EFFICIENCY RATIOS IN PERFORMANCE-BASED ROAD MAINTENANCE CONTRACTS

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ABSTRACT

Deteriorating infrastructure in the United States has become a top priority in the eyes of many federal, state, and local government agencies and legislative bodies. Over the past decade the Virginia Department of Transportation (VDOT) has been at the forefront of innovative efforts to address the challenge of maintaining a high level of quality and service in our nation’s transportation infrastructure. In particular, VDOT has led the way in highway asset management through Performance-Based Road Maintenance.

There has been significant legislation passed in Virginia to implement Performance-Based Road Maintenance (PBRM). The state legislators have endorsed these contracts because of powerful arguments and theories that suggest better roads for fewer dollars. Extensive academic research, performed by Virginia Tech’s Center for Highway Asset Management Programs (CHAMPS), has provided independent assessment and technical leadership to support innovations in these Performance-Based Maintenance contracts.

The Virginia Department of Transportation (VDOT) now has cost and level of service data that can be extremely useful to making PBRM contracts more effective. By looking at projects retrospectively, basic benefit-cost analysis becomes more accurate and more useful. The proposed analysis will give VDOT and other DOT’s a framework to compare level of service to dollars spent. Likewise, it will give legislators an effective tool to improve road maintenance policies.

The current framework for benefit-cost analysis (BCA) in highway maintenance is designed for means-based contracts and comparison between unrelated projects. Furthermore, there has been no BCA methodology adopted by transportation agencies for the purposes of analyzing performance-based road maintenance (PBRM). The development of a BCA methodology would allow transportation agencies to make informed corrections to contract criteria in a timely manner. Moreover, level of service (LOS) to cost ratios would give legislators a clear depiction of the current state of transportation infrastructure and the effectiveness of the previously allocated money. The methodology will also highlight categorical trends and tendencies.

The purpose of this research is to provide VDOT with a benefit-cost analysis methodology and example. This methodology will allow VDOT to: (1) design and implement better policies, (2) determine asset specific and asset group specific efficiencies and inefficiencies, and (3) make informed decisions based on recent and relevant data specific to region and road density.
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1. INTRODUCTION
Deteriorating infrastructure in the United States has become a top priority in the eyes of many federal, state, and local government agencies and legislative bodies. Over the past decade the Virginia Department of Transportation (VDOT) has been at the forefront of innovative efforts to address the challenge of maintaining a high level of quality and service in our nation’s transportation infrastructure. In particular, VDOT has led the way in highway asset management through Performance-Based Road Maintenance.

The table below shows the worsening grades given to Roads in the United States by the American Society for Civil Engineers. It also shows the growing costs necessary to repair and operate, as well as, the yearly funds invested (1 and 2).

TABLE 1 ASCE Report Card Score 2001 – 2009

<table>
<thead>
<tr>
<th>ASCE Report Cards (Year)</th>
<th>Grade for “Roads” Group</th>
<th>Costs in Repairs &amp; Operating Costs (per Year)</th>
<th>Yearly Funds invested in Transportation Infrastructure</th>
<th>Yearly Funds needed for Transportation Infrastructure</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>D+</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>2005</td>
<td>D</td>
<td>$54 billion</td>
<td>$59.4 billion</td>
<td>$94 billion</td>
</tr>
<tr>
<td>2009</td>
<td>D-</td>
<td>$67 billion</td>
<td>$70.3 billion</td>
<td>$186 billion</td>
</tr>
</tbody>
</table>

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2. BACKGROUND
In order to better understand the rationale behind this research project, it is important to review current concepts and methodologies being used in Performance-Based Road Maintenance (PBRM). This section provides a review of relevant literature and provides necessary background information to better understand the need that drives this research project.

