. This paper looks at the impact of using a real discount rate that does not take into account the individual inflation rates for each commodity, the decline of the purchasing power of the agency's dollar value, and the rate of transportation dollars being deposited for programming. A premise in using the real discount rate is the use of constant or real dollars when looking at future activities. Constant dollars essentially equate the future purchasing power of the dollar to be the same as today's purchasing power. The paper will demonstrate that this is not the case which is further substantiated by the adjustment in contract price that many State transportation agencies allow for this purpose.

Most agencies assume a 30-year Treasury rate as the basis when computing their real discount rate for use in pavement type selection. An improved approach would be to look at the agency's projected funding levels on an annual basis as the rate of return for their investment and using individual commodity rates of inflation to account for future expenditures. This would account for anticipated deposits that can be programmed for future work.

## **INTRODUCTION**

Pavement selection is a complicated issue, balancing performance requirements, costs, industry skills, and many more variables. It is proposed that longer life pavements will benefit from a LCCA and/or financial analysis, with less maintenance but higher initial costs.

This paper reviews the discount rate options available in LCCA, historical data on material cost inflation, and the impact of the purchasing power of highway funds on the ability to program projects. The case is made that long life cost estimates, taking into account financial projections, should be determined using a nominal discount rate that accounts for individual inflation commodity rates. When viewed from this perspective, longer life pavements may be a better economical choice in many cases.

In the early 90's, the Federal Highway Administration (FHWA) initiated a technology program to develop rational methods to calculate whole life or LCCA of pavement capital expenditures. Today, these same methodologies are used by many Departments of Transportation (DOTs) as a key part of the pavement selection process. A probabilistic LCCA decision process can evaluate multiple unequal initial cost options, examining the financial impact that downstream expenditures such as maintenance, restoration, rehabilitation and user cost may have on the overall investment. The final output is usually in present value or equivalent uniform annual cost dollars, allowing a single number comparison of various options.

While the process calls for many assumptions and inputs, probably the most critical economic assumption is what is known as the discount rate. The FHWA guidelines follow the Office of Management and Budget (OMB) procedures recommending the use of the real discount rate; however, the use of a nominal

discount rate is allowed.

The real discount rate reflects the time value of money with no individual inflation adjustments and is normally used in conjunction with non-inflated dollar cost estimates of future investments. The nominal discount rate includes an inflation component and is used in conjunction with inflated future dollar cost estimates of future investments. The OMB updates both the 30-year nominal and real Treasury interest rates yearly.

All DOTs use the real discount rate, as recommended by FHWA in *Life-Cycle Cost Analysis in Pavement Design* (Walls and Smith 1998). This paper examines the implication of this recommendation and the need to consider the use of a nominal discount rate. It is believed that the nominal discount rate better reflects historical material inflation factors and better assesses long term investments with higher initial costs, but lower maintenance, restoration, rehabilitation, and user costs.

## DISCUSSION

The use of the real discount rate to bring future constant dollars back to the present implies there will be sufficient future purchasing power available to compensate for inflation. When the real discount rate is used, the purchasing power of all future dollars are essentially the same value as today's dollars and discounted to account for future inflation and anticipated growth – the result is future actions are tabulated at less value than today's dollars. Future pavement costs are not actually accounted for as there is no way to see the effect of increasing individual pavement commodity prices as the real dollar has had the general inflation rate removed, not construction inflation.

The concept of investment also deserves attention. Most agencies do not collect revenues to invest in Treasury notes for future work; in fact, many are borrowing through bond programs to construct projects today and paying those bonds back with anticipated future dollars. Those agencies that are borrowing money are using projected revenue streams to pay the money back, i.e., the rate of return or investment dollars in this case is the anticipated revenue stream to be collected from the public. Intuitively, it would make sense that a LCCA, considering financial impacts, would base a discount rate on the ability to program future work, i.e., the ability to pay for future projects, per the agency's expected revenue stream increase.

**Discount Rate** FHWA Publication No. FHWA-SA-98-079 (Walls and Smith 1998) states that discount rates can significantly influence the analysis result. An example is given on p.13 of the *Economic Analysis Primer* (FHWA 2003). The discount rate is varied from 3% to 10% and shows present day dollars, as demonstrated in Table 1. The primer then states, "Thus, present values of costs and benefits 30 years in the future can be changed by more than a factor of 5 depending on the discount rate used."

