

Phase-to-Phase Cost Estimate Dynamics in Preconstruction Design of Transportation Infrastructure Projects

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Abstract –

Transportation infrastructure projects frequently experience cost changes throughout the pre-construction project development process (PDP). While transportation agencies employ contingency allowances and periodic estimate updates to manage this uncertainty, empirical understanding on how cost estimates evolve prior to contract letting remains limited. This study examines phase-to-phase cost changes across Concept, Preliminary Field Plan Review (PFPR), and Final Field Plan Review (FFPR) phases, using project-level cost estimate records from a state DOT. Nominal cost changes are compared across transitions, stratified by project size, and decomposed into inflation and real components using the National Highway Construction Cost Index (NHCCI). Results demonstrate PFPR-to-FFPR transitions exhibit significantly higher nominal cost changes than Concept-to-PFPR transition, but real components which represent actual project-wise modifications, are near-zero and statistically indistinguishable. Project size effects at early transitions persist after inflation decomposition, with small projects showing genuine downward scope revision. The findings suggest that nominal cost change patterns are primarily explained by inflation exposure rather than systematic differences in estimation behavior throughout PDP.

Keywords –

Cost estimation; Project development phase; Cost uncertainty; Transportation infrastructure

1 Introduction

Accurate cost estimation is critical for effective planning and delivery of transportation infrastructure projects. Inaccurate estimates can lead to a disruption in program budgeting, delay downstream projects, and reduce the efficiency of resource allocation [1,2]. Cost estimation accuracy remains a persistent challenge for

transportation agencies, particularly during pre-construction project development stages when scope is still evolving and information is incomplete.

Previous research documented systematic cost underestimation in transportation infrastructure projects, where they list various leading factors such as incomplete scope definition, optimism bias, unforeseen site conditions [1,2,3]. While studies suggest that larger and more complex projects tend to undergo higher uncertainty or risk [4], they primarily evaluate the estimation performance by comparing the estimates to the final construction costs or awarded bids [12,13]. As a result, the systematic relationship between project portfolio and cost estimation performance remains underexplored.

To manage uncertainty, transportation agencies apply contingency allowances and conduct regular cost estimate updates throughout project development [5,6,7]. Anderson et al. [2] describe a gated cost estimation framework for U.S. state highway agencies in which cost estimates are updated at defined milestones — from conceptual planning through preliminary and final design — with each estimate reflecting the available scope information at that stage. Industry practice typically assumes that uncertainty decreases as projects advance, and therefore employs declining contingency rates across development stages [8,9]. However, the empirical basis for these assumptions remains limited. Studies examining actual cost deviations between low bid and cost estimates have found that changes often exceed contingency allocations, suggesting that standard rates may be insufficient or that uncertainty patterns differ from conventional assumptions [1,10,11].

Prior work has begun to address intermediate cost dynamics. Eliasson [14] tracked cost estimates across Swedish national investment plan revision cycles, finding that most cost escalation occurs during planning stages and that distributions are highly right-skewed. Cantarelli et al. [15] examined cost dynamics between the pre-construction and construction phases for Dutch infrastructure projects. However, these studies differ

from the present work in two important aspects. First, they examine cost changes across multi-year investment plan cycles rather than within the formalized stage process of U.S. state DOT project development, where cost estimates are updated at specific pre-construction milestones tied to advancing design maturity. Second, neither study isolates the contribution of construction cost inflation to observed nominal cost changes, which is a particularly important consideration given the anomalous inflation environment of 2021–2025. Anderson et al. [2] proposed separating quantity and price uncertainty as a process-oriented approach to contingency management, but the empirical behavior of cost estimates across pre-construction gate transitions under this framework has not been systematically examined.

This study addresses these gaps by analyzing the phase-to-phase cost estimate evolution within the pre-construction process of transportation infrastructure projects. Using project-level estimate data from a state DOT, the analysis evaluates both the magnitude and variability of cost changes, the project size effects, and decomposes the nominal cost changes into inflation and real components using the National Highway Construction Cost Index (NHCCI) at Concept-to-PFPR and PFPR-to-FFPR transitions. By focusing on the intra-pre-construction transitions and separating the inflation-driven changes from the project-driven revisions, the study provides empirical evidence on how cost estimates evolve across project development stages and offer insights for contingency planning and pre-construction cost management.