2.1 Highway Asset Management
In recent years, infrastructure, specifically highway and bridge maintenance, has become a focus of local, state, and federal governments. Deteriorating infrastructure has attracted increasing attention and caused policy makers to rethink the way certain agencies conduct themselves. The Virginia Department of Transportation (VDOT) and the Virginia state legislature has been leading the way with innovative policies.
One of the major policy shifts in Virginia has been the switch to Performance-Based Road Maintenance (PBRM). PBRM is different from traditional road maintenance practices. Traditional road maintenance practices generally specify material, method, and technique, whereas, PBRM simply specifies a desired outcome.

Virginia Tech and VDOT established the VT-VDOT Partnership for Highway Maintenance Monitoring Programs (HMMP). Under this partnership, Virginia Tech’s Center for Highway Asset Management ProgramS (CHAMPS) provides independent assessment and technical leadership to support innovations in highway maintenance contracting and asset management practices. Faculty and graduate students in CHAMPS provide ongoing support to VDOT on matters related to the privatization of the interstate maintenance activities, innovation, and research in maintenance contracting and asset management practices (3). This research project is part of Virginia Tech’s continuous effort to implement innovative methodologies to enhance VDOT’s highway maintenance programs.

2.2 Benefit-Cost Analysis

There is a wide-ranging body of knowledge regarding Benefit-Cost Analysis (BCA), however, certain concepts apply better to highway maintenance than others. There has been extensive research done by the Federal Highway Administration (FHWA) with focus on BCA techniques for highway projects. The FHWA has established the following major steps in the BCA process (4):

1. Establish objectives
2. Identify constraints and specify assumptions
3. Define base case and identify alternatives
4. Set analysis period
5. Define level of effort for screening alternatives
6. Analyze traffic effects
7. Estimate benefits and costs relative to base case
8. Evaluate risk
9. Compare net benefits and rank alternatives
10. Make recommendations

These steps do not translate directly to PBRM contracts. In the case of PBRM contracts, it is hard to rank alternatives because the alternative to Performance-Based Road Maintenance is simply means-based road maintenance. On the other hand, a transportation agency could develop a graduated PBRM system where the optimal level of performance-based criteria is chosen for a given contract based on the results of the benefit-cost analysis.

The nature of BCA suggests a comparison between two or more alternatives. However, BCA can be a beneficial decision-making and policy-making tool with out alternatives. Ratio comparisons and cost and benefit breakdowns are an integral part of benefit-cost analysis. In PBRM contracts, level of service (LOS) is a measure of effectiveness. LOS percentages translate as the amount of benefit received from the contractor to the transportation agency.

It is important to be complete in the accounting of costs and benefits. In situations where there are legally binding contracts between the vendor and the transportation agency the Kalder-Hicks criterion should be addressed. The Kalder-Hicks criterion states that if there are two parties where one party benefits from an action and the other party loses because of that same action, then an improvement is possible by way of the party that benefits compensating the party that loses. In laymen’s terms, it means that gainers compensate losers. So, in a PBRM contract, fines associated with not meeting the minimum Level of Service should be accounted for.
3. **OBJECTIVES**

The purpose of this research is to provide VDOT with a benefit-cost analysis methodology and example. This methodology will allow VDOT to: (1) design and implement better policies, (2) determine asset specific and asset group specific efficiencies and inefficiencies, and (3) make informed decisions based on recent and relevant data specific to region and asset density. The main objectives of this research include:

1. Determine appropriate elements of analysis.
   a. Level of Service
   b. Costs and Benefits
   c. Comparability Adjustments
2. Determine and develop appropriate and relevant methods of analysis
   d. Traditional Cost-Benefit Analysis
   e. Level of Service to Cost Ratios
3. Establish methods of deducing information
   f. Interpreting Level of Service to Cost Ratios
   g. Breaking down Ratios
   h. Looking at costs by Asset Group and Asset
   i. Comparing Regions, Vendors, and Performance Criteria

The proposed analysis will be done on real projects using historical data. The projects being analyzed will be PBRM contracts between VDOT and various vendors.

4. **METHODOLOGY**

The following paragraphs present the research methodology that will be followed in order to achieve the three objectives listed in the previous section.