This "factor of 5" is roughly a 5% discount rate. Many agencies currently use a 4% discount rate that equates to a factor of about 3, or looking at it in another way, the future activity would only be 1/3 of the cost in today's dollars. The importance of selecting a discount rate based on extended periods of time can mitigate short term fluctuations.

High real discount rates may support relatively short-life pavements to the point where the process suggests a project can be reconstructed or rehabilitated with discounted dollars economically regardless of future program dollars or investment dollars. An example, as shown in Figure 1, would be a concrete pavement project

constructed in Kansas in 1989 at a square yard price of \$17. Using a LCCA in 1989 and reconstructing that pavement at year 20 with a 6.1% real discount rate (OMB 2011) would have indicated that 2009 costs discounted back to 1989 would have been \$5.20 per square yard. If the agency had invested that \$5.20 at the 1989 nominal Treasury interest rate of 8.2% (per OMB), the return would have been \$25.14. The actual cost in 2009 was closer to \$31 a square yard, approximately a 23% difference.

Table 1 Constant dollar discounted to present day

| Year | Constant \$ | 3% Discount | 5% Discount | 10% Discount |
|------|-------------|-------------|-------------|--------------|
| 30   | \$1000      | \$412       | \$231       | \$57         |

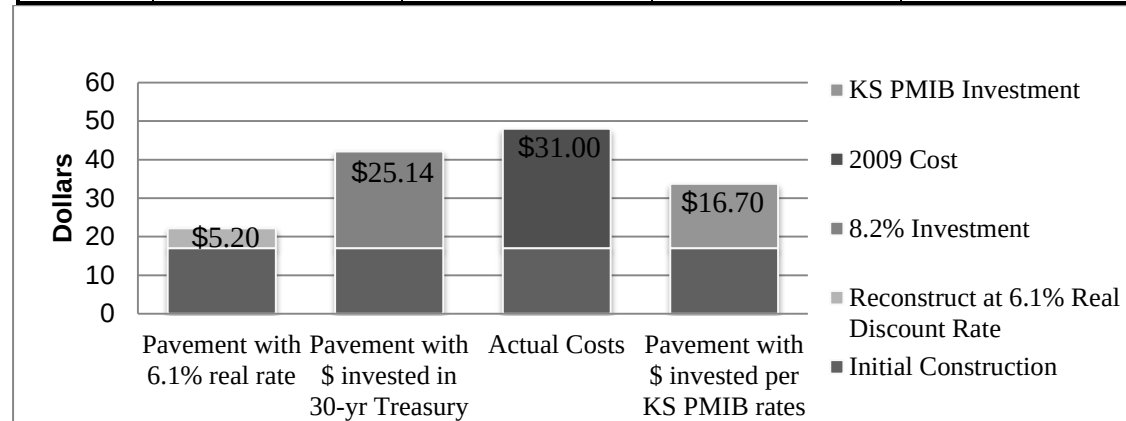


Figure 1. Square yard cost 1989 vs 2009 - invested vs actual

The Kansas Department of Transportation's (KDOT) investment of monies is controlled by state statute and falls under the Kansas Pooled Money Investment Board (PMIB). The Board has guidelines to follow for public funds and has established maximum time limits for various investments. Per PMIB, KDOT monies cannot be invested in 30-year Treasury notes because it violates the limitation imposed on p.8 of their *Investment Policy* (State of Kansas 2009), paragraph C. "Treasury or government agencies securities shall not exceed four years."

If the \$5.20 would have been invested in notes 4 years or less until 2009, the value would have been less than the \$25.14, as the short term investment rates were lower than 8.2%. The 1989 3-yr rate was 7.8% and fell to 3.0% in 2004, before coming up to 4.9% in 2007. Using the real discount rate of 6.1% in 1989 would not have brought back enough dollars to invest at rates consistent with Kansas policy to reconstruct or "purchase" the new pavement as projected in the LCCA. It is interesting to note that the \$5.20 invested per PMIB would have yielded about \$16.70, almost the amount of the initial construction, but barely 54% of what would be needed.

The above example points out what can happen if a high real discount rate is selected in combination with the policies a DOT must follow to invest their funds. Highway agencies today are facing critical financial decisions and do not have the opportunity to invest in long term maturity investments. The process to evaluate total pavement life expenditures must be reevaluated to reflect future budget constraints as well as individual commodity inflation factors.

