The Influence of State Policies on Critical Infrastructure Resilience: An Approach for Analyzing Transportation and Capital Investment

Risk and Infrastructure Science Center
Global Security Sciences Division

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The Influence of State Policies on Critical Infrastructure Resilience: An Approach for Analyzing Transportation and Capital Investment

by

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Executive Summary

During times of crisis, communities and regions rely heavily on critical infrastructure systems to support their emergency management response and recovery activities. Therefore, the resilience of critical infrastructure systems to crises is a pivotal factor to a community's overall resilience. Critical infrastructure resilience can be influenced by many factors, including State policies – which are not always uniform in their structure or application across the United States – were identified by the U.S. Department of Homeland Security as an area of particular interest with respect to their influence on the resilience of critical infrastructure systems. This study focuses on developing an analytical methodology to assess links between policy and resilience, and applies that methodology to critical infrastructure in the Transportation Systems Sector. Specifically, this study seeks to identify potentially influential linkages between State transportation capital funding policies and the resilience of bridges located on roadways that are under the management of public agencies.

The methodology developed in this study gathers and analyzes data from three primary areas that span the spectrum from governmental policy to the resilience of built systems: (1) historical capital funding mechanisms and processes gathered through a structured policy analysis are used to identify the various policy pathways that may fund actions that enhance infrastructure resilience; (2) State transportation capital funding records are examined to identify funding and bridge capital expenditure trends, and thereby assess the extent to which policies translate into capital funding; and (3) State-level bridge data are gathered from the National Bridge Inventory and analyzed statistically to connect funding trends with an aggregate measures of bridge resilience to physical impacts – bridge Sufficiency Ratings –over time.

To test the methodology developed, this study examines the specific case of State-level capital transportation policies from five States (California, Florida, Illinois, Oregon and Texas) and the resilience of bridges located on roadways under the management and oversight of State departments of transportation (DOTs). Overall, the results of these five case implementations showed that for some States in this study an apparent linkage exists between State policy information and the State spending information, but for other States the results were either mixed or inconclusive. Some notable results arose from each of the three individual components of the analytical methodology, as well. These, along with some overarching conclusions are discussed below.

The structured policy analysis identified that State DOT bridge funding policies can generally be characterized as either *proactive* or *reactive*. Proactive States tend to enact funding policies that are able to maintain an acceptable or benchmarked state of repair among State highway bridges. Reactive States enact funding policies intended to generate funding to recover from significant deficiencies that exist in their bridge inventory, due to inefficient previous funding programs or damage and distress caused by unforeseen or unanticipated and widespread hazards. This distinction between proactive and reactive has some tradeoffs; most notably that proactive policy approaches may enable better long-term performance planning due to the more easily anticipated nature of sustained annual funding through proactive actions.

The statistical modeling intended to identify linkages between State bridge capital expenditures and bridge sufficiency ratings as a measure of resilience to physical impacts offer insight for some States, but are unfortunately less conclusive for others. The strongest results – those for California and Florida – showed that increased funding for capital investment projects did positively influence bridge resilience outcomes. However, there was a significant distinction between those two States with respect to the source of funding. In California, a \$1 billion increase in investment in *Federal funding for interstates* is associated with a 13.4 point increase in the average bridge sufficiency ratings. In Florida, conversely, a \$1 billion increase in investment in *State capital outlay for bridges* (and more specifically, for rural bridges) is associated with a 4.9-point increase in average bridge sufficiency ratings. The distinction between Federal funding and State-level funding may be reflective of the proactive/reactive dichotomy identified during the policy analysis in that States with reactive policies may rely more heavily on Federal funding to support large, Statewide capital investment programs, such as the Bridge Seismic Retrofit program, or to support other State transportation capital investment so that State-level funding policies can instead focus on these specific capital investment programs. States with proactive policies may be in a better position to anticipate future funding needs and then take action at the State-level to ensure funding for those anticipated investment needs.

The results and conclusions from California and Florida are somewhat contradicted by the results from Texas, a State characterized by proactive policies, but in which the Federal funding variables are shown to be more influential with respect to bridge resilience outcomes. In the case of Texas, the magnitude of that influence was shown to be very small, which may instead indicate the need for further refinement of the analytical methodology, or for the incorporation of additional or better data to further clarify those results.

This study yielded notable methodological outcomes, including the general capability of the analytical methodology to yield – in the case of some States – significant results connecting State policies with critical infrastructure resilience, with the suggestion that further refinement of the methodology may be beneficial. The analytical methodology also demonstrated the importance of both high-quality, reliable, and readily available datasets to conduct these analyses. Transportation infrastructure is somewhat unique among critical infrastructure systems in that large and detailed datasets exist, but that availability does not necessarily ensure that data structure and quality are immediately capable of supporting longitudinal studies such as this. In the case of this study, significant collation and post-processing were required to yield a useable dataset, and therefore the dataset may itself be considered an analytical outcome.

The consideration of how State-level policies influence critical infrastructure resilience is increasingly important. Despite somewhat mixed analytical results, this study yielded some valuable analytical outcomes, as well beneficial methodological and data outcomes, that may serve as an important foundation for understanding the connection between State policies and the resilience of the Nation's critical infrastructure.

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Acronyms

ADT	Average Daily Traffic
ADTT	Average Daily Truck Traffic
AR	Autoregressive
BATA	Bay Area Toll Authority
BMIP	Bridge Maintenance and Improvement Program
Caltrans	California Department of Transportation
CDA	Comprehensive Development Agreement
DOT	Department of Transportation
EDC	Economically Disadvantaged
EMP	Equivalent Match Project
FAST	Fixing America's Surface Transportation
FDOT	Florida Department of Transportation
FHS	Federal-Aid Highway System
FHWA	Federal Highway Administration
FTA	Florida's Turnpike Authority
FTC	Florida Transportation Commission
FTP	Florida Transportation Plan
FY	Fiscal Year
GDP	Gross Domestic Product
HBP	Highway Bridge Program
HSS	Highway Statistics Series
IDOT	Illinois Department of Transportation
IJN!	Illinois Jobs Now!
IllinoisFIRST	Illinois Fund for Infrastructure, Roads, Schools, and Transit
ISHTA	Illinois State Toll Highway Authority
JTA	Jobs and Transportation Act
MAP-21	Moving Ahead for Progress in the 21st Century?
MBM	Major Bridge Maintenance
MYP	Multi-Year Plan
NBI	National Bridge Inventory
NBIS	National Bridge Inspection Standards
NHS	National Highway System
NIAC	National Infrastructure Advisory Council

ODOT	Oregon Department of Transportation
OTIA	Oregon Transportation Investment Act
PWP	Participation Waived Project
RF	Rating Factor
SHA	State Highway Account
SHS	State Highway System
SHOPP	State Highway Operation and Protection Program
SIS	Strategic Intermodal System
STRAHNET	Strategic Highway Network
STIP	Statewide Transportation Improvement Program
STTF	Statewide Transportation Trust Fund
TBSRP	Toll Bridge Seismic Retrofit Program
TCRF	Transportation Congestion Relief Fund
TCRP	Transportation Congestion Relief Program
TIGER	Transportation Investment Generating Economic Recovery
TMF	Texas Mobility Fund
TxDOT	Texas Department of Transportation
USDOT	U.S. Department of Transportation
UTP	Unified Transportation Program
VMT	Vehicle Miles Traveled

Introduction

During times of crisis, communities and regions rely heavily on critical infrastructure systems to support their emergency management response and recovery activities. As critical infrastructure systems are often themselves physically vulnerable to a wide range of threats, from natural disasters to kinetic attacks, the resilience of those infrastructure systems can have a direct and profound impact on a community's overall resilience. Although a myriad of factors can influence infrastructure resilience, State policies – which are not always uniform in their structure or application across the United States – certainly contribute to resilience. The U.S. Department of Homeland Security¹ is interested in characterizing the influence of State-level policies on the resilience of critical infrastructure systems. This report focuses on developing an analytical methodology to assess links between policy and resilience, and applies that methodology to critical infrastructure in the Transportation Systems Sector. Specifically, this study seeks to identify potentially influential linkages between State transportation capital funding policies and the resilience of bridges located on roadways that are under the management of public agencies (e.g., State departments of transportation [DOTs]), using data and information from five representative States within the United States.

To assess these linkages, this study gathers and analyzes data from three primary areas that span the spectrum from governmental policy to the resilience of built systems. First, researchers conducted a targeted policy analysis that focuses on historical capital funding mechanisms and processes in each of the five States to identify the various policy pathways that may fund actions that enhance infrastructure resilience. Second, they gathered State transportation capital funding records to examine quantitatively the State-level trends in funding over time, and thereby to assess the extent to which policies translate into capital funding. Third, the researchers gathered and assessed State-level bridge data to identify trends in bridge condition and other aggregate measures of physical resilience over time. Researchers then statistically analyzed these two latter datasets to determine whether quantitative changes in State-level bridge capital funding can be linked to changes in resilience, and if so, the strength of those linkages.

This paper contains five sections: Section 1 provides background information for this study, including the analytical scope, focusing research questions, and the analytical methodology and data; Section 2 presents the data collection and compiling processes conducted to enable the policy and statistical analyses; Section 3 presents the approach and findings for the focused policy analysis; Section 4 presents the statistical model formulation and results of the quantitative analysis of capital funding and bridge resilience; and Section 5 synthesizes these findings and offers several conclusions from this study.

1. Analytical Scope Sector and State Focus

To investigate the extent to which State policies influence critical infrastructure resilience, this study focuses initial efforts on the Transportation Systems Sector, and more specifically on roadway bridges as a discrete sub-set of the many assets that compose transportation systems. Roadway bridges were deliberately chosen for several reasons to investigate the linkage between State policies and infrastructure resilience. First, all 50 States in the United States manage bridges using similar institutional structures and management processes and procedures. That is, all State governments have a DOT that directly oversees the inventory, monitoring, and

management of bridges on public roadways throughout their respective State, and which is subject to similar State-level governmental policies and oversight. These similarities enable a more like-to-like comparison of State policies and institutional structures that may influence infrastructure, which may not be the case for other types of critical infrastructure sectors where governmental oversight and management could occur at various level of government or even within different structures at the same level of government.

Second, the U.S. Department of Transportation (USDOT) Federal Highway Administration (FHWA) requires that all bridges be regularly inspected by State DOTs according to the National Bridge Inspection Standards¹ (NBIS) and be recorded in the National Bridge Inventory (NBI), which the FHWA maintains at the Federal level primarily for the purposes of maintaining and monitoring the safety of the Nation's bridges. The NBI contains complete records dating back to 1992 that are readily available to the public, and contains, at present, more than 611,000 bridges for the United States and Puerto Rico. This federally maintained database of bridge information collected by State DOTs, but in compliance with national standards, ensures uniformity of State-level bridge information across all States in the Nation. Such uniformity and consistency better-enables comparative analyses of bridge condition and resilience across all assets. For other types of critical infrastructure, where no national standard for asset inventory and attribute information exists, or where data are collected and maintained disparately by different organizations at different levels of government (if at all), could require significant additional data collection and compilation effort to enable comparative analyses across States or other jurisdictions.

Lastly, the FHWA also catalogs and records all spending of both State funding and Federal aid funding that the USDOT provides to States. Furthermore, this catalog of historical funding records not just planned spending, but actual expenditures and capital outlays, thus reflecting an actual historical record of specific capital funding. Spending is also broken down and cross-cataloged using a multitude of factors (e.g., by bridge capital investment type, roadway classification, rural versus urban) that enable more a detailed and insightful analysis of the different ways in which funding spent on State transportation systems.

