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# Estimating Models for Engineering Costs on the State Highway Operation and Protection Program (SHOPP) Portfolio of Projects

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## Introduction

The State Highway Operation and Protection Program (SHOPP) is vital to California's transportation infrastructure and dedicated to maintaining and preserving the state highway system. Managed by Caltrans, the SHOPP funds essential projects such as repaving roads, repairing bridges, improving safety measures, and upgrading traffic management systems. These initiatives directly impact the 15,000 miles of highways that we rely on daily. Accurate cost estimation is crucial for budgeting, financial planning, maximizing funds, and avoiding cost overruns. By addressing critical maintenance needs, SHOPP extends highway lifespans, improves travel reliability, and enhances public safety, ultimately supporting economic growth.

This research developed robust cost-estimating models for the SHOPP. In addition, it worked to identify cost norms to provide a baseline for future estimates, evaluate regression and neural network models to determine the most accurate approach, enhance tools for Caltrans to estimate and manage costs at the portfolio level, and support the California Transportation Commission (CTC) and the Legislature in reviewing and assessing SHOPP costs.

## Study Methods

The study utilized comprehensive annual data sets of Caltrans State Highway project expenditures from 1983 to 2021, allowing for a robust analysis of cost trends and project efficiencies over nearly four decades. The research methods were multifaceted and rigorous.

*Data Collection and Refinement*

Extensive data was collected from various Caltrans project records, ensuring a comprehensive dataset. This data underwent thorough refinement to remove inconsistencies, outliers, and incomplete entries, thereby ensuring high-quality and reliable data for analysis.

*Subject Matter Expert (SME) Feedback*

Throughout the data collection and refinement process, feedback from SMEs was incorporated to validate the data and ensure its relevance and accuracy.

*Developing Cost-Estimating Models*

Statistical Model: This model used regression techniques, chosen for their ability to model the growth patterns typically observed in infrastructure costs. The problems with using standard deviations were examined.

AI Model: The neural network model leveraged artificial intelligence to handle complex, non-linear relationships within the data. This approach also examined the use of the 90th and 10th percentiles, offering a narrower range that might better reflect the actual distribution of costs but with a higher risk of underestimating or overestimating.

*Evaluating Model Performance*

Accuracy: Measured by comparing model predictions with actual historical costs.

Reliability: Assessed through repeated testing and validation to ensure consistent performance across different data subsets.

By integrating these methodologies and utilizing both statistical and AI models, the study developed robust cost-estimating models to predict future project expenditures accurately, aiding in better financial planning and resource allocation for Caltrans State Highway projects.

**Findings**

Enhanced Accuracy: The advanced cost-estimating models significantly improved the precision of project cost forecasts, narrowing the gap between estimated and actual costs, which could help to reduce budget overruns and to keep financial plans on track.

Efficiency in Estimation: The new models streamlined the estimation process, replacing traditional, labor-intensive methods with automated, data-driven approaches. This efficiency gain is critical for meeting project deadlines and optimizing resource allocation.
Data Utilization: Leveraging historical project data and integrating it with current market trends provided a robust foundation for cost estimation. Big data analytics refined the accuracy of the models, enhancing their predictive power for more reliable results.

Stakeholder Confidence: Improved accuracy and efficiency in cost estimates increases stakeholder confidence in project budgeting and financial planning, which is essential for securing funding, gaining approvals, and maintaining project momentum.

The use of advanced AI and statistical cost-estimating models, powered by Caltrans historical data, boosts forecast accuracy and efficiency for SHOPP projects.

**Policy Recommendations**

The study's innovative methodologies, featuring the use of machine learning and big data analytics, have transformed traditional estimation practices. The development of cost-estimating models tailored specifically for the SHOPP portfolio represents a significant contribution to transportation project management. These models serve as valuable resources for other state highway programs and transportation departments, providing a blueprint for similar initiatives.

*Next Steps*

1. Continuous Improvement: Establish mechanisms for the continuous improvement of the AI model, incorporating feedback from completed projects and updating the model to reflect new data and market conditions.
2. Further Research: Explore additional variables and techniques to further enhance the accuracy and reliability of cost estimates.
3. Wider Application: Implement these models in other state highway programs and transportation departments to test their applicability and effectiveness in different contexts.

The results of this study and next steps support better financial management and decision-making processes for California's highway operations, ensuring the efficient use of resources in maintaining and improving the state's transportation infrastructure.

## About the Authors

This project brings together a team of faculty members from the California State Universities who have special expertise in the estimating of project costs at the early "conceptual" stage. Caltrans refers to this stage as the Project Initiation Document, or Project Study Report, Phase. Elhami Nasr and Tariq Shehab are Professors at California State University, Long Beach, while Nigel Blampied is a Research Associate of the Mineta Transportation Institute at San José State University.

## To Learn More

For more details about the study, download the full report at transweb.sjsu.edu/research/2365

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