**Commodity Inflation and Construction** One of the premises of using the real discount rate is the concept of real dollars, as referenced on p. 5 of *Life-Cycle Cost*

*Analysis in Pavement Design* (Walls and Smith 1998), “Constant dollars, often called *real* dollars, reflect dollars with the same or constant purchasing power over time. In such cases, the cost of performing an activity would not change as a function of the future year in which it would be accomplished. For example, if hot-mix asphalt concrete (HMAC) costs \$20/ton today, then \$20/ton should be used for future year HMAC cost estimates.”

Using “real” dollars implies individual inflation rates are the same for all commodities and economic growth will outpace inflation; however, it is well documented that the purchasing power of the Federal Highway Trust Fund has not kept up with the increased cost of doing business in the road construction industry. Since 1993, the last time that the federal gas tax was increased, the purchasing power for highway construction has actually decreased.

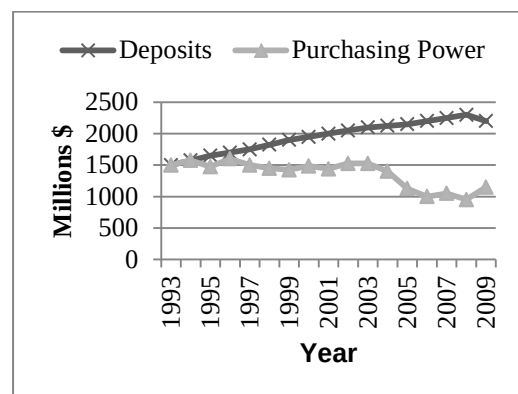


Figure 2a. Texas motor fuel tax deposits vs purchasing power

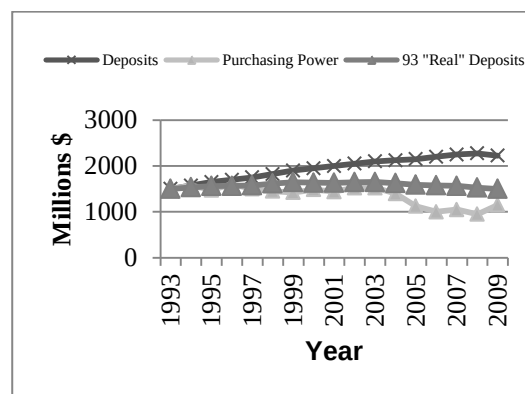


Figure 2b. Texas motor fuel deposits adjusted to 1993 dollars

On page 4 in a Texas DOT report on *Transportation Finance Challenges* (Dellisi 2010), the author states ‘According to a September 2007 report by the FHWA: “Highway construction and maintenance costs nationwide grew approximately three times faster from 2003 through 2006 than their fastest rate during any 3-year period between 1990 and 2003, substantially reducing the purchasing power of highway funds. These increases are largely the result of escalation in the costs of commodities used in highway projects, such as steel and asphalt, and reflect structural, not transitory, economic changes. We expect these commodity costs to remain elevated, and possibly continue expanding, in the near term.”

In Texas, construction inflation increased 65 percent between 2002 and 2008. Since the downturn in the national economy, prices have fallen almost 12%. But as the economy improves, it is likely that prices will continue their upward trend. The chart above shows that state motor fuel taxes have risen (until recently) as more people move to and drive in Texas, but adjusted for inflation, purchasing power is substantially less than in 1993.’ Texas has projected their motor fuel tax revenue will grow by 0.5 percent in 2010 and 1 percent from 2011 through 2020.

Figure 2a demonstrates the dramatic drop in the purchasing power of Texas’ motor fuel tax deposits. If the deposits are adjusted to reflect 1993 real dollars (as seen in Figure 2b), it’s shown that 2009 dollars are essentially the same as 1993 dollars – general inflation reflects a constant dollar amount going into the Texas motor fuel tax fund. There has been no significant growth over this time period.

Figure 3 shows the buying power of the Minnesota Department of Transportation (MNDOT) in their 20 year transportation plan (MNDOT 2009) that

clearly shows the buying power of their revenue stream is not keeping up with income projections. The MNDOT has projected their revenue increasing by 1.6% per year while projected construction inflation is increasing at 3.0% a year.

Figures 2a and 3 demonstrate not only the need for additional revenue generation, but also the recognition that we need to account for future cost increases in the basic materials that are used for highway construction. Failure to do so will only exacerbate the problem of not enough funds to fully program departmental needs.