2 Methodology

2.1 Data Source and Sample Description

This study uses 993 cost estimate records for 339 state-owned transportation infrastructure projects let between 2021 and 2025. The dataset contains cost estimates recorded across three pre-construction milestones within the project development phases (PDPs), encompassing Concept Design, Preliminary Field Plan Review (PFPR), and Final Field Plan Review (FFPR). The milestones serve as the checkpoints of project development of the pre-construction stage, each requiring an updated cost estimate before advancing to the next stage [2]. The study therefore contributes to the knowledge as an intra-pre-construction analysis of phase-to-phase estimate transitions.

The key variable is the approved cost estimates at each stage, representing the overall predicted construction cost including engineering and inspection (E&I) and contingency allowances. Cost estimates are recorded in current dollars at the time of estimation,

where phase-to-phase cost changes reflect the at-time-of-estimate dollar amount of revisions between estimate dates. The cost changes therefore encompass both the actual project-wise revisions and market price changes between the estimate dates. The approved estimate at each phase is selected as the phase representative estimate. Table 1 shows the summary count for dataset used in this paper.

Table 1. Data Count Summary after Data Preprocessing

	Stage	# of Update Records	# of Projects
Raw Dataset		993	339
Phase Representative Estimate	Concept	339	305
	PFPR	252	182
	FFPR	402	249
Cost Change Transitions	Concept-to-PFPR	168	
	PFPR-to-FFPR	136	

The reduced sample sizes at each transition reflect data completeness limitations. First, not all project types require a PFPR milestone, so some projects advance directly from Concept to FFPR without a PFPR estimate on record. Second, PFPR and FFPR records were unavailable for a subset of projects due to data availability constraints. Both factors contribute to the smaller Concept-to-PFPR transition sample relative to the full project count and similarly explain why the PFPR-to-FFPR transition sample is smaller than the number of projects with PFPR estimate. These reductions reflect project development processes and data availability rather than selective sample filtering.

2.2 Variable Construction

2.2.1 Phase-to-Phase Cost Changes

Project development phases are ordered chronologically from Concept to PFPR and FFPR. Phase-to-phase cost changes are constructed sequentially for each project. The updated cost is the approved cost estimate of the corresponding transition and the baseline is the approved estimate from the immediately preceding phase. The percentage cost changes are calculated to quantify how cost estimates evolve as project advance from one phase to another. Equation 1 below expresses the measure calculation, where i indicates projects and p indexes the phase.

$$\begin{aligned} & \text{Cost Change}_{i,p} (\%) \\ &= \frac{\text{Updated Cost}_{i,p} - \text{Baseline}_{i,p}}{\text{Baseline}_{i,p}} \times 100 \end{aligned} \quad (1)$$

Concept-to-PFPR and PFPR-to-FFPR transitions are considered in the primary analysis. This approach ensures a single representative estimate per each combination of project and phase, maintaining comparability while avoiding bias from projects with more frequent updates.

2.2.2 Project Size Classification

Project size is categorized using the awarded low bid amount to represent project scale and complexity. Project size categories were assigned from using empirical tertiles computed from full set of projects and held fixed across all analyses, ensuring approximately equal sample sizes across categories. Table 2 shows the count summary by size category and transition.

Table 2. Project Size Classification and Data Summary

Size	Size Range	Concept-to-PFPR	PFPR-to-FFPR
Small	<\$3.45M	55	40
Medium	\$3.45M-\$8.35M	60	51
Large	> \$8.35M	53	45

2.2.3 Inflation Decomposition

Cost estimates at each phase are prepared using contemporaneous unit costs, so nominal cost changes between phases reflect both real project-wise revisions and market price changes. To isolate the components, each phase-to-phase change is decomposed using the quarterly National Highway Construction Cost Index (NHCCI). The NHCCI values corresponding to the estimate date of each phase representative is retrieved to measure the market price-level changes. The inflation component and the real component are calculated as shown in Eq 2 and 3 below, where the real component represents the residual project scope and quantity after removing inflation.

$$\text{Inflation}_{i,p} (\%) = \left(\frac{\text{NHCCI}_{\text{updated}}}{\text{NHCCI}_{\text{baseline}}} - 1 \right) \times 100 \quad (2)$$

$$\text{Real}_{i,p} (\%) = \left(\frac{1 + \text{Nominal}_{i,p}/100}{1 + \text{Inflation}_{i,p}/100} - 1 \right) \times 100 \quad (3)$$

2.3 Statistical Analysis

The analysis consists of three stages to examine the

nominal cost dynamics, project size effects, and the role of construction cost inflation.

