AN EMPIRICAL STUDY ON COLLECTIVE STAKEHOLDER INSIGHTS INTO COST DRIVERS IN HIGHWAY CONSTRUCTION

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Abstract: Accurate early-stage cost estimation in highway construction is essential for effective project planning, particularly in developing regions. However, significant discrepancies often exist between estimates provided by owners and those of contractors, largely due to limited data and differing stakeholder perspectives. This study explores how collective stakeholder insights, specifically those of owners and contractors, can improve the identification and evaluation of key cost drivers (CDs). A comprehensive list of 34 CDs was developed through literature review and expert consultation, covering technical, contractual, economic, social, and environmental aspects. These CDs were assessed using a structured questionnaire, where respondents rated each factor based on its perceived influence on overall project costs and the effort required to define it in the early phases. The survey, conducted across four Western Balkan countries, yielded 96 valid responses. Results highlight areas of both consensus and divergence between stakeholder groups, reflecting their distinct roles, responsibilities, and information access. Design-related CDs were generally seen as both high-impact and high-effort, while contractual and economic often appeared as high-impact but easier to assess. The findings underscore the value of synthesizing diverse expertise in enhancing the reliability of preliminary cost estimates and demonstrate the potential of stakeholder-informed approaches in infrastructure project management.

Keywords: Stakeholder, Cost Driver, Influence, Effort, Highway Construction

1. INTRODUCTION

The expansion of highway networks is a key driver of economic growth, particularly in developing countries. In early planning stages, investment decisions largely depend on preliminary cost estimates. However, public institutions often struggle to produce reliable estimates, which can differ significantly from those provided by contractors (Li et al., 2021). These challenges are largely due to limited project information and the lack of comparable historical data, while gathering such information requires time and financial resources.

In this context, understanding the main cost drivers (CDs) affecting highway construction becomes essential. Although many studies have identified relevant CDs (Hashemi et al., 2020; Kim, 2013; Adel et al., 2016), their perceived importance often depends on the stakeholder's role in the project. Public clients and contractors may evaluate the same factors differently,

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PAGE 101-112

influenced by their specific responsibilities, access to information, and exposure to risk. Therefore, capturing these differing viewpoints can support more accurate early-stage cost assessments.

This study contributes to the broader concept of collective intelligence in construction project management by examining how stakeholder collaboration and shared insights can improve decision-making. Through a structured questionnaire, the research compares perceptions of key CDs between public clients and contractors. Respondents were asked to assess each CD based on its **perceived influence on construction costs** and the **level of effort** required to determine it—where effort refers to the resources (time and money) needed to accurately define the CD in the early planning phase. The aim is to bridge knowledge gaps and enhance the accuracy of cost estimation practices.

The paper is structured as follows: Section 2 reviews relevant literature, Section 3 outlines the methodology, Section 4 presents and discusses the results, and Section 5 offers key conclusions and implications.

2. LITERATURE REVIEW

An extensive review of literature on cost estimation for road infrastructure projects, covering articles published between 1998 and 2022, reveals a wide range of potential CDs. Their identification and categorization vary significantly across studies, with no universal consensus on which factors are most critical. This variability is influenced by differences in project contexts, stakeholder roles, and regional conditions.

Highway construction unit costs fluctuate considerably between countries and over time (Cirilovic et al., 2013) due to factors such as terrain type, resource prices, inflation rates, socio-economic conditions, and market status (Mahdavian et al., 2021). These aspects underline the complexity of establishing reliable cost models, as the accuracy of such models heavily depends on correctly identifying the key CDs.

Several studies highlight the importance of expert judgment in selecting CDs (Elmousalami, 2020). For example, Hashemi et al. (2020) emphasize that expert knowledge significantly guides the choice of CDs in machine learning-based cost estimation models. Methods like the Analytic Hierarchy Process (AHP) have been employed (Kim, 2013) to rank CDs based on expert evaluations. Similarly, Adel et al. (2016) conducted expert interviews to select variables typically available during the conceptual project phase.

Survey questionnaires remain one of the most commonly used tools for identifying and weighting CDs (Gardner et al. , 2016; Karaca et al., 2020; Al-Zwainy, 2018). Meharie et al., (2019) applied questionnaire to select CDs for preliminary highway construction cost estimation, identifying project size, number of bridges, and inflation rate as the most significant factors. Elbeltagi et al., (2014) asked respondents to assign weights (0-100 scale) to CDs based on their perceived influence on early-stage highway construction costs. Al-zwainy & Aidan, (2017) investigated road and bridge construction costs in Iraq by having experts rankings for 27 CDs on a five-point importance scale.