These components – similar State-governmental institutions, comparable infrastructure data across States, and a federally maintained record of State DOT spending – better enable a comparative analysis of State policy and infrastructure resilience across multiple States. Were these Federal-level databases of State-level data not available, a comparative study would require significant additional effort to collect, collate, and pre-process both funding and infrastructure data on a State-by-State basis to ensure comparable data across States.

To implement this study, five States were identified that provide a representative cross-section of State policy approaches in the Transportation Systems Sector across the United States and also provide a reasonably representative cross-section of various State-level factor, such as predominantly urban versus predominantly rural populations and transportation systems (e.g., California vs. Oregon), a range of natural hazards (e.g., seismicity in California, hurricanes in Florida), and geographical region (e.g., west coast, Midwest, east coast). These States are California, Florida, Illinois, Oregon, and Texas.

The five States included in this study are also generally regarded within the subject-matter expert community as having open attitudes toward the public availability of information and data, which is useful in accelerating data collection and policy analysis aspects of studies such as this one.

Focusing Research Questions

A series of focusing research questions helped to guide this research study and also to enable a determination of the types of data and analytical methods that would be needed to answer those questions. The primary focusing question, is then broken into a series of sub-questions intended to guide the analysis in connecting State policies to measures of resilience, and characterize some aspects of the methodology itself (e.g., data availability and adequacy).

Primary Analytical (Focusing) Question

What effect do State policies, particularly capital investment, have on highway bridge resilience?

Research Sub-Question 1: Policies → Investment

What effect do State policies have on infrastructure capital investment?

Research Sub-Question 2: Investment → Resilience

What effect does the level and type of capital investment have on infrastructure resilience?

Research Sub-Question 3: Data Availability & Adequacy

What types of data are available, and how adequate are those data, to support research sub-questions 1 and 2?

Research Sub-Question 4: Methodological Considerations

What external variables potentially influential to bridge resilience (e.g., State population, gross-domestic-product [GDP]) should be controlled for during analysis?

Policy Considerations

State policies can take many forms including legislation, regulations, funding and practices. The relationship between State policies and infrastructure resilience depends on various factors, including infrastructure ownership (i.e., whether by the State itself, by local governments within the State, or by private entities), as may influence funding and management, and the context of Federal standards that may dictate design and maintenance practices, regulate operations, or standardize performance criteria.

Highway bridges are influenced by a wide range of State and Federal policies, with one of the most significant among these being the provision by the State of funding for the construction of new bridges, and the maintenance and rehabilitation of existing bridges. Public bridges are predominantly managed and funded at the State-level; however a portion of funding for capital investment in bridges comes from Federal funding sources, that the FHWA administers. Still, the FHWA “does not make the determination as to which bridges should benefit from Federal funding. Almost all funding under the Federal-aid highway program is distributed to State departments of transportation, which determine, for the most part, where and on what the money is spent.”² Therefore, despite some Federal policy influence in the funding process, those Federal funds are distributed to the States for their use, and State-level policymakers and DOTs have tremendous influence over the highway bridges in their States and how funds are spent:

“bridge projects are developed at the State level, and State departments of transportation let the contracts, oversee the construction process, and provide for the inspection of bridges.”

Given the broad extent of State-level control over highway transportation and bridge funding, this study focuses exclusively on State-level capital improvement and investment policy, which also enables a more direct quantitative analysis of funding policy and capital expenditures. Although all State-level project funding and allocation is ultimately decided upon at the State-level, the origin of funds (i.e., State vs. Federal) will be identified, to the extent possible, to explore also if trends in funding sources have any correlation to highway bridge resilience.

Infrastructure Resilience and Performance Measures

The National Infrastructure Advisory Council (NIAC) defines critical infrastructure resilience as, “the ability to reduce the magnitude and/or duration of disruptive events. The effectiveness of a resilient infrastructure or enterprise depends upon its ability to anticipate, absorb, adapt to, and/or rapidly recover from a potentially disruptive event.”³ In 2011, Argonne National Laboratory reviewed existing definitions of resilience in order to develop a comprehensive indicator of infrastructure resilience, starting with the NIAC definition of resilience. This work finished in 2012 and led to the publication of a report titled “Resilience: Theory and Applications.”⁴ This document outlined the definition of resilience used for developing a measure for infrastructure resilience:

Resilience is “the ability of an entity—e.g., asset, organization, community, region—to anticipate, resist, absorb, respond to, adapt to, and recover from a disturbance.”⁴

This definition of resilience expands upon the 2009 NIAC definition by considering not only the capabilities to anticipate, absorb, adapt to, and recover from a disruptive event, but also the notions of resistance and response to the event.

Figure 1 illustrates the relationship between the different components of resilience and the occurrence of an adverse event. As shown, anticipation-, resistance-, and absorption-related actions are undertaken prior to the occurrence of an adverse event, whereas response, adaptation, and recovery occur afterward. The heavy line in Figure 1 represents the level of activity (e.g., production in the case of a manufacturing plant, traffic capacity in the case of a transportation system) or of the well-being (e.g., a population’s psychological health in the case of a community or region) of the object of analysis. Subsequent to the occurrence of an adverse event, activity/well-being declines. The resilience of the object of analysis determines both the amount by which the activity/well-being declines and the amount of time required to return to the pre-event equilibrium (or some other new equilibrium).

Figure 1: Resilience Curve for Critical Infrastructure (Source: Carlson *et al.*, 2012⁴)

Table 1 illustrates how the six components found in Argonne’s definition of resilience are connected to the actions that describe the capacity of an entity to be resilient to a manmade or natural event. The relationships illustrated in Table 1 provide a framework for considering different resilience enhancement options for infrastructure – regardless of infrastructure type.

Table 1. Relationship between Components of Resilience and Resilience-Enhancing Measures⁴

Anticipate	Resist	Absorb	Respond	Adapt	Recover
Preparedness	Mitigation		Response		Recovery
Activities taken by an entity to define the hazard environment in which it is subject	Activities taken prior to an event to reduce the severity or consequences of a hazard		Immediate and ongoing activities, task, programs, and systems that have been undertaken or developed to manage the adverse effects of an event		Activities and programs designed to effectively and efficiently return conditions to a level that is acceptable to the entity

While there are no standard measures of highway bridge resilience, the concept of “mitigation” – and its two constituent components, the abilities to “resist” and “absorb” impacts – offer some guidance for selecting potential indicators of bridge resilience in the context of capital funding. The ability of infrastructure to resist or absorb the impacts of physical threats is influenced by both the characteristics of the infrastructure’s design, as well as by the infrastructure’s condition, which can change or degrade over time due to usage or natural processes. Furthermore, the design of aging infrastructure can become non-compliant with design standards that evolve or are updated over time to meet newer or more stringent requirements, or in response to new threats or hazards.

As discussed earlier in this section, highway bridges are somewhat unique among critical infrastructure in the United States in that the FHWA requires that all bridges be regularly inspected according to the NBIS and be recorded in the NBI. However, the NBI is simply a catalog of bridge inspection information, and the NBIS represent minimum inspection standards related to the safety, physical condition, and structural performance of bridges. The NBI/NBIS

do not provide any guidance to States for how to make decisions about the improvement of their bridges. To better manage and make decisions about bridge infrastructure, State DOTs frequently collect inspection data in addition to the minimum standards outlined in the NBIS for use in asset management programs. Asset management programs integrate inspection and condition information into the maintenance planning and decisionmaking process for bridges (as well as pavements, and increasingly, other assets). Nonetheless, State DOT asset management programs do frequently integrate some of the aggregate-level inspection information from the NBI, which could prove useful as a broad measure of bridge resilience—particularly with respect to the “mitigation” dimension of resilience. As before, relying on data collected from the NBI does enable a broader comparative analysis, as data are collected consistently and according to national-level standards, for all bridges across the United States. These aggregate measures of bridge performance recorded in the NBI are discussed in greater detail in the next section.

2. Analytical Methodology and Data Methodology

Fundamentally, this analysis seeks to identify whether a relationship exists between State-level bridge funding policies and bridge resilience, as may be indicated by aggregate measures of bridge performance, as well as potential characteristics of that relationship. Figure 2 shows the analytical areas and process this study employed. Each of the three blue boxes represent the types of data that are collected to support the analysis; each of the two orange ellipses represent the types of analyses that are conducted to investigate relationship between the data. The data and information related to funding policies (Box 1) are generally qualitative in nature—coming from summaries of individual policies or legislation, expert interviews/opinion, and historical records of policy and political structures and practices. However, data pertaining to measures of bridge resilience (Box 3) are inherently quantitative in nature, as they derive directly from structured, quantitative bridge inspection information, and aggregate measures of performance that are calculated from that information. Therefore, to connect State funding policies with bridge performance and resilience measures requires the inclusion and examination of an additional data—bridge capital funding data (Box 2)—that serves to quantify the direct impacts of funding policy, and therefore enable an assessment of potential indirect impacts to bridge resilience.

Figure 2: State Policy Resilience Study Methodology

Funding Policy Data

State policies that are influential in bridge management can take many forms including legislation (e.g., the appropriation and dispersal of funding), regulations (e.g., bridge inspection activities), and standards of practice (e.g., design requirements and standards). Capital investment in bridges on public roadways, with few exceptions (e.g., public-private partnerships, such as some toll-roads), is most commonly funded through public legislation. Therefore, this study pursued information pertaining to State funding policies from three primary sources: general open-source research, records of past and current State legislation, and structured interviews with State DOT personnel who have direct knowledge of State bridge management practices and policy considerations. As discussed earlier, a portion of funding for capital investment in bridges does come from Federal funding sources that the FHWA administers. However, because these funds are dispersed to the States and ultimately programmed by State DOTs for capital investment in specific programs or projects, both open-source background research and discussions with State DOT personnel did include some cursory information pertaining to Federal funds, but researchers conducted no deeper analysis of Federal bridge funding policy.

Open-source research facilitates a better understanding of the general structure of transportation funding within each individual State, as well as the primary sources of annual transportation funding. This background research helps to build a foundation of understanding upon which a more detailed and nuanced understanding of bridge funding policies can be built through analysis of individual legislative policies and structured discussions with State DOT personnel. While this type and source of State policy data is generally qualitative in nature (e.g., the sources and flows of funding within DOT institutional structures), some quantitative data are also collected; for example, general tax rates in the case of State motor vehicle fuel excise taxes, or annual revenue amounts in the case of motor vehicle license sales.

Records of past and current State legislation build upon the foundation of the open-source research by detailing the historical context of State-level funding policies, providing some insight into funding priorities and special programs, and quantifying at the aggregate level the amount of funding appropriated for State transportation. In some cases, this latter component is broken down into programmatic areas (e.g., interstate investment, bridge improvement, public transportation). Legislation also outlines any special or targeted funding programs that States undertake. For example, California undertook legislation in response to a series of earthquakes in the late 1970s through early 1990s, to appropriate funding for a targeted Bridge Seismic Retrofit Program across the State (this program is discussed in greater detail in Section 3).

