Developing a Preliminary Engineering (PE) Cost Estimation Method for a Portfolio of Bridge Construction Projects in Project Planning Phase

Junghye Son, Ph.D., P.E and Nabeel Khwaja, P.E., Center for Transportation Research

This study provides state departments of transportation (DOTs) with a planning-phase PE cost estimation method that can be applied to a portfolio of bridge construction projects, accommodating different project sizes and types. Due to the uncertainties and limited availability in the planning phase, it is challenging to estimate PE costs with reasonable accuracy and usability. The study analyzed the PE cost ratios to construction cost (%PE) of 628 TxDOT bridge repair projects let between 2015 and 2019. The proposed method presents different %PE estimates by project size and three project types – bridge maintenance (BMN), bridge replacement (BR), and bridge widening and rehabilitation (BWR). This approach can assist DOTs in generating improved PE cost estimates than using a single %PE method while maintaining simplicity and usability suitable for a portfolio of projects during the project planning phase.

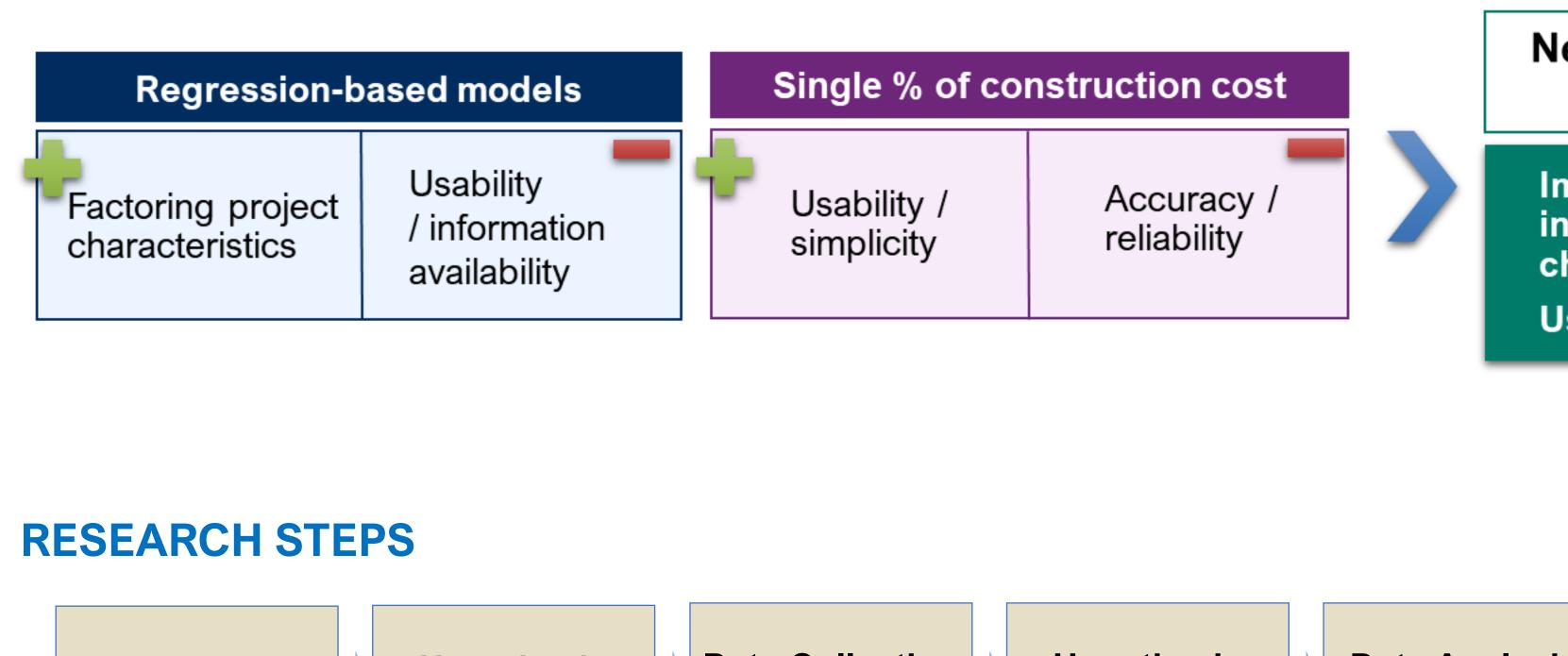## INTRODUCTION

Infrastructure Investment and Jobs Act

$110 billion in additional funding to repair our roads and bridges, which is the single largest investment in repairing and reconstructing our nation's bridges since the construction of the interstate highway system.

RESEARCH NEEDS

- DOTs are facing the increasing demand for highway bridge repair nationwide and the need to secure funding.
- Existing PE cost estimation approaches may not be effective for a large portfolio of projects as they are designed for individual projects.

RESEARCH METHDOLOGY

CURRENT PE COST ESTIMATION APPROACHES

Regression-based models		Single % of construction cost		Need an estimation method with
Factoring project characteristics	Usability / information availability	Usability / simplicity	Accuracy / reliability	Improved accuracy by incorporating project characteristics; Usability & simplicity

RESEARCH STEPS

Literature Review → Hypothesis Development → Data Collection & Processing → Hypothesis Testing → Data Analysis & Validation → Conclusions
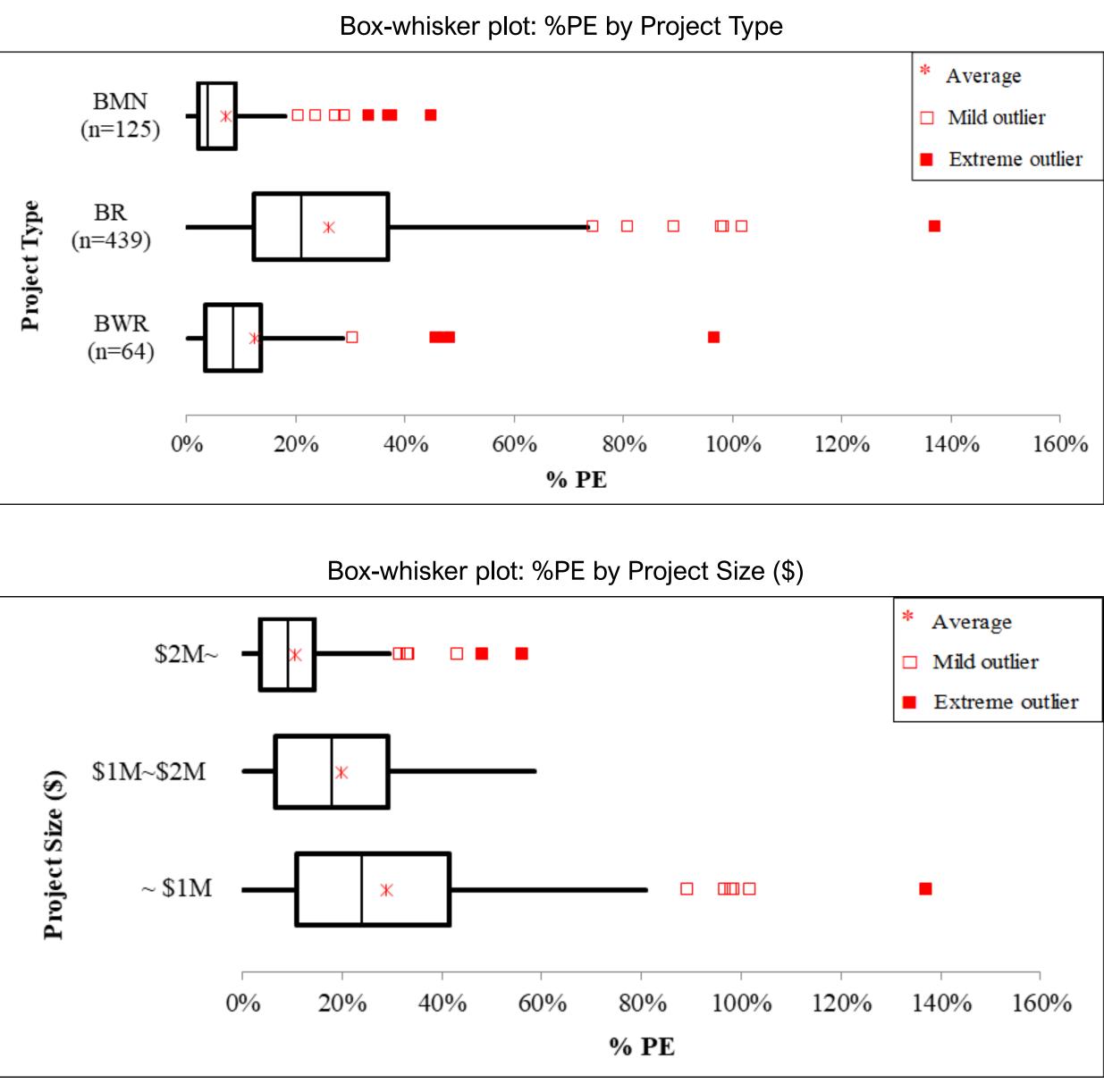
HYPOTHESIS TESTING