Overall, these studies confirm that while the specific set of CDs varies, incorporating diverse stakeholder insights through structured surveys and expert input is essential for capturing the multifaceted nature of cost influences in highway projects.

3. RESEARCH METHODOLOGY

Figure 1 illustrates the research methodology, which consists of two phases.

As mentioned, this study was structured in two main phases, aiming to identify and evaluate key cost drivers in highway construction projects based on the collective perspectives of project owners and contractors. It is conceptually situated within the broader discourse on collective intelligence in construction project management. Rather than relying on formalized or system-based models of collective intelligence, the research adopts a stakeholder-oriented approach that emphasizes the value of synthesizing distributed expert judgment. By aggregating the insights of both owners and contractors, the study reflects the underlying premise of collective intelligence — that the integration of diverse experiential perspectives can lead to more informed and robust decision-making in complex project environments.

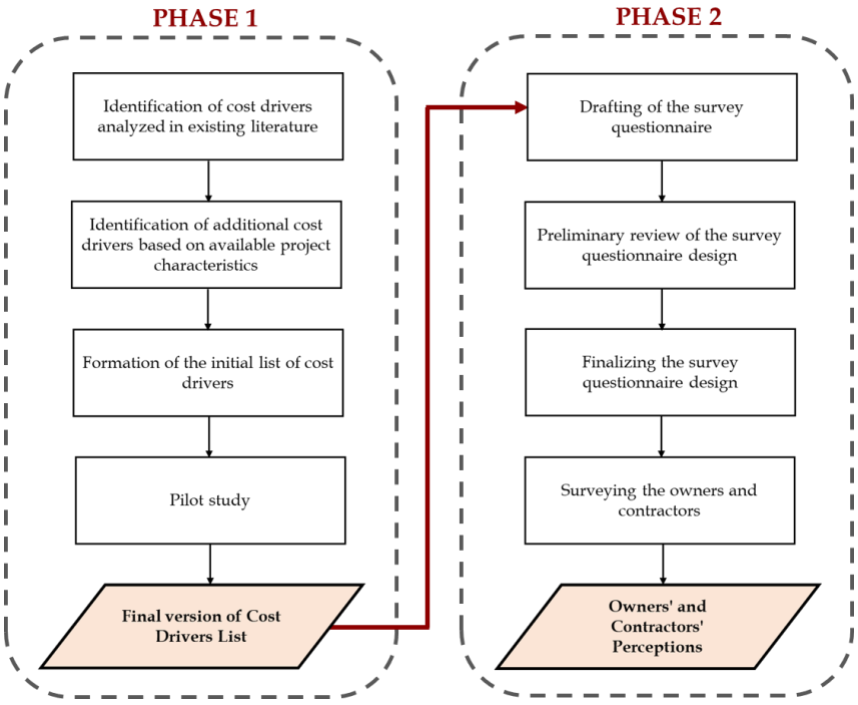

Figure 1. Research methodology

3.1 PHASE 1: DEVELOPMENT OF THE COST DRIVERS LIST

In the initial stage of Phase 1, CDs were identified through literature review, focusing on those most frequently cited in previous studies, such as road length and construction duration, as fundamental factors in highway construction costs. Special attention was also given to identifying less frequently explored variables that capture broader contextual aspects, including economic indicators and macro-level conditions of the project environment.

Recognizing that prior research often neglected structural elements with significant cost implications, the authors expanded their review to include literature on bridge and tunnel construction. This allowed the inclusion of additional CDs describing the presence and characteristics of these complex structures along highway alignments.

To further refine the list, a pilot study was conducted through interviews with three domain experts, each with over two decades of experience in construction project management. Their feedback led to the removal of less relevant items and the addition of new ones, particularly those related to environmental protection—highlighting the growing importance of sustainability in infrastructure development.

The final outcome of the pilot study was a refined list comprising 34 CDs, systematically grouped into seven categories (Table 1).