From p. 10 of the *Economic Analysis Primer* (FHWA 2003), “The essential time to consider inflation is when the project budget is being prepared, after economic analysis has shown the project to be economically viable. Future year or multiyear project budgets are appropriated in future year dollars rather than base year dollars. Failure to account for inflation in project budgets will almost always result in too few future year dollars being set aside to complete the projects...”

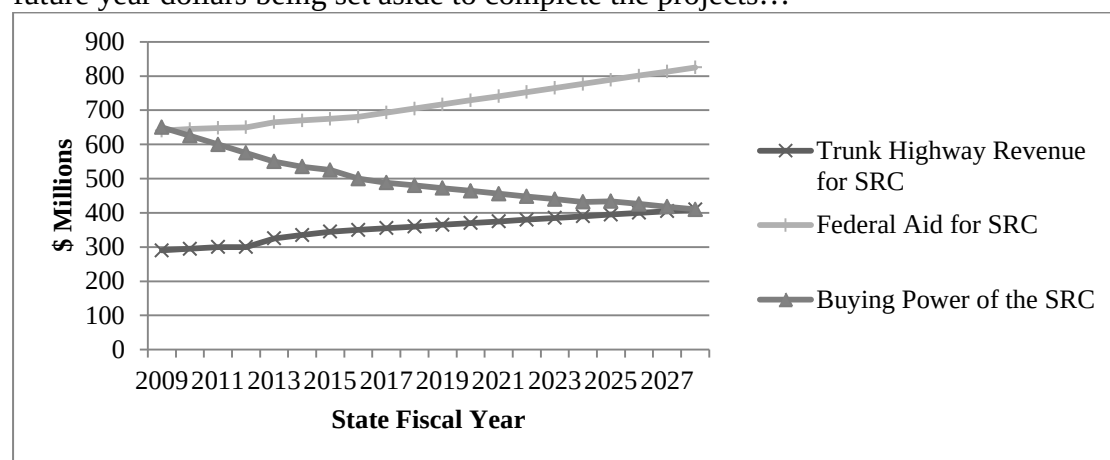
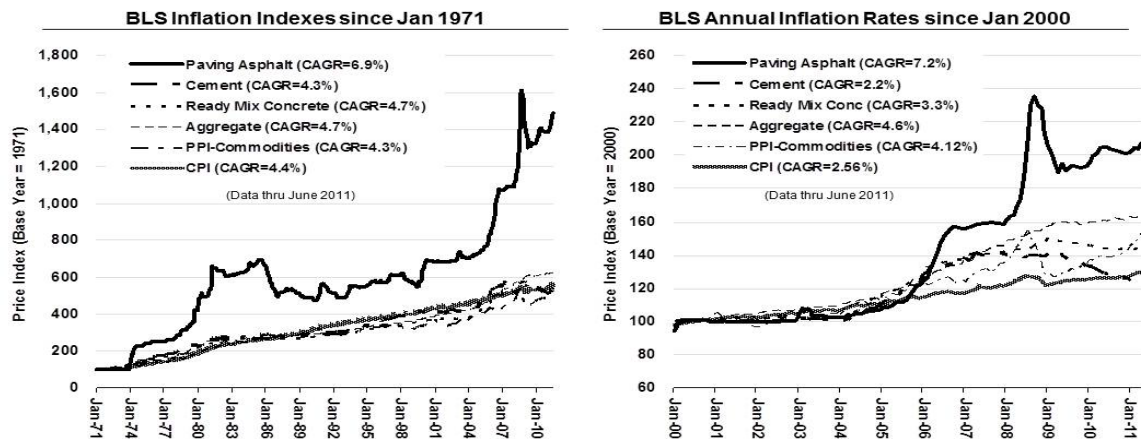


Figure 3. MN State road construction (SRC) revenues and future SRC buying power

A 1% difference in inflation rates has a major impact on predicted costs in 20, 30, and even 40 years. When that is coupled with the loss of buying power over time, it can be seen that it is even more important to consider longer life pavement options when looking at all of the variables going into the pavement selection process, including commodity rates of inflation.

From Special Experimental Project (SEP-14) Alternate Surfacing Bidding (Gisi 2009), “With the spiraling costs of single product one needs to consider what ramifications a decision made today based on costs will have in the future. Once a pavement type is selected the subsequent actions are tied to that pavement type as are the costs.”