Structured interviews with State DOT personnel serve two primary purposes. First, they enable a more nuanced understanding of the legislative and management structures, and funding policies from individuals who interact with these systems every day. Second, they provide some expert perspective on both the effectiveness of policies in achieving their intended outcomes, as well as some view of the future capital funding and investment policies at the State level. Researchers initially contacted State DOT personnel in bridge management and/or asset management offices to be interviewed for this study. Understandably, there is some self-selection among DOT personnel willing to participate: in some cases, the researchers were referred to other individuals within the State DOTs, in other cases the primary point of contact was willing and interested to

participate. Nonetheless, to ensure consistency in the information gathered from personnel across the State DOTs, the interviews were structured around a standardized question set, given in Appendix A. In most cases, additional information was also gathered as part of the organic nature of policy-oriented interviews. Appendix A provides the full list of individuals interviewed in each State DOT.

Bridge Capital Funding Data

Bridge capital funding data were initially pursued from two sources: the individual State DOTs, and from the FHWA Office of Highway Policy Information. The initial data collected directly from State DOTs (specifically, Florida and Illinois) clearly illustrated the differences in individual DOT accounting and reporting structures, suggesting that an equivalent comparison of funding across all five States would require significant additional effort. Therefore, to ensure greater consistency in the capital funding data across all State DOTs, the funding data collected and compiled by the FHWA became the primary source for such data in this study.

For each of the 50 States, as well as the District of Columbia, the FHWA's Office of Highway Policy Information maintains the Highway Statistics Series (HSS). The HSS compiles funding information, including data on apportionments, obligations, expenditures, and capital outlays. These spending figures are frequently broken down according to multiple different classification systems. For example, State capital outlays and maintenance for bridges are classified according to bridge improvement type (e.g., new bridge, bridge replacement, major bridge rehabilitation, or minor bridge rehabilitation). In another example, disbursements for State highways are broken down into capital outlays for State administered highways versus local roads and streets, as well as maintenance and services for the same. Each of the bridge funding data sets are organized by year and are published on FHWA's Website as HTML tables, but are also available for download in Excel and PDF versions. In many instances, only PDF and HTML versions are available, which can complicate data compilation.⁵

The Highway Statistics Series also included non-funding highway statistics that provide useful context for each State's public highways and roadways system, including the following:

- Number of Bridges, by ownership
- Number of Bridges, by functional classification
- Public Roadway Length, by ownership
- Public Roadway Length, by functional classification
- Public Roadway Length, by functional classification and ownership
- Federal Aid Highway System Length, by ownership
- Federal Aid Highway System Length, by functional classification
- National Highway System Length, by ownership
- National Highway System Length, by functional classification
- Vehicle-Miles of Travel, by functional system

Appendix B provides a full listing of the bridge capital funding data variables and non-funding related highway statistics variables from the FHWA's Highway Statistic Series used in this analysis.

Bridge Performance and Resilience Data - National Bridge Inventory

There are no standardized metrics used to rate the resilience of a bridge, however aggregate measures of bridge condition and performance may be used as a proxy for bridge resilience, particularly with respect to the mitigation dimension of resilience discussed in Section 1. The NBIS defines more than 116 inspection items⁶ for evaluation during bridge inspections and inclusion in the NBI, ranging from the numerical designation of the route and the physical alignment/geometry of the structure to detailed evaluations of the bridge structure and constituent components. While many of these inspection items provide valuable information in their own right—particularly with respect to bridge safety—a number of them are aggregated and evaluated to provide overall measures of bridge performance, which may be used as general indicators of a bridge’s general resilience and physical performance. Three aggregate ratings potentially relevant to this analysis are as follows:

1. **Functional Obsolescence:** A status that describes the functional adequacy of a bridge to perform its designed function (e.g., convey the flow of traffic or enable ships to pass underneath); it is not necessarily a measure of poor physical or structural condition. The determination of functional obsolescence considers NBI items related to Deck Geometry, Underclearances, Approach Roadway Alignment, Structural Condition, and Waterway Adequacy.⁷
 2. **Structural Deficiency:** A status that identifies if a bridge structure contains one or more structural issues; the calculation of structural deficiency does not indicate the severity of the flaw, but simply that several criteria fall below a defined threshold. The determination of structural deficiency considers NBI items related to Deck Condition, Superstructure Condition, Substructure Condition, Culvert and Retaining Walls (where applicable), Structural Condition, and Waterway Adequacy.⁸
 3. **Bridge Sufficiency Rating:** A score assigned on a scale of 0 to 100 (100 being best) that aggregates multiple factors, assigning maximum possible weights to each category. It incorporates factors related to the following:
 - a. **Structural Adequacy and Safety** – 55 percent max weight, considering Superstructure, Substructure, Culverts, and Inventory Rating
 - b. **Serviceability and Functional Obsolescence** – 30 percent max weight, considering Lanes on Structure, Average Daily Traffic, Approach Roadway Width, Structure Type, Bridge Roadway Width, Vertical Clearance Over Deck, Deck Condition, Structural Evaluation, Deck Geometry, Underclearances, Waterway Adequacy, Approach Roadway Alignment, and STRAHNET (Strategic Highway Network) Highway Designation
 - c. **Essentiality For Public Use** – 15 percent max weight, considering Detour Length, Average Daily Traffic, STRAHNET Highway Designation.
 - d. **Special Reductions** – 13 percent max weight, considering Detour Length, Traffic Safety Features, Structure Type.
- Weighting values are determined according to the severity of the deficiency among each of the inspection items incorporated into the sufficiency rating factors using a prescribed formula.⁸

These three indicators offer flexibility in how researchers can assess infrastructure resilience. Perhaps the best measure, Bridge Sufficiency Ratings incorporate both the concepts of structural

deficiency and functional obsolescence, as well as other important factors, resulting in a more comprehensive measure of resilience. It is notable that the Bridge Sufficiency Rating does not consider as many inspection items when incorporating those concepts, nor in the same way. However, the measures of Structural Deficiency and Functional Obsolescence may not fully align with the concept of resilience as discussed in Section 1. For example, Structural Deficiency may not mean that a bridge is unsafe or has heightened vulnerability to physical impacts. As mentioned, Structural Deficiency ratings do not indicate the severity of the flaw, but simply that several criteria fall below a defined threshold. Similarly, Functional Obsolescence simply captures whether or not a bridge design continues to meet current requirements (such as being able to convey the current volume of traffic demand), and may have little bearing on the physical condition or resilience of a bridge.

In this study, the Bridge Sufficiency Rating is selected as the primary measure of bridge resilience as it provides a more comprehensive assessment of bridge conditions. In addition to incorporating elements from both Structural Deficiency and Functional Obsolescence ratings, Bridge Sufficiency Ratings also incorporate information related to the Essentiality for Public Use (i.e., a proximate measure of criticality), as well as Special Reductions (e.g., weight restrictions) that may provide further insight into bridge resilience. The FHWA maintains and publishes electronic records of NBI data for 1995 to 2014 (more recent data was not yet published at the time of this study), which limits the timeframe of any analyses to 20 years.

Structured Policy Analysis

Two analytical methods are employed to connect the different types of data represented in Figure 2. The first analytical method involves a structured policy analysis to connect the Funding Policy Information with the Bridge Capital Funding Data. In this instance, a mixed-methods approach is undertaken to integrate qualitative and quantitative data. Qualitatively, the researchers synthesize the information gathered during each of the three phases of the Funding Policy data collection to identify discrete trends in the policy approaches across the five States. They then aggregate and generalize these trends to classify State-level funding policies, and to identify the historical timing of individual policies within each State.

Bridge Capital Funding Data are then quantified and plotted with respect to funding levels across time for each of the various funding variables collected from the FHWA HSS dataset.

Researchers can then examine this quantitative data in the context of the funding policies information that they synthesized earlier to ensure that trends in funding data reflect the policies intended to influence funding. In this respect, the quantitative dimension of the Structured Policy Analysis is an intermediate step in the overall analysis process to quantify directed funding policies using data and information from two different sources. The qualitative dimension of the Structured Policy Analysis—the synthesis of the legislative and interview-based policy information—is also extremely important in its own right as it gives unique insight into the structures and processes by which policy is both effected and enacted at the State level. The process and results of the Structured Policy Analysis are discussed in greater detail in Section 3.

Statistical Modeling

This study uses statistical analysis and modeling in two ways. First, researchers use statistical analysis to compile and plot the quantitative Bridge Capital Funding data to enable comparisons

with the State policies, as discussed above. Second, they compose statistical models to identify linkages between Bridge Capital Funding data and Bridge Resilience, as well as the strength of relationships between funding characteristics and resilience outcomes.

Repeated-measures models are well-suited to this analysis. These models are beneficial for multiple reasons. First, they assume that data observations are not necessarily independent; as in the case of bridge performance/condition, the number of deficient or poorly performing bridges in a given year has some relationship to the number of similarly performing bridges from the previous year (i.e., it is unlikely that there will be a sharp change in performance from year to year unless a major event occurs). Second, these models are able to incorporate and analyze multiple variables—for example, the influence of different levels of State and Federal funding over time, or the effects on multiple bridge performance variables. Third, they can incorporate lagging analysis to identify cases where changes in performance may not occur until some period of time after funding policies have changed. For example, given the amount of time necessary to study, design, and implement capital improvements, and also the amount of time it takes for systems to naturally degrade, changes in bridge performance may not become apparent for several years following a change in funding policy. Section 4 presents the composition of the statistical models used in this study, as well as model results.

3. Policy Analysis and Results

State DOT policies allocate funds to support critical transportation infrastructure, such as State-owned highways and bridges. The Federal Government is also responsible for providing a sizeable proportion of funding through fiscally constrained programs—such as the Fixing America’s Surface Transportation (FAST) Act of 2015 and other Federal transportation funding and authorization bills from previous years. At the same time, States are required to provide a match for these Federal funds for certain programs, and partially or fully fund other projects. State policies for generating revenue and allocating funds to these projects have changed over time to accommodate for changes in the State’s economic outlook and inflation. While some of these changes have constituted long-term effects on the State’s ability to generate revenue, a significant number of policies across the States analyzed in this study have involved infusions of funding through temporary relief programs and bonds.

This study focuses on State-level capital improvement and investment policy in five representative States: California, Florida, Illinois, Oregon, and Texas. The sections below discuss the general funding mechanisms in each State through Federal and State revenues. In addition, the section for each of the above States contains a subsection that provides a snapshot of bills, statutes, or legislative amendments that have governed key policies or have enacted major changes in funding policy between the years of 1993 and 2014.

Significant and Representative State Policies Analyzed

Illinois

Illinois State Bridge Program

Every year, the Illinois DOT (IDOT) develops a 6-year plan, called the Multi-Year Plan (MYP), in which it proposes an outline of prioritizing plans and programming for the State’s highway and bridge assets. Safely maintaining the system of roads and bridges under State jurisdiction is

the primary priority in the development of the MYP, which is also called the Illinois Highway Improvement Program. Under this Program, the vast majority of funds are allocated to projects that improve Illinois road and bridge condition. In preparing the MYP for fiscal year (FY) 2017-2022,⁹ a concerted effort was made to maintain the IDOT bridge system condition and to keep roadways as safe and well-maintained as possible. However, given the current economic and budget pressures in Illinois, and the expected uptick of system condition needs, both the MYP and the interviewed IDOT staff forecast that, the IDOT will not be able to maintain the current levels of acceptable condition on the State highway system.