Table 1. Cost Drivers List (Simić et al., 2023)

Category	ID	Cost Driver
Highway alignment	HA.1	The participation of certain terrain type in the total length of the section
	HA.2	The presence of extreme structures within the route
	HA.3	Number of interchanges
	HA.4	Length of bridges within the interchanges
	HA.5	Design speed
	HA.6	The participation of the highway alignment in the total length of the section
	HA.7	The participation of bridges in the total length of the section
	HA.8	The participation of tunnels in the total length of the section
Bridge	B.1	The longest bridge length
	B.2	The great pier height of extreme bridges
	B.3	The large span of extreme bridges
Tunnel	T.1	Number of tunnel tubes
	T.2	The longest tunnel length
	T.3	Tunneling-excavation method
Contract	C.1	Planned duration

	C.2	Contract type
	C.3	Procurement method
	C.4	The existence of contract-price adjustments
	C.5	Project funding by the national government or through loans and grants
	C.6	Project funding by more international financial institutions (IFI)
Economic	EC.1	Inflation (consumer price index)
	EC.2	Indices of producers' prices of diesel fuel (liquid fuels and lubricants)
	EC.3	Average gross wages per employee in the construction industry
	EC.4	Indices of producers' prices of elements and materials for incorporating into construction
	EC.5	Indices of value of new contracts
	EC.6	Indices of total issued building permits
	EC.7	GDP growth rate
Social	S.1	Control of corruption index
	S.3	Government-effectiveness index
	S.4	Political stability and absence of violence/terrorism
	S.5	Unemployment rate
Environmental	EN.1	Traffic noise protection measures
	EN.2	Surface and underground water protection measures
	EN.3	Flora and fauna protection measures

3.2 PHASE 2: STAKEHOLDER SURVEY AND PERCEPTUAL ANALYSIS

In the second phase, an empirical survey was conducted to collect perceptions from two key stakeholder groups: **project owners** and **contractors.** The respondents were asked to assess each of the 34 CDs using a **five-point Likert scale** on two dimensions:

- **Influence:** The perceived level of impact the CD has on the total construction cost of highway projects.
- **Effort:** The perceived level of effort required to accurately determine the given CD during project planning.

To reduce respondent bias, a **"Don't know"** option was included for each item in the questionnaire. Additionally, respondents were asked to provide information about their **professional background** to support interpretation of results.

The survey targeted professionals from Serbia, Bosnia and Herzegovina, North Macedonia, and Montenegro with relevant experience in highway construction. It was conducted in November 2022, with 150 questionnaires distributed both electronically and in print to qualified experts.

4. RESULTS AND DISCUSSION

4.1 RESPONDENTS' PROFILE

A total of 96 completed questionnaires were collected out of the 150 distributed, yielding a response rate of 64%. When compared to similar research efforts in the field of construction project management (Lind & Brunes, 2015; Doloi et al., 2012), this rate of participation is considered sufficient for exploratory analysis.

An overview of respondent characteristics is provided in Table 2. Although the sample size is not large, the credibility of the responses is supported by the respondents' strong professional affiliation with the topic. This lends confidence in the relevance and reliability of the results.

Tabela 2. Respondents' Profile

Stakeholder		Professional Experience (Years)			Total	% by Stakeholder
		<10	10-20	>20		
Contractor	Total	18	20	13	51	53.13
	% by professional experience	35.29	39.22	25.49		
Owner	Total	8	16	21	45	46.87
	% by professional experience	17.78	35.56	46.67		
General	Total	26	36	34	96	
	% by professional experience	27.08	37.50	35.42		

A large proportion of respondents (73%) reported having more than 10 years of professional experience, with 35% indicating over 20 years in the field. The sample is also well-balanced in terms of stakeholder representation, with contractors accounting for 53.13% and owners (investors) for 46.87% of the total respondents.

4.2 DESCRIPTIVE STATISTICS

Descriptive statistics were calculated for all 34 cost drivers to summarize expert perceptions of their influence on project costs and the effort required for their assessment. Table 3 presents the median, interquartile range (IQR), mean, and standard deviation for both dimensions.

The highest perceived influence was recorded for HA.2 (*The presence of extreme structures within the route*) and HA.1 (*The participation of certain terrain type in the total length of the section*), both with a median score of 5 and very low dispersion (IQR = 0 and 0.25, respectively), indicating a high level of consensus. Similar patterns were observed for HA.8 (*The participation of tunnels in the total length of the section*), T.1 (*Number of tunnel tubes*), and B.3 (*The large span of extreme bridges*).

In contrast, EN.3 (*Flora and fauna protection measures*) and EC.7 (*GDP growth rate*) received the lowest median influence scores (2–2.5), coupled with higher variability (IQR = 2.75 for EN.3), reflecting diverse opinions on their importance.

Regarding effort, most drivers were rated with a median of 3, but considerable variation in standard deviation and IQR values suggests differences in perceived complexity. For example, B.3 (*The large span of extreme bridges*) and T.3 (*Tunneling-excavation method*) had relatively high effort means (3.74 and 3.68), while EC.6 (*Indices of total issued building permits*) and S.5 (*Unemployment rate*) were perceived as less demanding.

