An Exploratory Aggregate Analysis of Interstate Highway Bridge Deck Expenditure & Condition




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Outline

- Introduction
- Data and Methodology
- Results and Discussion
- Concluding Remarks

Introduction

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Oversight bodies in USA

- USDOT
- FHWA
- GAO

Oversight body responsibilities include

– Measuring agency outcomes

– Assessing each agency outcomes relative to:

- previous year's outcomes
- agency spending levels
- outcomes of other agencies.

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Scope and Objectives of this paper

Scope: Interstate highway bridge decks in USA

Objectives:

- Establish empirical relationship between deck expenditure and deck condition
- Compare relative performance across states

DATA

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Data

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DATA SOURCES

1. FHWA's Office of Highway Policy Information:

- Database of state highway expenditures on highway construction and maintenance.
- Database of highway bridge features:
  - Average daily truck traffic per bridge
  - Deck condition rating (NBI)
  - Total Deck area in a state

2. National Climate Data Center (NCDC) database:

- For each state, the average freeze index, Annually, Years 1992 to 2012.

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Data on strength factors:

- Total expenditure per ft^2 of deck

Data on stress factors:

- Traffic (truck) loads
- Climate severity (Freeze index in degree-days)

Other data:

- Total area of interstate bridge decks in a state
- Deck condition

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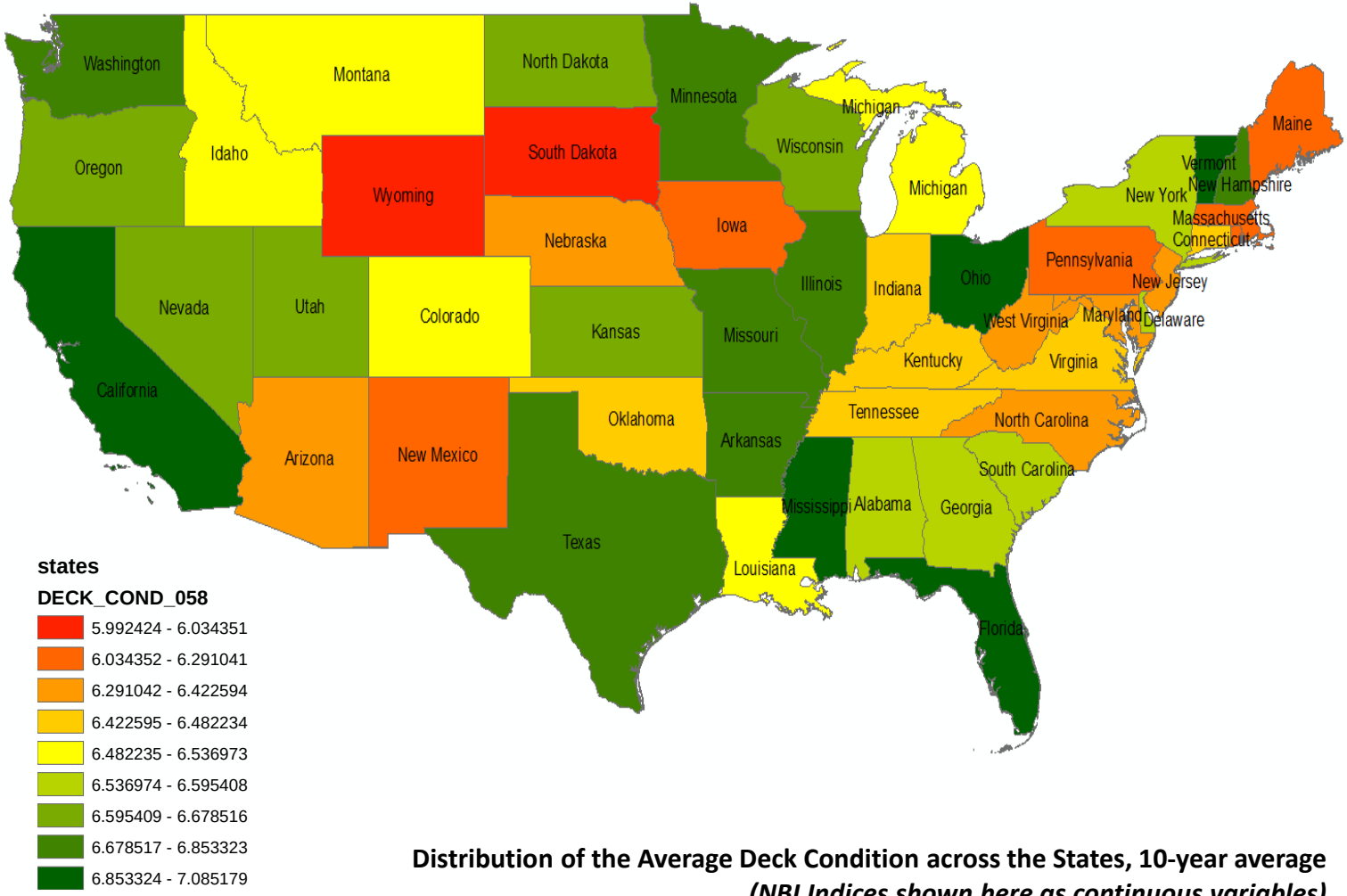