In the past, IDOT had maintained 93 percent of over 26,000 State bridges in acceptable condition. At the end of 2015, the number fell to 92 percent. The MYP projects that, under the current levels of funding, the number of bridges in acceptable condition will decrease to 86 percent by the end of FY 2022.

The MYP released in the spring of 2016, which covers FY 2017 through 2022, describes projects totaling in more than \$11 billion to be almost evenly divided for every year from 2017 through 2022. Of the \$11 billion, more than \$7.6 billion have been allocated for State Highway projects that include, among other major priorities, the *Bridge Maintenance Program*.

The total allocated budget for the Bridge Maintenance program for FY 2017-2022 is \$1.962 billion. This funding is programmed to cover the replacement or rehabilitation of 501 bridges. The following is a breakdown of the types of Bridge Maintenance projects programmed in this MYP: 185 interstate bridges, and 316 non-interstate bridges.

Additionally, covered under other programs such as System Maintenance, Congestion Mitigation, and System Expansion, are projects such as construction of new bridges (projected 26 total) and minor structural repairs (467 total).

The Bridge Maintenance Program includes the annual Major Bridge program, which determines funding eligibility for the individual bridge's rehabilitation. The Major Bridge fund request is initiated at the IDOT District Local Roads Engineer level (at one of nine IDOT Districts).

Each candidate bridge must be a deficient bridge with a computed "rating factor" (RF) that demonstrates its need to be addressed. To compute the RF, several criteria are taken into account. Such criteria include the following:

- Bridge sufficiency rating – a FHWA method used to evaluate data by calculating factors such as structural adequacy and safety, serviceability and functional obsolescence, essentiality for public use, and special reductions;
- Functional classification status – such as whether the bridge is a local road or load street, interstate, freeway or expressway, and others;
- Total project cost – eligible bridges are ones that are projected to cost more than \$1 million in this repair project;
- Number of lanes; and
- Average daily traffic.

The Illinois State Toll Highway Authority (ISHTA),¹⁰ often referred to as the Illinois Tollway, manages the highways and bridges located on the Illinois toll roads. The ISHTA is an agency that is separate from the IDOT and is not supported by any State or Federal funds. The funding for its highways and bridges is supported by toll and concession revenues.

General Funding Sources and Flow of Revenue

The source of funding for projects programmed in the MYP comes from Federal and State funds. In FY 2017-2022, it is expected that 77 percent (about \$8.6 billion total) of funding for State highway projects will come from Federal funds, and 18 percent (about \$2 billion total) will come from State Funds, such as motor fuel taxes and motor vehicle registration fees.

Figure 3 shows a simplified flow of revenue in Illinois that provides funding for State highway programs. Table 2, includes explanation for the flow of specific portions of revenue, and corresponds to the points in the figure by its number. This figure only includes ongoing revenue sources. Intermittent State Bond programs, State Capital programs, and Federal funds provided by means of competitive awarding (e.g., *American Recovery and Reinvestment Act*, which allocated funds to Illinois in form of Transportation Investment Generating Economic Recovery, or “TIGER” grants) provide additional resources for the State transportation system discussed in the following section.

Source: CMAP analysis of data from the Illinois Office of the Comptroller. All data is from FY 2012 and is rounded.

Figure 3: Simplified Flow Diagram of Illinois State Highway Funds
(Source: Chicago Metropolitan Agency for Planning¹¹)

Table 2: Explanation of specific funds as shown in Figure 3.

Reference Number on Figure 3	Explanation
1	Motor Vehicle License. Standard vehicle registration fees are \$101 for passenger vehicles and light trucks. Heavy truck fees vary by weight. Note that other registration fees, such as certificates of title, are not included in this flow chart.
2	Motor Vehicle Licenses Split. After deducting for debt service and other uses, including the \$2 surcharge for the Illinois Department of Natural Resources and the \$1 surcharge for the Illinois State Police vehicles, 37 percent of the remaining funds are sent to the State Construction Account Fund and 63 percent to the Road Fund.
3	Local Motor Fuel Tax Sharing. After a variety of diversions, 54.4 percent of the balance is allocated to local governments. Of this portion, 49.1 percent is distributed to municipalities based on population, 16.74 percent to counties over 1,000,000 in population, 18.27 percent to counties under 1,000,000 in population based on motor vehicle license fees received, and 15.89 percent to townships based on mileage of township roads.
4	Local Motor Fuel Tax Split. After the above diversions and allocations to local governments, 37 percent of the remaining funds are sent to the State Construction Account Fund and 63 percent to the Road Fund.
5	Motor Fuel Tax Split. By law, the Motor Fuel Tax Fund directs \$420,000/month to the State Boating Act Fund, \$3.5 million/month to the Grade Crossing Protection Fund, and \$30 million/year to the Vehicle Inspection Fund.
6	MAP-21. The Federal transportation authorization law, MAP-21 apportioned highway funds to Illinois. This Act was replaced by FAST Act in 2015.
7	The 55/45 Split. The 55/45 split is an “informal policy” ¹² that directs 45 percent of the transportation funds in the established accounts to northeastern Illinois (Chicago area) and the remaining 55 percent is allocated for downstate projects.

Policies that have Affected Highway Funding in Illinois

Due to an observed increased deterioration rate of the Illinois highway infrastructure and the State’s failure to keep up with its infrastructure needs by solely utilizing traditional funds described in the previous section, the Illinois government provided periodic infusions of funding for the use by the IDOT in order to address these needs.

Such infusions of funding include Illinois House or Senate Bills or amendments to bills that later became Public Acts, which have provided funding to the IDOT. These Public Acts include the following:

- Illinois Jobs Now! (IJN!)
- Public Act 98-94 (Amendment to the Build Illinois Bond Act)
- Public-Private Partnerships
- Jumpstart Illinois Capital Plan
- Illinois Fund for Infrastructure, Roads, Schools, and Transit (“Illinois FIRST”)
- IDOT Internal Cost-Effectiveness Policies

Illinois Jobs Now!

In 2014, Governor Pat Quinn signed a new capital construction bill that would authorize the IDOT to use more than \$1.1 billion to improve Illinois transportation by funding road and bridge projects. This amount was funded by another bill signed by Quinn, SB 3224, which authorized General Obligation bonds in the amount of \$1.1 billion.¹³

This amount was included in the Illinois FY 2015-2020 MYP, ¹⁴ \$184 million of which comprised the nearly 2 percent portion of the fund sources for the program (total State funds including IJN! for the 2015-2020 MYP comprised \$1.16 billion).

Public Act 98-94

In 2013, the Illinois General Assembly adopted Public Act 98-0094, authorizing an increase of Special Obligation Bonds (or “Limited Obligation Bonds”) for infrastructure purposes to \$3.223 billion. ¹⁵¹⁶ This Act was an amendment to the Build Illinois Bond Act adopted in 1985, ¹⁷ which authorized the use of special obligation bonds for purposes of developing and improving State infrastructure, fostering economic development and increased employment, development and improvement of educational and scientific programs, and protection and preservation of natural resources.

Public-Private Partnerships

To address some of the more pressing issues that affect most heavily used State highway bridges, in 2011, Illinois enacted the Public-Private Partnerships for Transportation Act that allows IDOT to build, finance, operate, and maintain highway projects using public-private partnerships, as long as the General Assembly adopts a resolution in support of the specific construction project. ¹⁸

Jumpstart Illinois Capital Plan

In 2009, House Bill 289 (which became Public Act 96-0005) was signed to give way to the amount of more than \$8 billion for IDOT to use for the purpose of developing, maintaining, and improving Illinois transportation. Of this amount, \$2 billion was authorized for the use on projects included in the 2010-2015 MYP in order to help the State system with the goal of reaching “90 percent acceptable condition.” ¹⁹ This Act later became the “first piece” of the aforementioned IJN! program. ²⁰

Illinois FIRST

In 2009, the Illinois General Assembly approved the then-Governor George Ryan’s plan to build, repair, and upgrade the State’s deteriorating infrastructure. This plan, dubbed as Illinois FIRST, ²¹ consisted of four Senate Bills:

- SB 1018, which primarily focused on environmental aspects of the program;
- SB 1028, which focused on transportation and mass transit financing;
- SB 1066, which included the liquor tax increase and school construction grants; and
- SB 1203, which authorized bonds and procedures.

The plan was a response to the Illinois infrastructure needs, including the need of repair of 750 bridges at the time. The transportation component of Illinois FIRST included the addition \$4.1 billion, of which \$3.7 billion was allocated for highways, roads, and bridges that were not included in the State’s annual road repair and construction program prior to the enactment of the plan.

IDOT Internal Cost-Effectiveness Policies

To meet this benchmark at a reduced cost and without sustainable new revenues, the IDOT had made changes to its program-development process. These changes modernize the planning

process by focusing on strategic project selection, which is expected to result in more realistic fiscal constraints and new measures to prioritize maintenance projects. Because system maintenance needs outweigh the levels of funding available, IDOT, under the direction of the Transportation Secretary Randall Blankenhorn, has pushed to make data-driven decisions to prioritize investments into maintenance of roads and bridges that are more heavily used to remain in a state of good repair. The data for these decisions is collected and prioritized at the level the nine IDOT Districts, which is then passed up to the IDOT for consideration into inclusion in the following year's MYP.

Figure 4: IDOT Bridge Maintenance Backlog (Source: IDOT FY2017-2022 MYP⁹)

An interview with IDOT's representatives revealed that although these types of funding infusions are a welcome change, they are also generally considered to be a counter-productive measure in terms of bearing negative economic, performance, and planning issues associated with "boom and bust" program cycles. As a result, the backlog of State miles—including bridges—began to grow in the recent years. The effects of the lack of policies that would allocate appropriate budgets to maintain IDOT bridges are shown in rising trends of backlogs in early 2000's and from 2014-onward in Figure 4. Approximately 92 percent of State-maintained structures are currently in acceptable condition, but according to the MYP for FY 2017-2022, without a sustainable increase in the regular funding in sight, this number is expected to drop to 86 percent by FY 2022.

California

California Highway Bridge Maintenance and Replacement

The California Department of Transportation (Caltrans) is responsible for maintaining the safety and integrity of over 25,000 bridges owned by the State and local governments. Currently, 8 percent of California bridges are classified as structurally deficient, and nearly 17 percent are functionally obsolete.²² The chart in Figure 5 shows how this number has fluctuated since 1993.

Figure 5: Percentage of Deficient National Highway System (NHS) Bridges in California (Source: USDOT 2016²²)

Caltrans oversees two major programs that provide programming and funds for new State highway bridge construction projects and bridge maintenance and rehabilitation projects. These programs are as follows:

- Statewide Transportation Improvement Program (STIP), which provides funds for new highway and bridge construction projects that add expanded capacity to California transportation; and
- State Highway Operation and Protection Program (SHOPP), which provides funds for maintenance and improvement programs on State highways and bridges.

California also owns and operates toll bridges. The Bay Area Toll Authority (BATA) is responsible for reimbursing Caltrans for maintenance and capital improvements on State-owned toll bridges through the revenue from collecting tolls.

It should also be noted that Caltrans has a program dedicated to improving local transportation infrastructure by administering Federal and State funding to more than 600 cities, counties, and local agencies. This program is called the Local Assistance Program, and its annual budget is approximately \$1 billion. The Local Assistance Program includes the Local Highway Bridge Program,²³ which is funded by the Federal Highway Bridge Program, and the State and Local governments provide their match (which is usually evenly split between the State and Local governments, each contributing 10 percent of the funding).