2.3.1 Global Cost Dynamics Across Phase Transitions

First analysis focuses on whether cost change behavior differs across phase transitions. Descriptive statistics characterize the distribution of cost evolution for both transitions, Concept-to-PFPR and PFPR-to-FFPR. Given the non-normality and right-skewed distribution, median is reported as the primary statistic, and nonparametric statistical tests are conducted. Mann-Whitney U test evaluates differences in central tendency across phases, while median-centered Levene's test assesses differences in dispersion. Given that all inferential tests are rank-based, significance results are robust to extreme outliers, and therefore all observations are retained in the analysis.

2.3.2 Project Size and Phase Transitions

The second stage evaluates whether project size influences cost change behavior within each phase transition. Cost changes are stratified by project size category, and the differences in central tendency are tested via Kruskal-Wallis test and differences in dispersion are examined using median-centered Levene's test. When Kruskal-Wallis test indicates statistical significance, post-hoc pairwise Mann-Whitney U tests with Holm-Bonferroni correction are conducted to control for multiple comparisons.

Cost changes are also compared across phase transitions within each project size category using Mann-Whitney U tests with median-centered Levene's tests.

2.3.3 Inflation Decomposition

The third stage examines how much of the observed nominal cost changes are attributable to the construction cost inflation rather than actual project-wise revisions. For each transition pair, the nominal cost change is decomposed into an inflation component and a real component as defined in Eq 2 and 3.

Mann-Whitney U and Levene's test are applied to assess whether the genuine project cost revision behavior differs between the two transitions. The decomposition results paired with the statistical results from nominal values would indicate whether the nominal difference between transitions is driven by differential inflation exposure rather than genuine differences in scope and quantity revision across pre-construction phase transitions. Moreover, the real components are stratified by project size category to assess whether size effect persists after inflation adjustment.

2.3.4 Analysis Implementation Details

All statistical analyses are conducted in Python 3.11,

using libraries such as scipy.stats, pandas, matplotlib, and seaborn. Statistical significance is assessed at $\alpha = 0.05$ throughout.

3 Result

3.1 Descriptive Statistics of Cost Revisions by Transition

After applying the data preprocessing into a single representative estimate per project-phase, the final dataset contains 168 Concept-to-PFPR transitions and 136 PFPR-to-FFPR transitions from 305 unique projects. Table 3 summarizes the distribution of percentage cost changes for phase-to-phase transitions.

Table 3. Summary Statistics of Cost Updates by Phase Transitions

Transition	Concept-to-PFPR	PFPR-to-FFPR
Count	168	136
Mean (%)	16.11	29.83
Median (%)	6.13	20.40
Std Dev (%)	33.75	34.12
Min (%)	-65.84	-53
Max (%)	238.35	209.9

Both transitions exhibit positive median cost changes, indicating that the cost estimates increase on average as projects advance through pre-construction. The distributions are right-skewed for both transitions, as can be seen from the divergence between the mean and median values. Despite the skewness, the selected nonparametric tests are rank-based and therefore the extreme observations do not affect significance conclusions.

3.2 Statistical Comparison Across Project Development Phases

The Mann-Whitney U test indicates a statistically significant difference at 5% level in the central tendency of cost changes between the transitions ($U=7502$, $p<0.001$). The PFPR-to-FFPR (20.4%) exhibits a substantially higher median cost change than Concept-to-PFPR transition (6.1%). In contrast, the median-centered Levene's test yields no significant difference in dispersion between transitions ($W=1.16$, $p=0.282$). The result indicates that the spread of cost changes is

comparable across two transitions despite the difference in the typical magnitude. Table 4 summarizes the test results.

Table 4. Statistical Test Results Between Transitions

Statistical Testing	Statistic	p-value
Mann-Whitney U	$U=7502$	<0.001
Levene	$W=1.16$	0.282

3.3 Project Size Effects and Transition

Analysis is stratified by project size categories within each transition to examine the heterogeneity in cost change behaviors across different project sizes. The results of Kruskal-Wallis and Levene's test for each transition are organized in Table 5 and the descriptive statistics by project size and transition can be found in Table 6.