DATA DESCRIPTION

- 628 bridge repair projects let between 2015 and 2019.
  - Bridge Maintenance (BMN): bridge maintenance not addressed as bridge rehabilitation, widening, or replacement.
  - Bridge Replacement (BR): replacement of structure on existing location.
  - Bridge Widening or Rehabilitation (BWR): rehabilitation or widening of deck, substructure, or superstructure of an existing bridge.
- Low-bid design-bid-build projects.
- Inflation adjustment to the December 2019 value.
- %PE: PE cost ratio to construction cost (original contract cost)

Descriptive Statistics of Data (Dec. 2019 dollar value)

Statistics	Project Type			
	BMN	BR	BWR	Total
Number of Projects	125	439	64	628
Average Original Contract Cost ($, M: million)	$2M	$2.6M	$3.9M	$2.6M
Average PE Cost ($)	$88.6K	$374K	$508.5K	$331K
Average %PE	7.1%	26%	12.4%	20.9%
Median %PE	3.9%	20.9%	8.5%	15.2%
Minimum %PE	0.005%	0.08%	0.3%	0.005%
Maximum %PE	44.9%	137.2%	96.7%	137.2%

HYPOTHESIS TESTING (Mann-Whitney U test, α=5%)

- *Hypothesis 1: %PE by Project Type*

  Hypothesis 1_0. The ratios of PE cost to the original contract cost are the same across the three bridge project types.
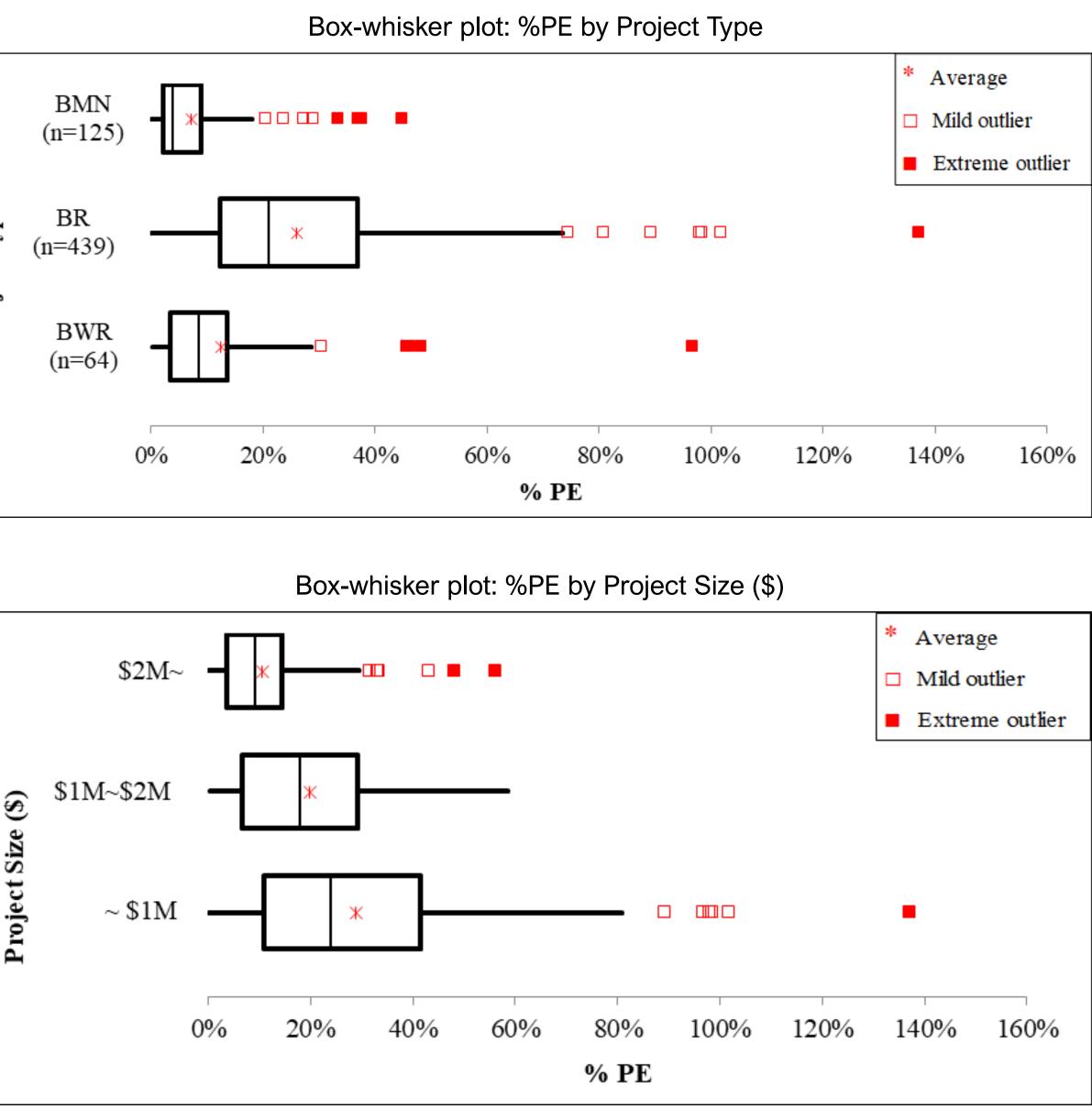
  Hypothesis 1_a. The ratios of PE cost to the original contract cost are different across the three bridge project types.

Box-whisker plot: %PE by Project Type

- *Hypothesis 2: %PE by Project Size*

  Hypothesis 2_0. The ratios of PE cost to the original contract cost are the same across project sizes.

  Hypothesis 2_a. The ratios of PE cost to the original contract cost are different across project sizes.

Box-whisker plot: %PE by Project Size ($)