General Funding Sources

The traditional funding sources for Caltrans include funds that are deposited into accounts that in turn disburse funding to the STIP, SHOPP, and other transportation programs. One of such accounts is the State Highway Account (SHA). The proportion of Caltrans funding from the aforementioned sources as reported in FY 2015 is as follows:

- 21 percent Federal;
- 25 percent State; and
- 54 percent local funding.

The State and the Federal government fund the SHA. The State's portion comes from the State Base Excise Tax on gasoline and diesel fuel, and the Price-Based Excise Tax on gasoline fuel. The provisions for the price-based excise tax are explained in one of the following subsections. The allocation of the revenue collected through the fuel excise tax is as follows:

- 64 percent is deposited into the State Highway Account; and
- 36 percent benefits transportation needs of cities and counties.

Figure 6: Flow of Funding for State and Local New Bridge Construction and Bridge Maintenance Programs in California

Figure 6 is a simplified diagram that shows the flow of State and Federal highway funding and toll collection that affects bridge programs.

Policies that Have Affected Funding in California

As is typical for many other States, revenues generated through “traditional” funding mechanisms, without change, are unable to provide adequate means of supporting the transportation infrastructure. In response to this deficit, California has enacted the following policies that provide funding for projects that support highways and bridges:

- Fuel Tax Swap
- Proposition 1B Transportation Bonds
- Transportation Congestion Relief Program, Proposition 42, and Proposition 1A
- Proposition 2: Loans to General State Funds

Fuel Tax Swap

The Fuel Tax Swap program²⁴ was enacted by the California Legislature in 2010 and was intended to provide a greater infrastructure budget flexibility by reducing the fuel sales tax by 6 percent and increasing the fuel excise tax to generate revenue that can be used for paying debt on highway and rail project improvement bonds. This program was designed to provide a relief to the State’s bond services, as the gas taxes cannot be used for this purpose.

While this swap was beneficial for servicing highway improvement bonds, it simultaneously hurt programs that relied heavily on the gas sales tax. For example, the Public Transportation Account, which primarily supports intercity rail and transit improvement programs and is funded by State fuel sales taxes, was faced with a budget cut as a result of the Tax Swap program.

In response to this deficit, Assembly Bill 105 (AB 105)²⁵ was adopted in 2011. AB 105 eliminated the sales tax on gasoline entirely and replaced it with the price-base excise tax that would be adjusted annually, and increased the excise tax on diesel fuel sales. This Bill also redirected the vehicle weight fees from the SHA to the Transportation Debt Service Fund to reimburse the California General Fund for servicing general obligation bonds issued for transportation improvement projects.

Proposition 1B Transportation Bonds

Proposition 1B, also known as the Highway Safety, Traffic Reduction, Air Quality, and Port Security Act²⁶ was adopted in 2006. This Act authorized the sale of \$19 billion in general obligation bonds the proceeds of which would benefit transportation projects. The administration of the Prop 1B funds is the responsibility of the California Transportation Commission together with Caltrans.

Projects funded with Prop 1B bonds include SHOPP projects and programs on seismic retrofitting of local bridges and overpasses. Currently, it is estimated that roughly 75 percent of projects funded by Prop 1B bonds are complete or are near completion.²⁷

TCRP, Proposition 42, and Proposition 1A

In 2002, California adopted Proposition 42,²⁸ which specified the use of existing gasoline sales tax revenues to be for specified State and local transportation improvement projects from FY 2003 to FY 2008, and prescribed their use for transportation purposes thereafter.

Prior to Proposition 42, revenues from most of the State sales tax on gasoline and diesel fuel were designed to be dedicated to transportation purposes. However, revenues from most of the State sales tax on gasoline fuel have been historically used for various general purposes, such as education, health, and others, leaving only a small portion of the State gasoline sales tax revenue to be used for transportation.

In 2000, the Transportation Congestion Relief Act²⁹ was enacted, which created the Transportation Congestion Relief Program (TCRP) and the Transportation Congestion Relief Fund (TCRF). Under TCRP, the State gasoline sales tax would be used for specified transportation programs during FY 2003-2008, but would be available for various general State purposes after FY 2008.

The \$4.9 billion of TCRF revenues included the following:

- \$1.5 billion transfer to the TCRF in FY 2000 from the California General Fund and directly from gasoline sales tax revenues; and
- \$3.3 billion transfer to the TCRF from the Transportation Investment Fund over 5 years (approximately \$678 million per year)

Enacting Proposition 42 in 2002 restricted the use of the sales tax for general purposes after FY 2008, and specified proportions of this revenue to be used for specific transportation programs starting with FY 2009 as follows:

- 40 percent to transportation improvement projects funded in the STIP;
- 40 percent to local streets and roads improvements, with half of the amount being allocated to counties and the other half to cities; and
- 20 percent to public transportation.

However, Proposition 42 also specified that the use of these revenues for transportation purposes can be suspended under certain conditions.

In 2006, a new measure, Proposition 1A,³⁰ was approved that would limit the conditions under which the Proposition 42 suspensions could take place. Specifically, Proposition 1A suspension conditions are as follows:

- Any suspension of funds otherwise designated for transportation projects must be treated as a loan to the State General Fund that must be repaid in full, including interest, within 3 years of the suspension;
- Such suspensions can only take place at most twice in 10 consecutive FYs; and
- A new suspension may not be ordered until all prior suspensions have been paid back in full.

Because by the time Proposition 1A was adopted several Proposition 42 suspensions had taken place in FYs 2004 and 2005, the suspension repayment schedule according to Proposition 1A was later changed by enacting a repayment and rededication to transportation uses by June 30, 2016.

Proposition 2 Loans to General State Funds

In 1998, as a measure to increase revenue for transportation funds, Proposition 2³¹ was adopted as a constitutional amendment. Proposition 2 allowed loans to be made to California's State General Fund from transportation funds. The loans must be repaid in the same budget year. In addition, the Governor is allowed to extend the 1-year loan period by declaring monetary emergency or in the event that the level of the General Fund has dropped from the prior year level.

California Seismic Bridge Retrofit Programs

In addition to legislative measures that have affected funding for California's highway bridges with the purposes of maintenance and repair or replacement, natural disasters in the 70's, 80's, and 90's have prompted the California legislature to create additional programs to ensure the integrity of their transportation infrastructure.

After the Sylmar earthquake that took place in the Los Angeles area in 1971 damaging a number of bridges, Caltrans introduced the Seismic Safety Retrofit Program. The initial program was completed in 1989 and cost \$55 million. Following the Loma Prieta earthquake in 1989, which caused significant bridge damage and loss of life, Caltrans established the current Seismic Retrofit programs.

Initially, Caltrans identified 1,029 State highway bridges to be retrofitted. This motion was dubbed as the Phase I Program. However, after the 1994 Northridge earthquake, Caltrans initiated the Phase II program and added 1,155 State-owned bridges to the list of bridges in need of retrofiting.

Below is a list of policies that have affected the funding levels for the Bridge Seismic Retrofitting Programs in California:

- Assembly Bill 1175
- Assembly Bill 144
- Assembly Bill 1771
- Senate Bills 226 and 60
- Proposition 192: Seismic Retrofit Bond Act

Assembly Bill 1175

In 2009, the California Assembly passed AB 1175 to add the Antioch Bridge (built in 1978) and the Dumbarton Bridge (built in 1982) to the Toll Bridge Seismic Retrofit Program (TBSRP), because it was determined that the two bridges were in need of "seismic strengthening."³²

The cost to retrofit the two bridges was estimated at \$950 million—\$637 million for the Antioch Bridge and \$313 million for the Dumbarton Bridge.

This Bill also allowed BATA to administratively raise the tolls on the bridges in its jurisdiction to cover the cost of retrofitting the two bridges by authorizing more rigorous toll collection enforcement mechanisms.

Assembly Bill 144

In 2006, in response to the observed shortfall in funding for the TBSRP, the California Legislature adopted AB 144.³³ Caltrans had reported that due to cost overruns and other challenges incurred while addressing the TBSRP, the new estimated cost to complete the Program would be \$3.6 billion. AB 144 allowed Caltrans to collect additional funds to meet this deficit by authorizing funding from various sources as follows:

- At least \$2.15 billion from an additional \$1 toll charge on State-owned toll bridges in the BATA region;
- At least \$820 million from consolidation of all toll revenues and refinancing existing bonds under the BATA;
- \$300 million from State funding sources that support the SHOPP, project savings, or the Federal Highway Bridge Replacement and Rehabilitation Program; and
- \$330 million from other sources.

If the cost overruns exceed \$3.6 billion, this Bill authorizes the BATA to provide additional resources under the toll consolidation and its other powers including the authority to raise the toll fees.

Assembly Bill 1171

In April 2001, Caltrans advised the legislature of the increased cost estimates of the seismic retrofit projects. It was estimated that the continued seismic retrofitting work was on track to incurring approximately \$2 billion in cost overruns. This number includes \$557 million for non-BATA bridges and \$1.4 billion for the San Francisco-Oakland Bay Bridge east and west span replacement.

To address these financing issues, AB 1171³⁴ authorized measures to allow an addition to the Caltrans' seismic retrofit program funding from other sources, such as transferring funds from the State share of the Federal HBRR program without harming the STIP projects programmed before FY 2002, borrowing funds through the Infrastructure Bank, and authorizing the Caltrans to issue bonds. AB 1171 also authorized the BATA to uphold the \$1 seismic retrofit toll surcharge that was originally set to expire in 2008.

Senate Bills 226 and 60

In 1997, the Legislature enacted SB 60 and 226,³⁵ which established a plan for financing mechanisms of the TBSRP. The Bills prescribed funding sources and the amounts from each source to finance the work. The State's share of funding included \$790 million from the Seismic Retrofit Bond Fund (discussed in the following section), \$795 million from the SHA, and \$80 million from the Public Transportation Account (funded primarily through the diesel fuel State sales tax). The local share included \$955 million, most of which was to come from the addition of a \$1 toll surcharge for seismic retrofit work on the BATA bridges through FY 2008 (this date was later repealed by AB 1171).

These funds were designed to cover the seismic retrofit or replacement of the following bridges at their respectively indicated costs:

1. Benicia Bridge at \$101 million
2. Carquinez Bridge at \$83 million

3. Richmond-San Rafael Bridge at \$329 million
4. San Mateo-Hayward Bridge at \$127 million
5. San Pedro-Terminal Island (Vincent Thomas) Bridge at \$45 million
6. San Diego-Coronado Bridge at \$95 million
7. San Francisco-Oakland Bay Bridge at \$1.5 billion

Seismic Retrofit Bond Act (Proposition 192)

In 1996, the California Legislature passed Proposition 192³⁶ to authorize the issuance of bonds in order to finance the bridge seismic retrofitting. The Act provided for a bond issue of \$2 billion and earmarked \$650 million for the seismic retrofitting of toll bridges. Proposition 192 also appropriated money from the State General Fund for bond debt payments of the \$2 billion principal plus the \$1.4 billion interest, according to the California Legislative Analyst's Office estimation.

Oregon

Oregon Bridge Program

The Oregon Department of Transportation (ODOT) produces an annual Bridge Condition Report and Tunnel Data,³⁷ in which bridge performance measures and condition ratings are based on the NBI in conjunction with infrastructure integrity data collected by the ODOT. ODOT owns and maintains 2,738 bridges. ODOT measures bridge conditions using two general categories:

- Structurally deficient—as defined by the FHWA (e.g., deteriorated bridge deck, substructure or superstructure, requiring repair); and
- Other ODOT-defined characteristics such as impact on freight mobility, bridge safety, and serviceability needs.