Figure 4 demonstrates the varied rates of inflation for several commodities and is based on U.S. Department of Labor data (Bureau of Labor Statistics (BLS) 2011). As the rates fluctuate, the yearly buying power of the construction dollar fluctuates. The OMB real discount rate uses the gross domestic product (GDP) deflator figure as the inflation factor to deduct from the 30-year Treasury rate. Since 1971, the GDP deflator compound annual growth rate (CAGR) is very close to the Consumer Price Index (CPI) of 4.4%, well below the paving asphalt CAGR of 6.9% but close to the cement CAGR of 4.3%. Since 2000, the CPI CAGR is 2.56%, which is 0.36 points higher than the cement CAGR and 4.66 points below the paving asphalt CAGR of 7.2%. The data clearly demonstrates that the individual inflation rates are not the same.



U.S. Department of Labor, Bureau of Labor Statistics, <http://www.bls.gov/ppi/home.htm> (Data thru June 2011)

Figure 4 Inflation rates for various construction materials

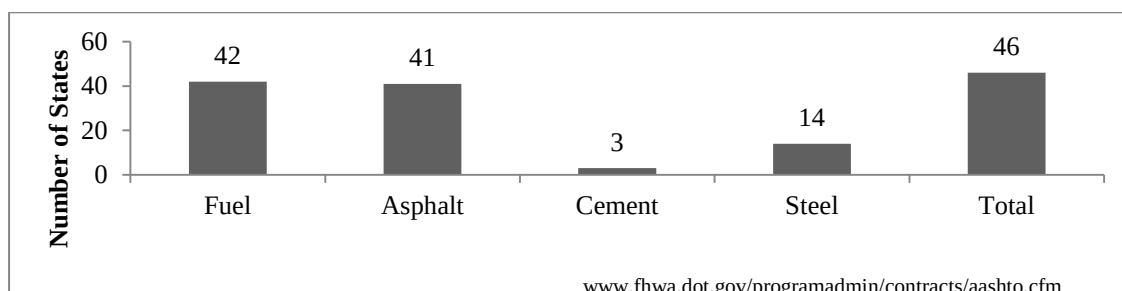


Figure 5. AASHTO survey on the use of price adjustment clauses

From Highway Research Record 100 (Lee and Grant 1965) “The indiscriminate use of indexes of price changes to situations where they do not apply can cause serious distortions in the decision-making process. Nationwide composite cost indexes should not be used when state or local indexes are available. Neither should composite indexes be used if component indexes are available.” The real discount rate is based on a nationwide composite index, the GDP deflator - not a highway construction index and certainly not local indexes.

It is interesting to note that the *FHWA Strategic Plan* (FHWA 2010), states in the Highway Industry Trend section **Construction Cost Inflation**, “Construction costs have escalated greatly in recent years due to the supply and demand of raw materials and shipping. Construction inputs could continue to increase on the order of 6 to 8 percent per year from 2008 to 2012.” The OMB real discount rate for 2012 is 2.0% calculated by subtracting 1.8% (GDP deflator) from 3.8% (30-year Treasury note rate). There is a significant difference between 6% and 1.8%.

The majority of state highway agencies are using a price adjustment factor, as shown in Figure 5, to compensate for the volatility of liquid asphalt, fuel, cement, and/or steel; while at the same time, using a real discount rate in their LCCA. This certainly contradicts using real dollars in a LCCA. As stated earlier in the discussion of constant dollars, if HMAC costs \$20/ton today, the \$20/ton should be used for future HMAC cost estimates. There is no allowance for adjusting the price of a constant dollar by indexing; however, that is what is done when using a price adjustment factor.

An American Association of State Highway and Transportation Officials (AASHTO) survey of the use of price adjustments clauses (AASHTO Subcommittee on Construction 2009) reported that 46 states have price adjustment clauses in their

specifications. Of the 46, 42 index for fuel, 41 for asphalt, 14 for steel, and 3 for cement.

A recent Massachusetts Institute of Technology study (Lindsey et al. 2011) evaluated Bureau of Labor Statistics (BLS) data from 1977 to 2010 and determined 4 construction commodities had 4 different rates of inflation. To account for future projected costs, a stochastic analysis was done to estimate annual escalator factors for concrete, steel, asphalt and lumber. Table 2 shows a comparison of lumber, steel, concrete, and asphalt for 90% reliability. The study recommends using an escalation factor with the real discount rate when calculating present value costs.