Table 5. Statistical Test Results for Project Size Effects Within Each Phase Transition

	Kruskal-Wallis Test		Levene's Test	
	H	p-value	W	p-value
Concept-PFPR	9.09	0.011	0.09	0.914
PFPR-FFPR	3.16	0.206	2.85	0.062

Table 6. Descriptive Statistics by Project Size and Phase Transition

	N	Median (%)	Mean (%)	Std (%)
Concept-to-PFPR				
Small	55	1.46	9.00	29.40
Medium	60	8.44	18.93	40.55
Large	53	8.30	20.30	28.53
PFPR-to-FFPR				
Small	40	20.85	24.43	31.59
Medium	51	19.00	26.16	31.59
Large	45	26.30	38.80	43.20

For Concept-to-PFPR transition, the Kruskal-Wallis test indicates a significant difference in median values of cost changes across ($H=9.09$, $p=0.011$). Post-hoc

pairwise comparisons with Holm-Bonferroni correction show ‘Small’ projects have a notably different pattern from both ‘Medium’ (U=1188, p_adj=0.025) and ‘Large’ (U=1028, p_adj=0.025) projects, while ‘Medium’ and ‘Large’ projects do not differ from each other (p_adj=0.934). ‘Small’ projects exhibit lower median cost changes at Concept-to-PFPR compared to the ‘Medium’ and ‘Large’ projects, suggesting that the smaller projects carry more stable or complete project definitions at the concept stage. Meanwhile, Levene’s test results indicate that the spread of revisions do not differ by size, unlike the typical magnitude of revision.

For PFPR-to-FFPR transition, neither central tendency (H=3.16, p=0.206) nor dispersion (W=2.85, p=0.062) shows significant project size effects. The results suggest that the size-relevant heterogeneity in revision behavior has largely been resolved and that projects are going through comparably sized revisions by the latter phases of project development.

Table 7. Statistical Test Results for Project Size Effects Within Each Phase Transition

Size	Kruskal-Wallis Test		Levene’s Test	
	H	p-value	W	p-value
Small	601.0	<0.001	0.002	0.968
Medium	1166.0	0.032	0.017	0.897
Large	763.0	0.002	3.083	0.082

Table 7 shows the results of Mann-Whitney U and Levene tests comparing the two transitions within each size category. All three size categories show significantly larger nominal cost changes at PFPR-to-FFPR transition than Concept-to-PFPR in central tendency. Dispersion does not exhibit significance across transitions within any size group. The consistent pattern of higher nominal changes suggest that a common mechanism affects all project scales uniformly at the later stages.

3.4 Inflation Decomposition

3.4.1 Transition Significance After Decomposition

This section decomposes nominal changes into inflation and real components using quarterly NHCCI values corresponding to the estimate date of each phase representative. Table 8 presents the decomposition of nominal cost changes into inflation and real components for each transition.

Table 8. Inflation Decomposition Results

Transition	Concept-to-PFPR	PFPR-to-FFPR
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N	168	136
Nominal (%)	6.13	20.40
Inflation (%)	10.60	22.65
Real (%)	-0.67	2.04

The median inflation component exceeds the median nominal change for both transitions. Correspondingly, the median real components are near-zero in both transitions, indicating that the construction cost inflation during the data period accounts for a substantial amount of the nominal cost changes at both transitions.

Mann-Whitney U test and Levene test was again applied on the real components, showing no significant difference for both central tendency (U=11092, p=0.664) and dispersion across transitions (W=0.746, p=0.389). This result contrasts with the significant nominal cost change difference, reflecting that the actual project-wise revision is statistically indistinguishable in both magnitude and variability. The nominal difference between transitions is driven by inflation rather than genuine differences in estimation behavior across pre-construction phases.

3.4.2 Project Size Effect After Decomposition

Statistical testing was reapplied to test for significance of project size on real cost change after inflation decomposition. Kruskal-Wallis test at Concept-to-PFPR remains significant (H=9.09, p=0.011), with post-hoc comparisons identifying that the ‘Small’ projects have a substantially different central tendency from the ‘Medium’ (p_adj=0.033) and ‘Large’ (p_adj=0.017) projects. ‘Small’ projects show a negative median value of real cost component (-8.23%), indicating a genuine downward scope revision at the early phase, while ‘Large’ projects show positive median values (6.02%). No significant size effect is observed in the real cost components at PFPR-to-FFPR transition (H=0.498, p=0.779). The within-size comparisons across transitions show that only ‘Small’ projects show significance where the real cost differences shift from -8.23% at Concept-to-PFPR to +1.82% at PFPR-to-FFPR. The persistence of size effect after inflation decomposition confirms the existence of a genuine heterogeneity in project-revision-driven cost change.