Distribution of the Average Deck Condition across the States, 10-year average
(NBI Indices shown here as continuous variables)

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Part 1: The Relationship between Deck Condition and Deck Expenditure

- Response variable:
  - Rehabilitation and maintenance expenditure (EXP) in $2010.
- Explanatory variables are
  - deck condition in previous year (Cond)
  - freeze index (FRZ)
  - total deck area of bridges in the state (AREA)
  - traffic loading (annual average daily truck traffic (AADT)).
- Model form

$$Total\_EXP = \beta_0 + \beta_1\, Cond + \beta_2 FRZ + \beta_3 AADT + \beta_4 AREA$$

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Part 2: Assessing the Relative Performance across the States

Inputs:

- Expenditure ($/ft^2 of deck)
- Average climate severity
- Average truck traffic per bridge
- Average condition of all decks

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- **Expenditure ($/ft^2 of deck)**
  - Expenditure ↑ Deck condition ↑
- **Average climate severity**
  - Climate severity ↑ Deck condition ↓
- **Average truck traffic per bridge**
  - Truck traffic ↑ Deck condition ↓

1. In states with favorable (mild) climate, bridge decks suffer less exposure to freezing conditions, free-thaw cycles, ice, and harmful deicing salts.

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Excellent performing states

- Low expenditure ($/ft^2 of deck)
- Unfavorable climate
- High truck traffic per bridge
- Yet, good condition of decks

Poor performing states

- High expenditure ($/ft^2 of deck)
- Favorable climate
- Low truck traffic per bridge
- Yet, poor condition of decks

RESULTS & DISCUSSION

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Part 1. The Relationship between Condition and Expenditure

- Inverse relationship between the deck condition and the expenditure
  - A lower average condition in one year leads to higher expenditures the following year.
- The higher the total area of bridge deck, the higher the total expenditure per ft^2 (but relationship is non-linear; hence, scale economies exist)
- A higher freeze index is generally associated with higher expenditure.

$$Total\_EXP = \beta_0 + \beta_1\, Cond + \beta_2 FRZ + \beta_3 AADT + \beta_4 AREA$$

R-squared	0.3734	Adj R-squared	0.3177	Root MSE	3.1e+5

	Coef.	t	P>|t|	[95% Conf. Interval]	
AVG DECK CONDITION (NBI)	-382373.4	**-2.17**	0.035	-736482	-28264.75
TOTAL DECK AREA	0.004872	**2.91**	0.006	0.0015	0.0882
FREEZE INDEX	29.7635	**0.35**	0.730	-143.1713	202.6985
AVG TRUCK TRAFFIC	0.01444	**1.32**	0.194	.007628	0.0365110
Constant Term	2562771	**2.27**	0.028	289499	4836043