Table 2. Lumber, Steel, Concrete, and Asphalt Escalation Rates

| 90% Reliability |        |       |          |         |
|-----------------|--------|-------|----------|---------|
| Year            | Lumber | Steel | Concrete | Asphalt |
| 10              | 2.12%  | 2.24% | 0.57%    | 3.84%   |
| 15              | 1.41%  | 1.48% | 0.40%    | 3.21%   |
| 20              | 1.07%  | 1.14% | 0.28%    | 2.93%   |
| 25              | 0.72%  | 0.99% | 0.23%    | 2.82%   |
| 30              | 0.74%  | 0.85% | 0.15%    | 2.69%   |

**Investment Return** Once the inflation rates are selected, the next decision is what to use as an investment return rate for the project in question. One way to account for the investment would be to use the rate of return that the agency gains on their revolving fund balance. Most, if not all state agencies are bound by fiscal policy set by their respective Department of Revenue. The only funds that can be invested are the difference in initial costs between the alternatives that would remain in their revolving fund.

The concept is supported on p. 11 in the *Economic Analysis Primer* (FHWA 2003), “The time value of resources is also referred to as the time value of money or the opportunity cost (or value) of resources. It reflects the fact that there is a cost associated with diverting the resources needed for an investment from other productive uses or planned consumption within the economy. This cost is equal to the economic return that could be earned on the invested resources (or dollars used to buy them) in their next best alternative use.” What must be remembered in this scenario is that society has already dedicated the funding to transportation, i.e., it cannot be diverted to “other productive uses”.

A better option is to use the agency’s projected revenue stream (as a percent increase) over time as the investment value. The estimated dollars coming into the treasury essentially becomes the internal rate of return that the agency can use to compare alternatives that are reliant on future funding to accomplish pavement preservation or rehabilitation. The following equation (Cady 1986) shows how to account for the agency’s revenue stream,

$$F' = F[(1+f)/(1+q)]^n$$

Where,

F' = present worth of future services;

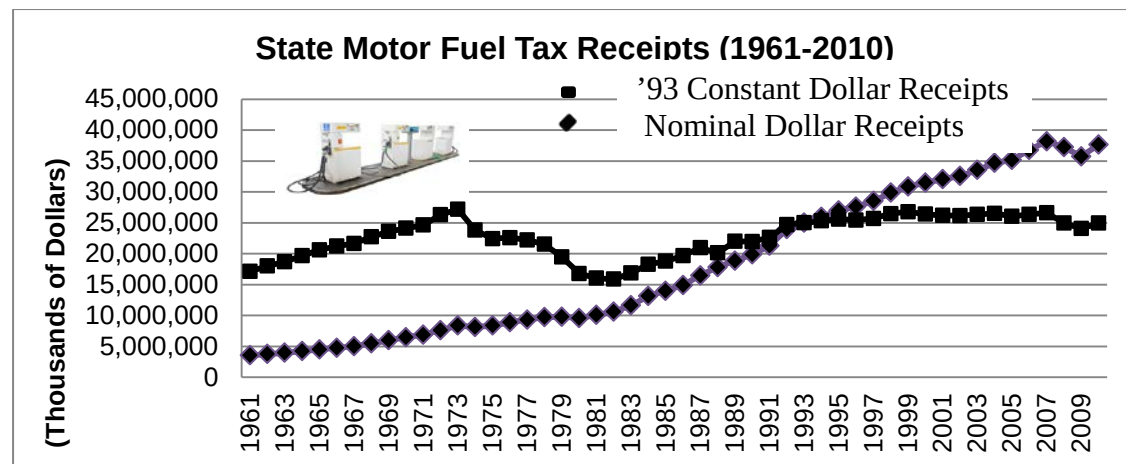
F = present cost of services (products);

f = rate of inflation for service;

q = rate of increase in funding;

n = time of expenditure in years.

This scenario would better reflect state budget constraints as well as accounting for the different inflation rates of the commodities under consideration.



[www.fhwa.dot.gov/policyinformation/statistics/2010/index.cfm](http://www.fhwa.dot.gov/policyinformation/statistics/2010/index.cfm)

Figure 6 State Motor Fuel Tax Receipts

Looking at Figure 6, we see the Federal Highway Trust Fund receipts (FHWA 2010) collected in nominal dollars as well as those same dollars converted to 1993 constant dollars. The rate of increase from 1993 to 2010 was approximately 2.4%. 2.4% appears to be a reasonable rate to use as “q” in the above equation. It is interesting to note that real dollars essentially remained flat since the last federal gas tax increase in 1993.