Table 9. Descriptive Statistics by Project Size and Phase Transition After Inflation Decomposition

	N	Median (%)	Mean (%)	Std (%)
Concept-to-PFPR				
Small	55	-8.23	-2.44	27.94

Medium	60	0.69	6.34	33.77
Large	53	6.02	10.50	28.64
PFPR-to-FFPR				
Small	40	1.82	3.81	19.93
Medium	51	6.01	2.66	22.62
Large	45	-1.12	4.12	31.41

4 Discussion

The study examined how cost estimates evolve across pre-construction phase transitions in transportation infrastructure projects, analyzing the cost change magnitude, dispersion, and inflation-adjusted dynamics between Concept, PFPR, and FFPR phases.

4.1 Nominal Cost Changes Across Transitions

First analysis indicates that the PFPR-to-FFPR transitions exhibit significantly higher median cost changes (20.4%) than Concept-to-PFPR transitions (6.1%), while the dispersion across two transitions does not differ significantly. The pattern suggests that the cost changes are directional rather than structural. Estimators at both transitions revise costs with similar variability, but the typical magnitude of the revisions is higher for the latter phases.

The cost change pattern within pre-construction has not been documented in prior literature. Eliasson [14] and Cantarelli et al. [15] showed that cost escalation is focused during planning stages, but treated pre-construction as a single stage. This study identifies that within the pre-construction stages, the PFPR-to-FFPR transition carries a substantially higher nominal cost revision magnitude and that the contingency should be sufficiently allocated at least until the PFPR phase.

The comparable dispersion across transitions adds a further nuance that the estimators revise costs with similar variability, but the typical magnitude of the revisions is substantially larger at the later gate. The distinction suggests that the uncertainty structure of the cost revision does not change across pre-construction project development, despite the typical cost revision growing larger.

4.2 Project Size Effects on Nominal Changes

Project size significantly influences nominal cost change behavior at Concept-to-PFPR, with ‘Small’ projects exhibiting lower median changes than both ‘Medium’ and ‘Large’ projects. However, no significant size effect emerges at PFPR-to-FFPR transition and dispersion does not differ significantly across size

categories at either transition.

The asymmetric size effect indicates that project scale introduces heterogeneity primarily when scope definition is least complete. Smaller projects systematically over-estimate at concept stage and revise scope downward as design develops, while ‘Large’ projects carry under-estimated concept costs that enlarge as design matures.

Importantly, all three size categories show significantly larger nominal cost changes at the PFPR-to-FFPR transition than Concept-to-FFPR transition. Such consistency suggests that the transition-level difference is not simply driven by project-wise characteristics, but rather a time-period mechanism affecting all project types uniformly.

4.3 Impact of Construction Cost Inflation

The inflation decomposition analysis uncovers that the median of real component, representing the scope and quantity revision after removing the NHCCI price-level effects, is near-zero in both transitions. Mann-Whitney U and Levene tests on the real components show no significant difference across transitions in either central tendency or the dispersion. This contradicts with the significant nominal differences in Section 4.1, highlighting that once the market price escalation is removed, the estimate revision behavior is statistically indistinguishable across the two transitions in both magnitude and variability.

The finding reframes the nominal patterns observed in the earlier analysis. The higher nominal changes at PFPR-to-FFPR transitions do not reflect larger project-wise changes or revisions but rather covers a period of steeper NHCCI escalation.

However, the size effect persists even after inflation decomposition, confirming that it is a byproduct of genuine differences in project scope or quantity revision. Kruskal-Wallis test on real components at Concept-to-PFPR transition remains significant, implying that the estimators tend to over-estimate ‘Small’ projects at concept phase and revise the project cost downward at the PFPR stage when preliminary design is developed. On the contrary, ‘Large’ projects carry under-estimated concept costs that grow as scope is clarified. Insignificant size effect at the PFPR-to-FFPR indicates that the size-related differences in revision behavior have been resolved by latter stages. Within-size comparisons further show that only ‘Small’ projects exhibit significant real component differences across transitions, from -8.23% at Concept-to-PFPR to 1.82% at PFPR-to-FFPR, which is a pattern of early over-estimation followed by a stabilization.