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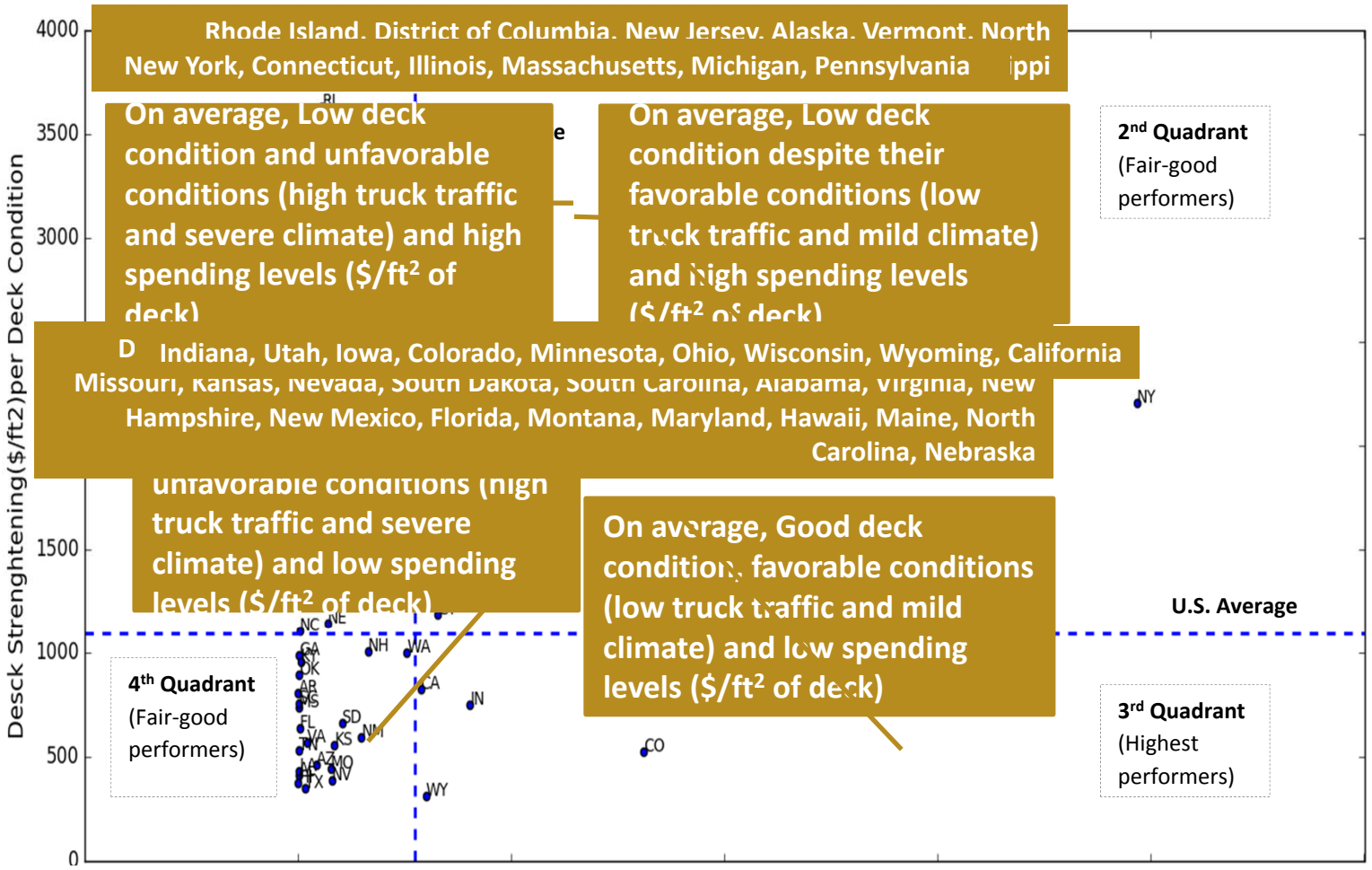

The position of a state in a quadrat can be a reflection of the prudent use of the taxpayer funds by the state agency.

CONCLUSION

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- The framework shows how oversight agencies can increase the overall accountability of individual highway agencies.
- The observed differences in the state performance could be due to differences in:
  - Agency supervision/audit quality
  - Work culture in the agency
  - Geotechnical conditions in the state
  - Design/construction practices
  - Material quality in the state's quarries
- Results can help agencies seen/perceived as poorly performing, to carry out critical self-assessment to:
  - identify the possible causes of such performance or
  - investigate reasons for any misperception.

Future Work

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- Key Assumption In Current Paper: One (1) degree-day of FRZ and One (1) truck have equivalent effects on deck damage, and hence on deck repair expenditure.
- Future papers could relax the above assumption by:
  - Establishing appropriate weights between the deterioration factors and use these weights to determine the agencies' quadrant positions
- Consider other model specifications; e.g., the lagged panel model.
- Consider average statewide values of other design variables that:
  - Constitute "stressors" or "strengtheners" of deck condition
  - Measure the stability of the state quadrant position (performance ranking) across the years
- Extend the work to the other bridge components (superstructure and substructure) and other highway functional classes

KEY REFERENCES

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Q&A

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