In 2015, ODOT reported that over 20 percent of the bridges on Oregon's State highway system were either structurally deficient or had another ODOT-defined deficiency. The above characteristics are basis for determining a given bridge's need to be selected as a project for the Oregon STIP, which mostly uses Federal funds. The STIP is Oregon's 4-year transportation capital improvement program which identifies the funding for and scheduling of transportation projects and programs.

However, a large portion of the bridge condition improvement is from work programmed through the Major Bridge Maintenance (MBM) program, which was established in 1990 with the focus of addressing major and emergency bridge repairs. Bridges qualifying for the MBM program are often in a severe enough condition that they cannot be funded on the local or District level, and they do not qualify—or cannot afford to wait—to be included into the upcoming STIP.

The MBM is a program much smaller in fiscal proportion to the STIP, and is a fully State-funded program. The MBM covers approximately 200 bridge programs annually, with a total estimated value of \$8 million. In 2014, the MBM program addressed a number of such projects, 30 of which were maintenance projects of high urgency due to their severe deterioration, at a total cost of about \$1.2 million. These projects included repairing significant bridge scour issues, replacing

bridges that could no longer support the high weight of timber industry-related traffic, and fixing cracks in bridge steel beams.

General Funding Sources

According to Oregon's 2011-2013 Legislatively Adopted Budget,³⁸ the ODOT's highway funding is made up from 33 percent Federal funding, 31 percent State funding, and 36 percent bond funding. At the same time, the ODOT budget during the 2012-2015 fiscal years has been able to provide for major maintenance projects on less than 8 percent of Oregon's bridges. The 2016 Bridge Condition Report notes that bridges should have major preservation work performed every 30 to 50 years, but the current budget renders the ability to service each bridge to a frequency of once in 100 years. It also notes that to replace State highway bridges in Oregon on a 100-year cycle would require 27 bridges to be replaced each year, but the current budget only provides for an average annual replacement of three bridges.

State funding for bridge maintenance, repair, and replacement programs comes from the Oregon State Highway Fund,³⁹ which in turn is funded through several revenue sources such as the following:

- **Motor Fuel Taxes**, which were increased from \$0.20 per gallon to \$0.22 per gallon in 1992, then to \$0.24 per gallon in 1993, and to \$0.30 per gallon in 2011;⁴⁰
- **Driver's License Fees**, which were increased as a result of the Jobs and Transportation Act discussed in a later section;
- **Car Registration and Title Fees**, which were increased concurrently with the implementation of the Oregon Transportation Investment Act (OTIA) discussed in a later section; and
- **Weight-Mile Taxes**, which are fees for heavy vehicles, based on their weight and distance traveled. These taxes were adjusted with each aforementioned fuel tax increase.

In addition to these programs, over time, several of the programs have been covered by periodic infusions of infrastructure investments. The sections below describe major policies that have enabled these programs.

Policies that have Affected Highway Funding in Oregon

Oregon Jobs and Transportation Act

The Oregon Jobs and Transportation Act (JTA) was passed in 2009 and was implemented in 2011. Its implementation provided an annual \$300 million increase in revenue for highway, road, and street funding.⁴¹ For bridges specifically, the JTA is designed to provide a \$10 million annual increase.

This Act was a measure to increase the stable income for the ODOT budget by increasing the user fees. In particular, the following changes were implemented:

- Increase in vehicle registration fees from \$27 to \$81 per year;
- Increase in vehicle title fee from \$55 to \$110 per year;
- Addition of the new First Time Title Fee; and
- Increase in fuel tax to \$0.30 per gallon.

Oregon Transportation Investment Act

In 2003, Oregon passed the third Oregon Transportation Investment Act (OTIA III), which provided the ODOT with \$1.3 billion in bonds to replace 149 and repair 122 of the 2,738 total State highway bridges. This infusion of funding provided for a significant increase in building new bridges and an increase of bridges that were previously classified as “distressed” to become “acceptable.” Figure 7 shows a spike in the number of new bridges built in the 2000-2009 decade as a result of OTIA III, in an otherwise noticeably declining trend.

The OTIA III was preceded by OTIA II and I programs, which were also bond programs of smaller amounts designed for a number of specific projects with shorter timeframes of 1-2 years.⁴²

Despite the significant improvements made possible by the OTIA III funds, there is considerable pressure from Oregon’s legislators and infrastructure users to instead implement measures that will provide a stable level of funding rather than financing through bonds (an example of such measures is the aforementioned JTA). For one, according to the ODOT Bridge Engineering Section representative, the repayment of these bonds has been a major concern for ODOT in the recent years due to burdensome interest rates. Additionally, such bond programs are not guaranteed to continue to occur systematically in the future, and therefore cannot be counted on as a stable source of revenue that supports the State’s infrastructure resilience.

Figure 7: Comparison of Numbers of Oregon Bridges Built and Remaining in Service, by Decade
(Source: 2015 Bridge Condition Report⁴³)

Florida

General Highway and Bridge Programs in Florida

There are currently 6,783 bridges on the Florida State Highway System. The Florida Department of Transportation (FDOT) maintains 6,370 bridges, while city and county authorities maintain the rest. As of the end of FY 2013/14, of the 6,370 bridges for which the department has maintenance responsibility, 331 bridges needed to be repaired and 31 bridges needed to be replaced. This proportion is typical of Florida's achievement in maintaining one of Nation's lowest record of percentage of bridges that are structurally deficient or functionally obsolete.

The programming for construction, maintenance, repair, and replacement of Florida bridges is captured in the annual 5-year Florida Transportation Plan (FTP)—a Statewide transportation plan that documents Florida's long range transportation goals and objectives. The FTP also provides the policy framework for FDOT's Program and Resource Plan, legislative budget request, and the Work Program. The 5-year Work Program, in turn, is the document used for programming projects using the goals outlined in the FTP as the principle behind the programmed work.

Project programming in Florida's Work Program is prioritized for need-based activities. Repair and replacement of structurally deficient or functionally obsolete bridges is considered a priority, need-based activity that is typically addressed prior to any other FDOT projects (e.g., capacity expansion-related projects).

Two of the major bridge programs in Florida are the *State Bridge Replacement Program* and the *State Bridge Repair Program*.⁴⁴ These programmed through these programs are ones placed into the annual Deficient Bridge List (as a result of inspection rating), and the Work Program uses this list for programming their repair.

Under the Bridge Replacement Program, bridges are either *strength replaced* or *economy replaced*. Strength replacement of bridges is required for bridges that are either structurally deficient or functionally obsolete in terms of weight restrictions. These bridges are required to be programmed for construction within 6 years of deficiency identification. Bridges that are economy replaced are ones whose deficiencies would otherwise require structural repair; however, it has been determined that it is more cost effective to replace them instead. These bridges are required to be programmed for construction within 9 years of deficiency identification.

The Bridge Repair Program is one that governs the *rehabilitation*, *periodic maintenance*, and *routine maintenance* of the bridges that receive a structural appraisal of "fair" or "poor." Adequate implementation of the Work Program is enforced by not only the FDOT, but also the Florida Transportation Commission (FTC), who typically performs checks into the Work Program prior to the beginning of the projects, and after their completion. The FTC uses a number of metrics to evaluate the adequate completion of the work by using appropriate resources. For example, one of the FTC's metrics includes a production measurement to ensure maximized use of transportation resources for a given project.

The maintenance of Florida's toll bridges is the responsibility of Florida's Turnpike Authority (FTA)⁴⁵ through utilization of tolls as the main revenue source for project funding. The FTA operates as a "separate business unit" of the FDOT and is a public-private partnership.

General Funding Sources and Flow of Revenue

The State Highway System (SHS) and the Bridge Program are among key programs that the FTP directs. The scopes of work under the SHS programs include construction, addition or improvement of lanes, interchanges, entry/exit ramps and bridges which are on or planned to be on the SHS. Bridge repair, replacement, and routine maintenance is administered under the FTP's Bridge program.

The funding for construction, repair, replacement, or maintenance of Florida's bridges depends on their category of being on or off the SHS or the Federal-Aid Highway System (FHS). They can also be on both at the same time. For each of these situations, the funding is allocated as follows:

- Bridges that are on the SHS and on the FHS are funded using State, Federal, and/or bond funds.¹
- Bridges that are on the SHS but off the FHS are funded using State and/or bond funds.
- Bridges that are off the SHS but are on the FHS are funded using Federal and/or local funds;
- Bridges that are off the SHS and off the FHS are funded using the federally mandated minimum of 15 percent of State's FY 2009 Highway Bridge Program apportionment that has been set aside. FDOT administers these projects, despite being off the SHS or the FHS.

The funds that are used to fund the SHS and Bridge programs in Florida are allocated from the Statewide Transportation Trust Fund (STTF). Traditional revenues for the STTF include the following sources:

- State motor fuel tax;
- Aviation fuel tax;
- Motor vehicle license and tag fees;
- Rental car surcharge;
- Documentary stamps;
- Federal aid reimbursements (Federal funding); and
- Other miscellaneous revenue.

Figure 8 shows the distribution of these revenues as programmed in the FY 2017-2022 Work Program.⁴⁶

In addition to these traditional revenues, funds can be deposited into the STTF that must go towards specific projects identified by a legislature. The FDOT keeps track of these funds to

¹ It is important to note that one of FDOT's policies call for using the maximum available Federal funds before using State funds.

ensure that they are allocated for their purpose. Therefore, an increase in the total STTF revenue does not necessarily constitute an increase in funding for all FDOT or SHS projects.

For construction of new bridges, the FDOT also manages the Right-of-Way Land program (pursuant to 334.044⁴⁷), which provides for the acquisition of land to be used for roadway or bridge construction. Majority of the funds for land acquisition come from the Right Of Way Acquisition and Bridge Construction Trust Fund. The revenues into this fund consist of net proceeds from bonds and fund advances from the STTF.

The following subsections contain a summary of specific statutory Florida policies (statutes) as well as policies called for by the FTP that have influenced the programming for bridge funding.

Figure 8: A distribution of FDOT STTF forecasted revenues for FY 2017-2022

Policies that have Affected Highway Funding in Florida

This section contains a list and a brief description of key Florida Statutes (F.S.) and FTP policies in accordance with which the FDOT has maintained its record number of bridges that are in good condition throughout the State.

These policies include the following:

- F.S. Section 339.046

- F.S. Section 206.46
- F.S. Section 339.08
- F.S. Section 339.135
- Establishment of the Strategic Intermodal System
- FTP Policies

[F.S. 339.046 Department mission, goals, and objectives](#)

F.S. Section 339.046, last updated in 2000,⁴⁸ includes two key principles that are considered the backbone Florida's transportation infrastructure benchmark. These principles are Preservation and Economic Competitiveness.

The *Preservation* principle includes the following mandates:

- Ensuring that 80 percent of the SHS surface is in good condition and meets FDOT standards;
- Ensuring that 90 percent of the FDOT-maintained bridges are in good condition and meet FDOT standards; and
- Ensuring that the FDOT achieves 100 percent of the acceptable maintenance standard on the SHS.