Tabela 3. Descriptive statistics

ID	INFLUENCE					EFFORT				
	Count	Median	IQR	Mean	Std. Dev.	Count	Median	IQR	Mean	Std. Dev.
HA.1	96	5	0.25	4.66	0.71	95	3	1	2.94	1.46
HA.2	96	5	0	4.74	0.58	95	3	1	3.22	1.41
HA.3	96	4	2	3.71	1.13	95	3	1	3.05	1.09
HA.4	94	4	1	3.84	0.91	95	3	1.25	3.45	1.05
HA.5	96	4	1	3.41	1.03	94	3	2	2.88	0.98
HA.6	96	4	2	3.90	1.05	95	3	2	3.04	0.93
HA.7	96	4	1	4.28	0.80	95	3	2	3.28	1.00
HA.8	94	5	1	4.63	0.57	95	3	1	3.45	1.06
B.1	94	4	0.25	3.78	1.03	95	3	3	3.14	1.29
B.2	93	4	0	3.99	0.83	95	3	2	3.44	1.10
B.3	95	4	2	4.14	0.85	95	4	2	3.74	1.01
T.1	96	5	1	4.33	0.87	95	3	1	3.11	1.28
T.2	96	4.5	1	4.18	1.01	95	3	2	3.19	1.39

T.3	95	4	2	3.95	0.93	93	4	1	3.68	1.11
C.1	95	4	1	4.01	0.99	94	3	1	3.35	1.14
C.2	95	4	1	3.74	1.04	94	3	1	2.73	1.30
C.3	92	4	2	3.75	1.01	94	3	2	2.71	1.28
C.4	93	4	1	3.68	0.86	93	3	1	2.89	1.25
C.5	96	3	1	3.38	0.95	94	3	2	2.86	1.20
C.6	95	3	1	3.03	0.95	94	3	2	2.82	1.14
EC.1	96	4	1	3.45	1.04	95	3	2	2.78	1.35
EC.2	96	4	2	3.75	0.93	95	3	2	2.77	1.32
EC.3	96	3	2	3.16	1.00	94	2	1	2.44	1.20
EC.4	96	4	2	3.66	0.83	95	3	2	2.72	1.33
EC.5	94	3	2	3.11	1.06	92	2	2.75	2.50	1.27
EC.6	94	3	1	2.65	1.26	92	2	2	2.36	1.25
EC.7	95	2	1	2.44	1.08	91	2	2	2.45	1.22
S.1	95	3	2	3.32	1.20	92	3	2	2.82	1.33
S.3	95	3	1	3.46	1.16	94	3	2	2.91	1.37
S.4	96	3	1	3.29	1.05	94	3	2	2.86	1.29
S.5	95	3	1.25	2.80	1.24	92	2	2.5	2.29	1.25
EN.1	96	2.5	1	2.71	1.11	95	3	2.25	3.05	0.96
EN.2	96	3	2	3.09	1.05	95	3	2	3.23	0.89
EN.3	96	2.5	2.75	2.69	1.02	95	3	2	3.20	0.94

4.3 PERCEPTION ANALYSIS

4.3.1. Aggregate Stakeholder Perceptions

The average stakeholder perceptions from the questionnaire responses are presented in Figure 2. Each data point represents a CD from the predefined Cost Driver List. Each plotted point corresponds to a CD from the established Cost Driver List. The horizontal axis reflects the average perceived influence of each CD on highway construction costs, while the vertical axis represents the average perceived effort required to accurately estimate or define that cost driver.

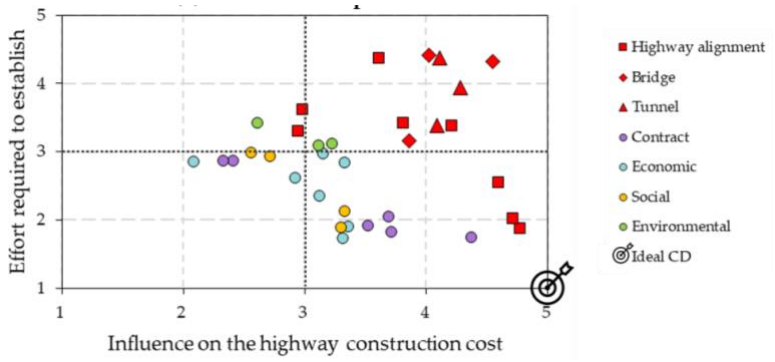

Figure 2. Average stakeholders' perceptions (Simić et al., 2023)

To facilitate interpretation, cost driver categories are differentiated by color coding. Categories linked to the design phase—namely *Highway Alignment*, *Bridges*, and *Tunnels*—are marked in the same color (red), but are distinguished by using different point shapes. This visualization method enhances the clarity and interpretability of the distribution of results.