4.4 Implications and Limitations

The findings provide several implications for pre-

construction cost management, regarding the role of construction cost inflation in nominal cost changes, genuine size-based differences in scope revision behavior, and empirical basis of phase-specific contingency frameworks.

First, the phase-to-phase cost changes should be interpreted with caution as indicators of estimation performance or project scope management quality. Once inflation is removed, the real components show no significant differences across transitions. A large nominal cost changes at PFPR-to-FFPR may not reflect heavy project revision, but instead the market-price exposure during the development period. The same applies in the opposite direction, where inflation needs to be considered separately when aiming for a substantial cost change due to project-wise adjustments.

Second, project size introduces genuine heterogeneity in scope revision behavior at the early pre-construction stages. The real component analysis confirms that the 'Small' projects show genuine downward scope revision at the Concept-to-PFPR transition, in comparison to the 'Large' projects. Size-based risk differentiation is meaningful at the early phases of project development where scope ambiguity varies systematically across project scales. Applying uniform contingency rates at the early stage of project development may not adequately reflect this heterogeneity.

Lastly, the results suggest a refinement to the phase-based declining contingency frameworks [8,9]. The frameworks assume that uncertainty decreases as projects advance, implying that later-stage estimates require lower contingency. However, the findings show that the dispersion of the cost revisions, whether nominal or real, is statistically comparable across phase transitions and project scale. The spread of possible cost outcomes does not decrease as projects advance through pre-construction. Furthermore, the real cost components are statistically indistinguishable across transitions, indicating that project-wise revision behavior does not materially change between phases once inflation effects are removed. Taken together, results suggest that uncertainty persists throughout the pre-construction process and that the contingency rates may overlook the persistence of residual uncertainty at later stages.

To successfully implement the findings, several limitations should be addressed. The dataset is drawn from a single state DOT, which may limit generalizability to agencies with different PDP structures or project portfolios. Second, the dataset covers projects let between 2021 and 2025, coinciding with an anomalous inflation period. The generalizability of the near-zero real component findings should also be evaluated across different economic conditions. Future work should extend the analysis to investigate the effect of additional project-level characteristics and examine

the relationship between pre-construction cost evolution and the final contract award outcomes to further understand the cost change dynamics.

5 Conclusion

This study examined the pre-construction cost estimate evolution in transportation infrastructure projects by analyzing the phase-to-phase cost changes between Concept, Preliminary Field Plan Review (PFPR), and Final Field Plan Review (FFPR) phases. The analysis focused on the intermediate cost estimate transitions rather evaluating the cost estimation performance on final outcomes, providing an intra-pre-construction perspective on cost change dynamics.

Four findings can be drawn from the analysis. First, the nominal cost changes differ significantly across transitions, with PFPR-to-FFPR transition having higher median increases than the Concept-to-PFPR, while the dispersion remains stable across both transitions. Second, project size influences cost change behavior at the early phases of project development. Small projects show significantly lower Concept-to-PFPR changes compared to the other size categories. However, all size categories show larger nominal changes at the later transition, indicating a common transition-level mechanism. Third, inflation decomposition reveals that the construction cost escalation, measured by NHCCI, accounts for a substantial amount of observed nominal changes. The real cost components are near-zero and statistically indistinguishable across transition. Lastly, the size effect at Concept-to-PFPR persists after adjusting for the inflation, confirming that the size findings reflect actual differences in project detail or scope revision behavior rather than inflation exposure.

These results suggest that nominal cost changes alone provide a potentially limited representation of pre-construction cost dynamics. The observed differences in the magnitude of cost changes across phases are largely attributed to market-price influences rather than systematic differences in project-wise revisions. Moreover, the variability of cost changes remains persistent throughout the project development. This indicates that uncertainty is not fully resolved through phase advancement and that cost growth and uncertainty reduction should be treated as distinct dimensions of estimation behavior.

By separating the inflation-driven changes from cost revisions from actual project adjustments and examining the distributional patterns across phases and project sizes, the study provides empirical evidence on how cost estimates evolve within pre-construction. The results contribute to a foundation for more data-informed contingency assignment and highlight the importance of distinguishing between magnitude, dispersion, and

inflation effects when evaluating cost uncertainty in transportation project delivery.

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