Table 3 Cost Comparison Using Selected Discount Rates

|                            | Today's Cost       | Inflated Cost       | NPV using Real Discount Rate (per Caltrans) | NPV using Nominal Discount Rate and 7.2% inflation for Hot Mix and 4.3% inflation for Concrete Pavement |                             |
|----------------------------|--------------------|---------------------|---------------------------------------------|---------------------------------------------------------------------------------------------------------|-----------------------------|
| Activity                   |                    |                     | DR = 4.0%                                   | DR = 3.8% (per OMB)                                                                                     | DR = 2.4% (for programming) |
| 380 mm Hot Mix -Initial    | \$1,389,244        | \$1,389,244         | \$1,389,244                                 | \$1,389,244                                                                                             | \$1,389,244                 |
| Rehab costs (4 activities) | \$1,067,330        | \$37,803,206        | \$263,311                                   | \$4,924,897                                                                                             | \$10,071,719                |
| <b>Total</b>               | <b>\$2,456,574</b> | <b>\$39,192,450</b> | <b>\$1,652,555</b>                          | <b>\$6,314,141</b>                                                                                      | <b>\$11,460,963</b>         |
| 300 mm JPCP - Initial      | \$1,126,701        | \$1,126,701         | \$1,126,701                                 | \$1,126,701                                                                                             | \$1,126,701                 |
| Rehab costs (3 activities) | \$481,965          | \$4,421,923         | \$93,986                                    | \$610,432                                                                                               | \$1,222,412                 |
| <b>Total</b>               | <b>\$1,608,666</b> | <b>\$5,548,624</b>  | <b>\$1,220,687</b>                          | <b>\$1,737,132</b>                                                                                      | <b>\$2,349,113</b>          |
| 260 mm CRCP - Initial      | \$1,298,866        | \$1,298,866         | \$1,298,866                                 | \$1,298,866                                                                                             | \$1,298,866                 |
| Rehab costs (2 activities) | \$193,650          | \$1,119,242         | \$50,440                                    | \$233,577                                                                                               | \$404,248                   |
| <b>Total</b>               | <b>\$1,492,516</b> | <b>\$2,418,107</b>  | <b>\$1,349,306</b>                          | <b>\$1,532,442</b>                                                                                      | <b>\$1,703,114</b>          |

**Example** A comparison is made between using the real discount rate (recommended by FHWA); using individual inflation factors and bringing them back based on the OMB nominal discount rate, and using nominal rates based on revenue stream and inflation forecasts. Table 3, and Figure 7, show the nominal vs. real discount rates (for 30 years) based on OMB Circular No. A-94, Appendix C (Office of Management and Budget 2012) for a long life pavement project in California based on Table 621.1J and 633.1 in the California Department of Transportation (Caltrans) Highway Design Manual (Caltrans 2008).

The first column is the action; the second column is the cost of the action in today's dollars; the third column is the inflated cost based on the individual commodity rates (7.2% for hot mix and 4.3% for concrete pavement); the fourth column is the constant dollar discounted to present value, using the real discount rate of 4 % per Caltrans procedure; the fifth column is the rehabilitation action inflated for

each commodity and discounted back to present value by the OMB nominal discount rate of 3.8%; and the sixth column is the inflated number brought back to present day based on a 2.4% revenue stream discount rate.

The first design is a 380 mm hot mix pavement on a 150 mm aggregate base with 4 rehabilitations, at year 18, 33, 48, and 63. The second design is a 300 mm jointed plain concrete pavement (JPCP) with dowels on a 75 mm asphalt base with 3 rehabilitations, at year 20, 40, and 60. The third design is a 260 mm continuously reinforced concrete pavement (CRCP) section on a 75 mm asphalt base with two rehabilitations, one at year 25 and the second at year 50.

As expected, the data in Table 3 shows the real discount rate total costs for future actions are less than constant dollar costs (today's cost). This assumes that you will have more dollars in the future to invest than discounted due to inflation and economic growth. The last column demonstrates what would happen if program dollars were used in a LCCA.