As shown in Figure 2, CDs associated with design processes and technical solutions predominantly occupy the upper-right quadrant of the graph, representing high-impact and high-effort items. This distribution is consistent with the nature of design activities, which generally require significant time and financial investment and play a key role in determining total construction costs.

Interestingly, only three design-related CDs appear in the lower-right quadrant, which is considered optimal as it combines high impact with low assessment effort. These variables refer to terrain type, the presence of extreme structures along the alignment, and the number of tunnel tubes. Experts are typically able to identify these parameters with reasonable accuracy during early planning stages. The remaining CDs in this favorable quadrant are related to Contractual, Economic, and Social aspects. Their presence here is expected, as these variables are often publicly accessible (implying low effort) and can have a substantial correlation with cost outcomes, as supported by previous research (Mahdavian et al., 2021; Zhang et al., 2017).

4.3.2. Stakeholder Group Comparison

Figure 3 shows owners' and contractors' average perceptions separately.

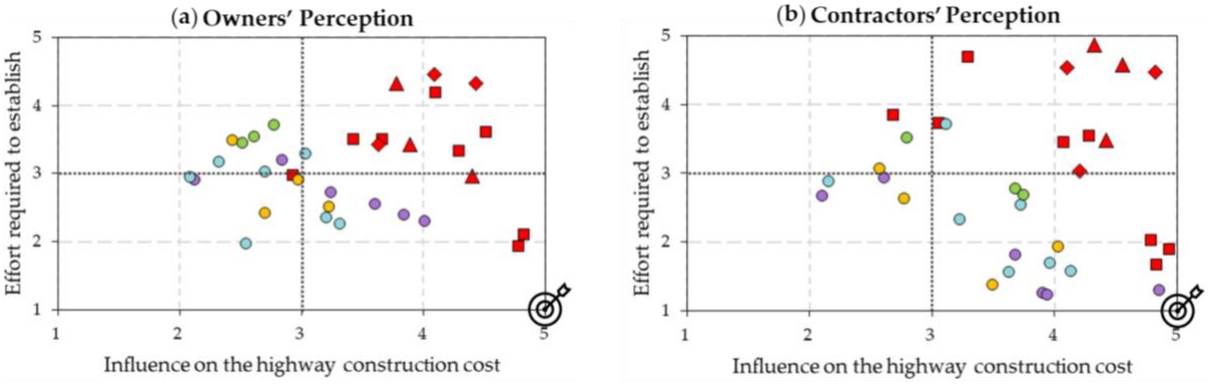

Figure 3. Contractors' and Owners' average perceptions (Simić et al., 2023)

A comparison of responses between contractors and owners highlights notable differences in how CDs are perceived. Contractors identified more CDs in the most desirable quadrant (high influence – low effort), with six additional drivers compared to owners. This suggests that owners tend to see certain drivers as more difficult to assess and less impactful.

Environmental CDs were more frequently placed by owners in the quadrant indicating high effort but low influence, reflecting their greater concern for regulatory and sustainability issues. Contractors, on the other hand, recognized the cost implications of environmental factors more strongly, rating them as more influential

Contractors also rated *Contractual* and *Economic* CDs as more impactful and easier to assess, likely due to their practical experience with these aspects during project execution. Notably, *The existence of contract-price adjustments* (C.4) was seen by contractors as the most influential CD—understandably so, considering recent global price fluctuations caused by the pandemic and geopolitical instability.

Overall, all CDs received influence ratings above 2 (low influence), indicating their general relevance and validating the structure of the predefined CD list.

5. CONCLUSIONS

This study demonstrates that incorporating diverse stakeholder perspectives significantly enhances the understanding of CDs in highway construction projects. By comparing the perceptions of public owners and contractors, the research reveals both areas of strong consensus, particularly regarding the influence of technical and design-related factors, and notable differences, especially in the evaluation of contractual, economic, and environmental aspects. These differences underscore the importance of aligning stakeholder insights to improve the accuracy and efficiency of early-stage cost estimation. The findings support the broader value of collective intelligence in project management, emphasizing that collaborative approaches can lead to more informed and balanced decision-making in complex infrastructure projects.