The *Economic Competitiveness* principle puts emphasis on directing transportation resources and investments in a manner that will ensure Florida's strategic and economic prevalence. To do this, the Statute calls for performing a macroeconomic analysis to determine linkages between transportation investment and the State's economic performance.

The effectiveness of the preservation and economic competitiveness-driven policy-making is evidenced by the fact that Florida has continued to achieve and maintain its high percentage of bridges in a state of good repair despite a drop in system capacity expansion observed after early 2000's compared to previous decades, as shown in Figure 9.

STATE BRIDGES

Bridge Construction by Decade

4,956 - National Highway System 1,291 - Surface Transportation Program
177 - Non-Federal Aid

■ National Highway	2	30	68	118	406	1,091	924	683	631	707	296
■ Surface Transportation	-	17	32	96	154	240	212	133	172	140	95
■ Non-Federal Aid	1	-	-	-	3	58	44	17	25	20	9

Excludes bridges maintained by Central Florida Expressway Authority and Miami-Dade Expressway Authority

Figure 9: Construction of New State Bridges in Florida by Decade
(Graphic Courtesy of Florida Department of Transportation Office of Work Program and Budget)

F.S. 206.46 State Transportation Trust Fund

F.S. Section 206.46, which was last updated in 2010,⁴⁹ established the State Transportation Trust Fund and required that all money in this Fund are used solely for transportation purposes. It also

established provisions for the transfer of its funds into other key funds that service Florida's transportation infrastructure. These provisions include the following:

- A maximum of 7 percent of the total funds in STTF to be deposited into the Right-of-Way Acquisition and Bridge Construction Trust Fund (created in F.S. 215.60550), such that the latter can use it for administration and servicing of bonds and for coverage of outstanding bonds.
- A minimum of 15 percent of all State revenues deposited into the STTF to go towards Florida's public transportation projects.

[F.S. 339.08 Use of Moneys in State Transportation Trust Fund](#)

F.S. Section 339.08, which was last updated in 2015,⁵¹ was created along with F.S. 206.46, and prescribed the purposes of the allocation of the funds in the STTF. Specifically, it lists the following uses for these funds, among others:

- To provide funding construction and maintenance of the State Highway System—including reimbursements to cities and counties for SHS improvement expenditures;
- To provide loans and credit enhancements for construction or maintenance of highway transportation facilities;
- To provide funding for the economic development; and
- To pay other expenditures of the FDOT.

[F.S. 339.135 Florida Strategic Intermodal System; Legislative Findings, Declaration, and Intent](#)

The FDOT's Work Program is governed by the F.S. 339.135, which was last updated in 2016. According to this Statute, the Work Program is to be created for the ensuing FY and the four consecutive FYs succeeding it for the allocation of funds in the STTF and other funds that FDOT manages. The Statute also specified the requirement of the Work Program to be developed in accordance with the FTP (pursuant to 339.61⁵²) and assigned *priority to the need-based programming* of funds for the purposes of resurfacing, bridge repair and rehabilitation, bridge fender system construction or repair, and others.

[Strategic Intermodal System](#)

In 2003, in parallel with the addition of the *Economic Competitiveness* clause in F.S. 339.046 and pursuant to F.S. 339.135, the Florida legislature established the Strategic Intermodal System, which is defined as the "high priority network of transportation facilities to State's economy and mobility."⁵³ The Strategic Intermodal System (SIS) is largely a subset of the SHS, which consists of highways connecting the strategic locations in the State of Florida, such as major airports, and seaports. The SIS receives priority second to the need-based programming requirement for repair, replacement, or expansion of the facilities that are identified as strategically significant for interregional, interstate, and international travel.

[FTP Objectives and Strategies](#)

In addition to the statutory requirements that the FDOT programs must follow, the FTP outlines additional objectives and strategies to ensure the safety and integrity of FDOT's facilities. For example, the following are several of the FTP objectives for the SHS for FY 2014/15 through 2019/20:⁵⁴

- Allocate up to 75 percent of new discretionary capacity funds to the SIS;
- Deliver a transportation system that supports quality of life and environmental stewardship;
- Develop/redevelop multi-modal corridors to support future mobility;
- Make strategic investments that support Statewide and inter-regional mobility; and
- Maximize the use of existing facilities.

The strategies to achieve the above objectives include the following:

- Enhance Florida's role as global hub that provides efficient and reliable connectivity for trade and visitors; and
- Focus investments on the SIS to produce the greatest impact for commerce and economic growth.

Some of Florida's success in generating adequate levels of State revenue for funding the transportation infrastructure is credited to the FDOT's top-down decisionmaking policies. That is, most of the decisions for programming and funding allocation for bridge repair, replacement, construction, and maintenance projects are made at the FDOT level, unlike many other States where such decisions are often delegated to counties and city governments.

Texas

Texas State Bridge Program

The Texas Department of Transportation (TxDOT) puts in a significant effort into securing funding for highway infrastructure and the more-than 48,000 bridges in Texas. The bridge capacity in Texas reportedly expands by an addition of 400 new bridges per year, on average. According to TxDOT's Educational Series document,⁵⁵ forecasting funding for Texas transportation infrastructure is one of the Department's most important endeavors. This effort includes forecasting future revenues and future expenditures. The future expenditures are based on budgets established within TxDOT programs such as the Unified Transportation Program (UTP) and the STIP. The UTP and STIP are programs that capture the Texas transportation planning needs.

The TxDOT Bridge Program, reflected in the UTP as Category 6—Structures Replacement and Rehabilitation—addresses the specific purpose of replacing or rehabilitating structurally deficient or functionally obsolete bridges. Category 6 consists of three funding programs:

- **Bridge Maintenance and Improvement Program (BMIP or Category 6 BMN)**, which includes rail replacement program, is to improve physical conditions, not functionality, or the on-system bridges by addressing issues affecting structural conditions before deterioration becomes irreversible;
- **Highway Bridge Program (HBP or Category 6 ON/OFF)** is for the rehabilitation or replacement of structurally deficient or functionally obsolete bridges; and
- **Railroad Grade Separation Program.**

A given bridge's funding eligibility for repair or maintenance under these programs is determined by and based on a number of factors. For example, for consideration for HBP funds,

the Bridge Division prioritizes bridges by ranking them according to their deficiency status: from lowest to highest sufficiency rating and favoring structurally deficient bridges over ones that are functionally obsolete. Also, a bridge cannot be eligible for BMIP funding if it is eligible for HBP funding.

Under the FAST Act, TxDOT's Bridge Program (UTP Category 6) is supported by the National Highway Performance Program and the Surface Transportation Program. However, for all TxDOT-administered construction projects that include bridges, regardless of the UTP funding category, matters of bridge planning, structural design, plan development, and plan specifications and estimates review are under the purview of the Bridge Division. As such, UTP programming categories other than Category 6 can also include bridge maintenance programs with varying sources of funding, which include projects funded with a split share between the Federal, State, and Local governments or are completely funded by the State.

General Funding Sources and Flow of Revenue

The STIP is a 4-year financially constrained plan that secures Federal funds for transportation projects. Projects included in the STIP, when approved by the FHWA and the Federal Transit Administration, are the only transportation projects that can utilize Federal funds.

The UTP is a 10-year plan used along with the STIP to guide the mid-range development of thousands of projects.

The sources of State revenue for funding projects programmed by the UTP and the STIP include the following major funds:

- State Highway Fund;
- State General Revenue;
- Texas Mobility Fund (TMF); and
- Other bonding and borrowing programs.

The State Highway Fund consists of various sources of revenue as dedicated by the Texas Constitution for Highways. One of the most important revenues to the State Highway Fund is the State motor fuel tax, three fourths of which is deposited into the Fund. The Texas State motor fuel tax rate has been fixed at \$0.20/gallon since 1991.

Federal funds provide another significant portion of revenue for the State Highway Fund—approximately one-third of the funding. The following diagram shows a comparison of revenues deposited into the State Highway Fund between FYs 2001 and 2010.

The third largest source of revenue for the State Highway Fund is the motor vehicle registration fee collection.

As is shown in Figure 10, revenues from sources other than the Motor Fuels Tax and Federal Funding made up about 24 percent of the State Highway Fund in 2001. In 2008, this percentage increased to 61 percent as a result of additional funding mechanisms, such as bonds and other sources.⁵⁶

A small portion of the budget comes from the *State General Revenue*, which is primarily meant for debt service on highway improvement general obligation bonds.

Traditionally, these funds have comprised the “pay-as-you-go” infrastructure financing system in which construction, repair, and maintenance projects took place as funding became available. However, with this system no longer being able to sustain the needs of the Texas highway system, new financing tools have been made available to TxDOT, such as bonds, short-term borrowing programs, and comprehensive development agreements (CDAs). Over time, several amendments to the Texas Constitution gave way to these bond programs, which generate revenue for the State Highway Fund. Another portion of bond proceeds is generated from the TMF which was adopted in 2001 as a deviation from the “pay-as-you-go” system and allowed for borrowing of money for construction and maintenance of the highway system for the first time. The following section provides a detailed explanation of the Texas State policies that enable funding through non-traditional means.

Figure 10: A Comparison of Revenues Deposited into the State Highway Fund
(Source Data: Texas Legislative Budget Board⁵⁶)

Policies that have Affected Highway Funding in Texas

In August 2001, TxDOT adopted a goal of maintaining at least 80 percent of the more-than 48,000 bridges in Texas “in good or better condition” within 10 years.⁵⁷ As discussed previously, Texas has adopted several policies that have allowed the issuance of bonds and other means of generating revenue to contribute to the State highway infrastructure budget that will help in achieving this objective among other TxDOT highway infrastructure benchmarks. These policies include the following:

- Texas Transportation Funding Amendment (Proposition 1);^{58,59}
- Highway Improvement General Obligation Bonds (Proposition 12);^{60,61}
- State Highway Revenue Bonds (Proposition 14);⁶²
- TMF;⁶³
- CDAs;⁶⁴ and
- Local Government Assistance Programs.⁶⁵

Proposition 1

In November of 2014, Texas voters overwhelmingly approved the ballot measure known as Proposition 1 (Prop 1) – the Texas Transportation Funding Amendment—which authorized a portion of the State tax revenues imposed on oil and gas sales that typically go into the Economic Stabilization Fund (an emergency fund also known as the “Texas Rainy Day Fund”) to be deposited into the State Highway Fund instead without creating new taxes or fees. It was estimated that approximately \$1.7 billion would be available to transfer to the State Highway Fund for the FY 2015.

With this addition in funding, it was possible to add a number of projects to the FY 2015 UTP. TxDOT began awarding contracts for Prop 1-funded projects in March 2015.

Proposition 12

In 2007, Texas adopted the constitutional amendment providing for the issuance of General Obligation Bonds by the Texas Transportation Commission to provide funding for highway improvement projects. This amendment, often referred to as “Prop. 12,” authorizes the Commission to issue bonds as part of the State’s constitutional debt limit. In 2009, a statute was amended that limited the amount of bond proceeds that can be spent up to an aggregate amount of \$5 billion.

Also in 2009, House Bill 1 authorized the issuance of these general obligation bonds to pay all or part of the costs of highway improvement projects, and in 2010, the first Proposition 12 General Obligation Bonds were issued.

Proposition 14

In 2003, Texas adopted the constitutional amendment providing for authorization of the issuing of notes or the borrowing of money on a short-term basis by a State transportation agency for transportation-related projects, and the issuance of bonds and other public securities secured by the State Highway Fund.