If an agency followed the real discount rate scenario as shown in Table 3, the JPCP section would be selected by about a 10% difference in estimated total present value costs over the CRCP section and about 35% over the hot mix section. Comparing the OMB nominal rate with inflation, the CRCP section is 13% more cost effective than the JPCP section and 412% more cost effective than the hot mix section. If constant dollars (today's dollars) were to be used in the determination, the difference between the three alternates would be 7% in favor of CRCP over JPCP and 64% over the hot mix section, exclusive of user costs.

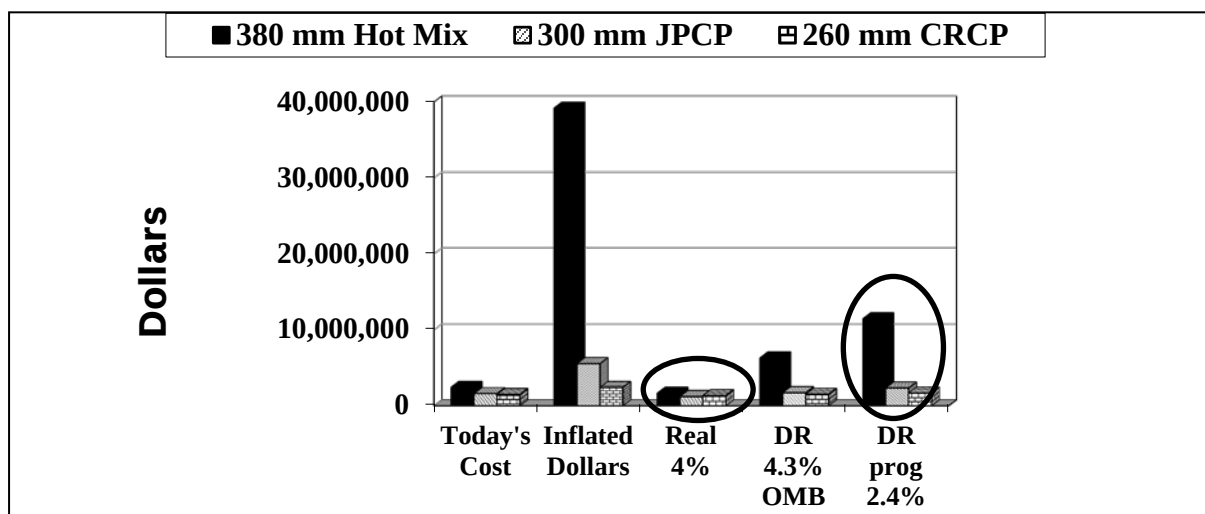


Figure 7 Discount Rate Comparisons

If the agency looked at their projected income and considered inflation in their calculation, the CRCP section would be 37% less expensive than the JPCP section and 673% less expensive than the hot mix section. Looking at the numbers from a different perspective, if the hot mix section is selected, significant additional future funding will be required to compensate for the cost differential when looking at long range program cost allocations as seen in Figure 7.

## SUMMARY

Long life pavements are a proven strategy that minimizes future maintenance and rehabilitation costs that can reap future benefits allowing program dollars to be utilized more efficiently. Using individual commodity inflation rates and a realistic

revenue stream rate will better support construction of long life pavements. If an agency does not have a policy or procedure to forecast for long range income deposits, utilizing individual escalation rates in conjunction with the real discount rate will better predict needed cost allocations to accomplish scheduled rehabilitation actions.

The Federal Highway Trust Fund is dedicated to transportation funding. As such, the factors relative to transportation costs (inflation and revenue stream) should be used in the life cycle cost process when making pavement determinations. Funding for a highway project cannot be diverted to build a school or hospital; therefore, using the GDP deflator and ignoring road construction inflation rates to determine the real discount rate should be corrected in the LCC analysis by using nominal discount rates.

Furthermore, the real discount rate procedure assumes constant purchasing power over time; however, revenues deposited to the road use tax fund have not kept up with road construction inflation. Additionally, the use of indexing for specific bid items belies the concept of constant dollars, one of the premises for using the real discount rate. Good stewardship of the nation's infrastructure requires an understanding of basic fundamentals in regard to short vs. long term expenditures and ensuring that proper procedures are fiscally prudent.

## RECOMMENDATION

The nominal discount rate procedure should be used for pavement life cycle cost/financial analysis utilizing individual inflation (or escalation) factors for future work and bringing those costs back to the present based on a projected revenue stream that will more accurately reflect real world budgets and lead to more cost effective longer life pavement choices.

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