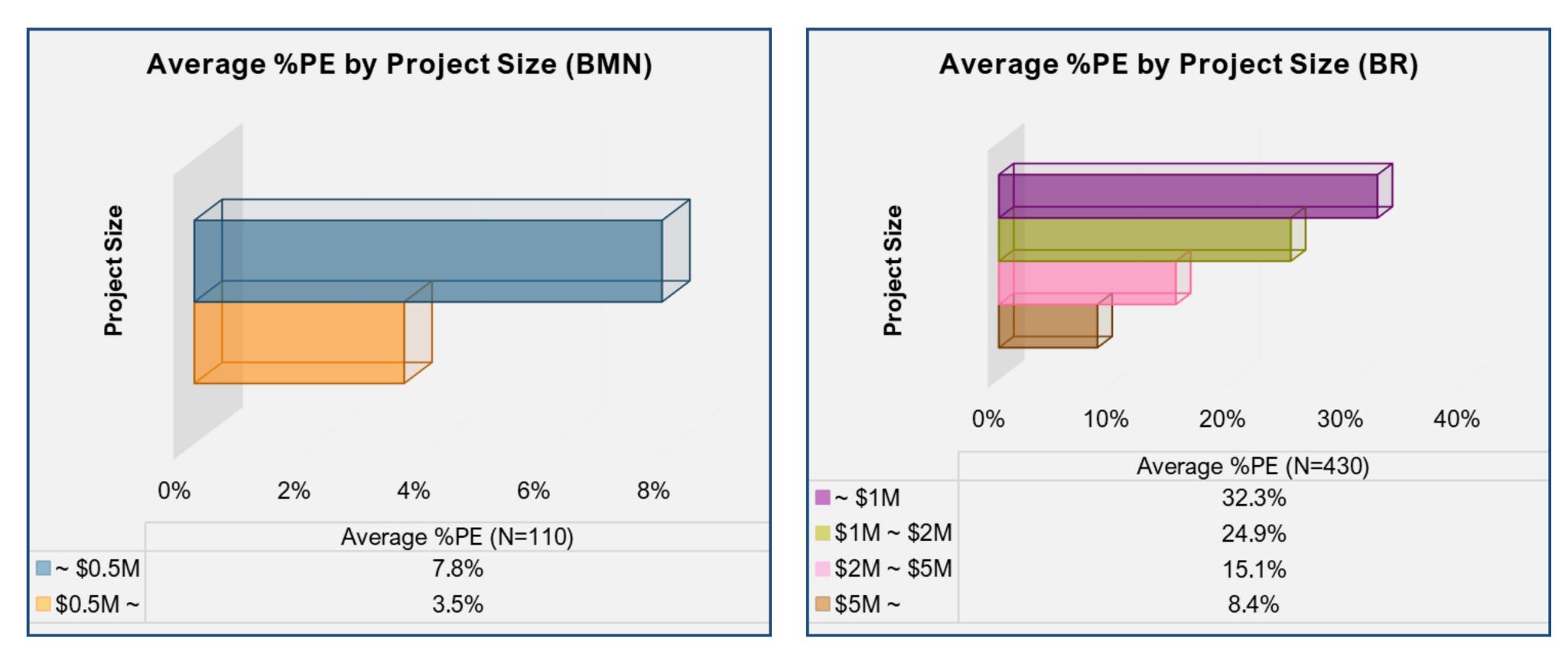**The PE cost ratios to original contract cost significantly varied by project size and project type.**

ANALYSIS

PE COST RATIOS BY PROJECT TYPE AND SIZE

Average %PE by Project Size (BMN)

	Average %PE (N=110)
~ $0.5M	7.8%
$0.5M ~	3.5%

Average %PE by Project Size (BR)

	Average %PE (N=430)
~ $1M	32.3%
$1M ~ $2M	24.9%
$2M ~ $5M	15.1%
$5M ~	8.4%

BWR (N=53)	
Average %PE	9.1%

- For BWR project groups, the test results did not conclude that the distributions of %PE differed across project size groups, possibly due to the small sample size.

CONCLUSIONS

- The ratios of PE cost to construction cost of bridge repair projects were statistically different across three project types (BMN, BR, BWR) and project sizes.
- The suggested PE cost estimation method (multiple-percentages-of-construction-cost method) improves the accuracy and efficiency when applied to a portfolio of projects while maintaining usability.
- The proposed method can help DOTs save time and effort in PE cost estimation for a portfolio of bridge repair projects during the planning phase where limited project information is available.

LIMITATIONS

- The data were collected from a single DOT (TxDOT).
- Future research can expand the analysis to other project types, such as rehabilitation or new roadway construction.
- BWR project group had a smaller sample size.

ACKNOWLEDGEMENT

collaborate. innovate. educate.