The questionnaire used in this study included 34 predefined cost drivers, systematically grouped into seven categories. Respondents were asked to assess each cost driver along two dimensions: *influence* (the perceived impact on overall construction costs) and *effort* (the perceived complexity and resources required to accurately evaluate the factor during early planning). This dual-dimensional approach provided deeper insight into stakeholders' evaluations, helping to identify which factors are not only considered important but also realistically assessable during the early planning stages, thereby offering practical guidance for enhancing the reliability of preliminary cost estimates.

REFERENCES

Adel, K., Elyamany, A., Belal, A. M., & Kotb, A. S. (2016). Developing Parametric Model for Conceptual Cost Estimate of Highway Developing Parametric Model for Conceptual Cost Estimate of Highway Projects

Al-Zwainy, F. M. S. (2018). A state-of-the-art survey to estimate construction costs in highway and bridge projects: analytical diagnostic study. International Journal of Civil Engineering and Technology, 9(5), 795–821.

Al-zwainy, F. M. S., & Aidan, I. A. (2017). Forecasting the Cost of Structure of Infrastructure Projects Utilizing Artificial Neural Network Model (Highway Projects as Case Study). 10(May).

Cirilovic, J., Vajdic, N., Mladenovic, G., Asce, M., & Queiroz, C. (2013). Developing Cost Estimation Models for Road Rehabilitation and Reconstruction : Case Study of Projects in Europe and Central Asia. Journal of Construction Engineering and Management, (2013).

Doloi, H., Sawhney, A., Iyer, K. C., & Rentala, S. (2012). Analysing factors affecting delays in Indian construction projects. International Journal of Project Management, 30(4), 479–489.

Elbeltagi, E., Hosny, O., Abdel-Razek, R., & El-Fitory, A. (2014). Conceptual Cost Estimate of Libyan Highway Projects Using Artificial Neural Network. Journal of Engineering Research and Applications Www.Ijera.Com, 4(8), 56–66.

Elmousalami, H. H. (2020). Artificial Intelligence and Parametric Construction Cost Estimate Modeling: State-of-the-Art Review. Journal of Construction Engineering and Management, 146(1).

Gardner, B. J., Gransberg, D. D., & Jeong, H. D. (2016). Reducing Data-Collection Efforts for Conceptual Cost Estimating at a Highway Agency. Journal of Construction Engineering and Management, 142(11), 04016057.

Karaca, I., Ph, D., Gransberg, D. D., Ph, D., Asce, M., Jeong, H. D., … Asce, A. M. (2020). Improving the Accuracy of Early Cost Estimates on Transportation Infrastructure Projects. Advances in Civil Engineering, 36(5), 1–11.

Kim, S. (2013). Hybrid forecasting system based on case-based reasoning and analytic hierarchy process for cost estimation. Journal of Civil Engineering and Management, 19(1), 86–96.

Li, M., Baek, M., & Ashuri, B. (2021). Forecasting Ratio of Low Bid to Owner's Estimate for Highway Construction. Journal of Construction Engineering and Management, 147(1), 04020157.

Lind, H., & Brunes, F. (2015). Explaining cost overruns in infrastructure projects: A new framework with applications to Sweden. Construction Management and Economics, 33(7),

554–568.
Mahdavian, A., Shojaei, A., Salem, M., Yuan, J. S., & Oloufa, A. A. (2021). Data-Driven Predictive Modeling of Highway Construction Cost Items. Journal of Construction Engineering and Management, 147(3), 04020180.
Meharie, M. G., Gariy, Z. C. A., Ngumbau, R., Mutuku, N., & Mengesha, W. J. (2019). An Effective Approach to Input Variable Selection for Preliminary Cost Estimation of Construction Projects. Advances in Civil Engineering, 2019, 5–9.
Simić, N., Ivanišević, N., Nedeljković, Đ., Senić, A., Stojadinović, Z., & Ivanović, M. (2023). Early Highway Construction Cost Estimation: Selection of Key Cost Drivers.
Tayefeh Hashemi, S., Ebadati, O. M., & Kaur, H. (2020). Cost estimation and prediction in construction projects: a systematic review on machine learning techniques. SN Applied Sciences, 2(10), 1–27.
Zhang, Y., Minchin, R. E., & Agdas, D. (2017). Forecasting Completed Cost of Highway Construction Projects Using LASSO Regularized Regression. Journal of Construction Engineering and Management, *143*(10), 04017071.