**Objective #1:** To determine appropriate elements of analysis it will be necessary to discuss with Virginia Department of Transportation officials what information is relevant, useful, and should be accounted for. Specifically, legal costs and costs of monitoring will be discussed. The costs of each project will be used to calculate a Net Present Value, so that values and ratios will be comparable across time.

4.1 **Calculating Costs and Benefits**

The cost data for the analysis being done will include multiple elements. It is important to account for as many costs as possible, including costs that are not directly associated with the project. Costs elements will include the Project Value (PV), Legal Costs (L), Incentives and Disincentives in the contract (I), Costs of Monitoring (M), Risks and Liabilities (R), and an adjustment for Inflation \(((1 + r)^Y)\). The formula for cost will be the following:

\[
C = (PV + L + M + I + R)(1 + r)^Y
\]

This formula accounts for all possible tangible costs associated with the project or contract. This formula produces a dollar value for the costs associated with the project. For the purposes of this project, it will be assumed that the cost is complete and includes all possible tangible costs.

4.2 **Calculating Level of Service**

When calculating the Level of Service, it is important to be consistent across projects. In other words, each project’s Level of Service should be calculated in the same way as all of the others. If different methods are used to calculate the Level of Service, irregularities might arise, and misinterpretations of
ratios will occur. For this analysis, the Level of Service will be calculated by adhering to the following process.

1. Calculate the Actual Rating for each Asset Item by dividing the Number of Passing Samples by the Number of Samples.

2. Calculate the Total Possible Score for each Asset by multiplying the Number of Samples by the Asset Item Weighting. Then calculate the Actual Asset Item Score by multiplying Number of Passing Samples by the Asset Item Weighting. In each Asset Group, divide the sum of the Actual Asset Item Scores by the sum of Total Possible Score to get the Actual Rating for the Asset Group.

3. Multiply the Actual Rating for the Asset Group by the Asset Group Weighting to get the Actual Asset Group Score.

4. Calculate the Total Rating by obtaining the sum of Actual Asset Group Scores.

The Total Rating obtained is the Level of Service to be used for the ratio analysis. It is acceptable to have different numbers of assets. However, the Asset Groups must remain constant in number and definition.

Objective #2: To determine and develop optimal methods of analysis, it will be necessary to understand and implement (a) traditional benefit-cost analysis methods, and (b) level of service to cost ratios. The processes and methods developed should be well-documented, so that the analysis being done can be repeated or adopted to different types of projects and contracts.

Of the ten major steps of Benefit-Cost Analysis identified by the Federal Highway Administration (FHWA), four can be translated directly to Performance-Based Road Maintenance. For the purposes of this project, the following major steps identified by the FHWA will be given particular attention: Setting analysis period, Estimating costs and benefits, Comparing net benefits and ranking “alternatives”, and Making recommendations.

Once calculated, Level of Service to Cost ratios can be analyzed and compared using a number of different methods. Basic statistical methods can be used to evaluate and assess ratios in relation to each other. Additionally, Virginia Department of Transportation performance targets can be used to evaluate the ratios in relation to the respective target(s).

Objective #3: Establishing methods for deducing information will be the most important objective. In order to deduce valuable information it will be necessary to (a) interpret level of service to cost ratios, (b) break down relevant ratios, (c) view weighted costs by asset group and asset, and (d) compare regions, vendors, and contract performance criteria. To determine what other information would be valuable, discussion with VDOT officials will be necessary.

5. CONCLUSIONS

Level of Service and Cost information alone are usually very one dimensional and only useful in particular situations. However, when combined, these two pieces of information can show very useful information about how efficient a transportation agency is being. Also, trends in level of service to cost ratios can indicate where more money or attention is needed. In addition, these ratios can be used to evaluate the performance of vendors maintaining our roads. Instead of evaluating based solely on the
performance, which is affected by a multitude of factors, we can look at their efficiency over time and under certain conditions to determine if they are improving or performing at some standard of efficiency.

ACKNOWLEDGMENTS

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REFERENCES


3. Center for Highway Asset Management Programs http://www.champs.eng.vt.edu/