The short-term debt is secured by the State Highway Fund to carry out the functions of the department. The purpose of this program is to ensure that TxDOT can have as many projects underway as possible without carrying a “cushion” in the State Highway Fund balance in the event that payments come in more quickly or revenues come in more slowly than anticipated. The bonds are referred to as “State Highway Fund revenue bonds” or “Prop. 14 Bonds.” The first Proposition 14 State Highway Fund bonds were issued in 2006. A statute was amended in 2007, by which the Transportation Commission is authorized to issue an aggregate total of \$6 billion in bonds, with no more than \$1.5 billion issued in any 1-year period and with a maximum maturity of 20 years.

TMF (Proposition 15)

As briefly discussed earlier, in 2001, Texas adopted the constitutional amendment creating the TMF and authorizing grants and loans of money and issuance of obligations for financing the construction, reconstruction, acquisition, operation, and expansion of State highways, turnpikes, toll roads, toll bridges, and other mobility projects. Under this amendment, the Texas Transportation Code can use the TMF as leverage for the issuance of bonds to be repaid from the Fund. These bonds can be used for refunding obligations and related credit agreements of the TMF, and paying issuance costs and interest on bonds issued from funds in the TMF. The bonds under this program must have maximum maturity of 30 years. The program issuance limitation is based on a certified revenue estimate that the Comptroller provided; and the debt service payments are secured by revenues of the TMF.

In 2003, the legislature identified revenues to be dedicated to the TMF. The sources of revenue for the TMF in FYs 2001-2015 include the following:

- Motor vehicle inspection fees;
- Driver license point surcharges;
- Driver license fees;
- Driver record information fees;
- Court fines; and
- Inter-State deposits and treasury investments

CDAs

The earliest version of the CDA in Texas was referred to as an “Exclusive Development Agreement” outlined in House Bill 749 in 1991. This legislation allowed the then-Turnpike Authority to develop projects using public/private partnerships. In 1997, the Turnpike Authority was transferred to TxDOT along with its enabling statutes. In 2001, TxDOT was provided an increased ability to utilize such agreements.

In 2003, the Texas Legislature authorized the Transportation Commission and the TxDOT to realize the benefits of private sector participation when needed, to help respond to transportation demand, leveraging limited traditional highway funding to ensure safer, more reliable infrastructure.

Local Government Assistance Programs

The Federal Highway Authority annually provides the TxDOT Highway Bridge Program with funds programmed for on- and off-system bridges. The FHWA typically funds 80 percent of the costs and requires a 20-percent contribution from other sources. In 1995, the Texas Transportation Commission began providing half of this contribution—which is 10 percent—and required that the local governments provide the other 10 percent. However, over time, it became harder and harder for the local governments to meet the requirements to provide their portion of funding. In order to maintain the State’s infrastructure integrity and keep these projects moving forward, the TxDOT Bridge Division designed additional assistance programs that will ease the financial burden on qualifying regions. These programs include the following:

- **The Participation Waived Project / Equivalent Match Project (PWP/EMP)** where the State covers local governments' contribution of up to 10 percent toward a given project, provided that the local government will in turn use its available funding to support other deficient bridges within their jurisdiction;
- **The Economically Disadvantaged Counties (EDC) Program** which was established in 1998 to adjust the local participation amount requirements based on the qualifying county's ability to provide its share of funds; and
- **The State Infrastructure Bank** which is a revolving account within the State Highway Fund, and from which loans may be made to local governments for funding critical projects such as bridges.

Policy Outcome Summaries

The tables below summarize the funding outcomes of the legislation mentioned in previous Sections of this report. It should be noted, however, that most policy legislation discussed in this report is broad in its focus, appropriating funding for broad areas such as highways, surface transportation, or State DOT operations as a whole that benefit State highway bridges; the few exceptions being legislation tied directly to the California bridge seismic retrofit program or the OTIA. In addition, due to the legislative information presented for the State of Florida is focused more on the governing policies rather than individual Bills, a summary for Florida is excluded from being tabulated in a fashion similar to that of the other States.

Table 3: Illinois

Legislation or Policy and year	Summary and monetary benefits to infrastructure (if provided in this study)	Amount that went towards bridges (if provided in this study)	Notes
Illinois Jobs Now! 2014	\$1.1 billion in bonds authorized for IDOT to use on funding road and bridge projects	Not provided	The FY 2015-2020 MYP indicated a total budget of \$1.16 billion, \$184 million of which came from IJN! Bonds.
Public Act 98-94 2013	\$3.2 billion in Special Obligation bonds for infrastructure purposes	Not provided	
Public-Private Partnerships for Transportation Act 2011	Allocation dependent on General Assembly's adoption of a resolution in support of specific construction projects	Not provided	
Jumpstart Illinois Capital Plan 2009	\$8 billion for IDOT to be used for the purpose of developing, maintaining, and improving Illinois transportation.	Not provided	The FY 2010-2015 MYP received \$2 billion of Jumpstart Illinois funds in order to help the State system in achieving its 90% acceptable condition.

Illinois FIRST 2009	This Act was aimed at planning to build repair, and upgrade the State's "deteriorating infrastructure." The transportation component of Illinois FIRST included allocating \$3.7 billion for highways, roads, and bridges that were not included in the State's annual road repair and construction program prior to the enactment of this Act	Not provided	The allocation included funds for addressing the need to repair 750 deficient bridges at the time.
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Table 4: California

Legislation or Policy and year	Summary and monetary benefits to infrastructure (if provided in this study)	Percentage of Amount that went towards bridges (if provided in this study)	Notes
Fuel Tax Swap 2010	This Act provided a higher level of transportation revenue mainly aimed at paying debt on highway and rail project improvement bonds.	Not provided	
Proposition 1B 2006	This Act authorized the sale of \$19 billion in bonds whose proceeds would benefit transportation projects.	Not provided	Projects funded with Prop 1B bonds include SHOPP projects and programs aimed at the seismic retrofitting of local bridges and overpasses.
TCRP (2000), Proposition 42 (2002), and Proposition 1A (2006)	These Acts were enacted in order to limit the conditions under which tax revenue—such as motor fuel taxes— to be used for purposes other than transportation.	Not provided	
Proposition 2 (1998)	This act allowed loans to be made from funds designated for transportation improvement to the State General Fund. These loans would provide the benefit of interest income.	Not provided	
Assembly Bill 1175 (2009)	This Act added the Antioch Bridge and the Dumbarton Bridge to the Toll Bridge Seismic Retrofit Program	\$950 million	The Bay Area Toll Authority was authorized to administratively raise the tolls on its bridges to cover the cost of retrofitting these two bridges.
Assembly Bill 144 (2006)	This Act was designed to combat Toll Bridge Seismic Retrofit Program cost overruns by authorizing additional toll surcharges, bond refinancing, transfers from other funds, and other sources.	\$3.6 billion	

Assembly Bill 1171 (2001)	This Act was a response to increased cost estimates of the Toll Bridge Seismic Retrofit Program and the seismic retrofit of non-BATA bridges.	\$557 million for non-BATA bridges and \$1.4 billion for the San Francisco-Oakland Bay Bridge	To meet the funding challenges, funds were transferred from the State share of the Federal HBRR program (without harming the STIP projects programmed before FY 2002), in addition to funds borrowed from the Infrastructure Bank, Caltrans bond proceeds, and the upheld \$1 seismic retrofit toll surcharge on the BATA bridges that was originally set to expire in 2008.
Senate Bills 226 and 60 (1997)	These Bills prescribed funding sources and amounts from each source to finance the Toll Bridge Seismic Retrofit Program.	\$2.6 billion	\$790 million from the Seismic Retrofit Bond Fund; \$795 million from California's SHA; \$80 million from the Public Transportation Account; \$955 million from local funds and BATA tolls.
Seismic Retrofit Bond Act (1996)	This Act authorized the issuance of bonds in order to finance bridge seismic retrofitting	The Act provided \$2 billion in bonds and earmarked \$650 million for the seismic retrofitting of toll bridges.	The repayment of the \$2 billion plus \$1.4 in interest for the bonds was set to come from the State General Fund.

Table 5: Oregon

Legislation or Policy and year	Summary and monetary benefits to infrastructure (if provided in this study).	Percentage of Amount that went towards bridges (if provided in this study)	Notes
Oregon JTA (2009)	This act imposed increased user fees that would increase revenue generation for the State transportation infrastructure.	\$10 million annual increase for bridges	
OTIA (2003)	This act provided ODOT with bond proceeds to address nearly 10 percent of Oregon's ageing bridges.	\$1.3 billion	The \$1.3 billion was the result of OTIA III, which was preceded by OTIA II and I that were programs of smaller time-frames and much smaller amounts.

Table 6: Texas

Legislation or Policy and year	Summary and monetary benefits to infrastructure (if provided in this study)	Percentage of Amount that went towards bridges (if provided in this study)	Notes
Proposition 1 (2014)	This Act authorized the portion of the State oil and gas sales that would otherwise be deposited into the Texas Economic Stabilization Fund to instead be deposited into the State Highway Fund. In FY 2015, this sum was estimated at nearly \$1.7 billion.	Not provided	
Proposition 12 (2007)	This Act authorized the issuance of \$5 billion in General Obligation bonds by the Texas Transportation Commission to benefit transportation projects.	Not provided	
Proposition 14 (2003)	This Act authorized the issuance of \$6 billion in State Highway Fund Revenue bonds to benefit transportation projects.	Not provided	
TMF (2001)	The TMF was established and was to be used as leverage for the issuance of bonds to be repaid from the Fund.	Not provided	The establishment of the TMF was the first instance of Texas deviating from their “pay-as-you-go” transportation funding scheme and allowed transportation project financing through bonds.
CDAs	The earliest version of CDAs in Texas (referred to as “Exclusive Development Agreement”) was proposed in House Bill 749 in 1991, and allowed the then-Turnpike Authority to develop projects using public/private partnerships. After the Turnpike Authority was absorbed by the TxDOT in 2003, TxDOT became authorized to realize the benefits of public/private partnerships.	Not provided	

Observations and Conclusions

Based on the data collected on policies that affect funding in the above five States, there is pattern of policy enactments. Specifically, the policy actions taken by State DOTs and legislators to maintain adequate funding levels to support their transportation infrastructure can be viewed as either predominantly *proactive* or predominantly *reactive*.

States that have predominantly proactive policies are ones that enact policies in order to maintain an acceptable or benchmarked level of adequacy with respect to State highway bridge conditions. States with policies that can be viewed as reactive are ones that set forth policies intended to generate funding to recover or restore from significant deficiencies that exist in the highway bridges due; these deficiencies may be due to inefficiency in previous funding programs or damage and distress caused by natural disasters (or the threat thereof).

Texas, despite the trend that most policies simply enable the TxDOT to issue bonds, can be viewed as a State with a proactive approach to bridge capital funding policies because they result from TxDOT recognizing a forecasted shortfall in the traditional funding mechanisms to maintain its infrastructure. Illinois also falls into the proactive category as the numerous bonding programs enacted over the years have helped to maintain a higher state of repair of transportation infrastructure. The concern expressed by IDOT staff about the potential decrease Statewide bridge condition (i.e., the number of State highway bridges in acceptable condition) over the next decade due to an anticipated lack of additional funding indicates that their priority is to proactively secure funding for the future maintenance and capacity expansion projects. Lastly, Florida is in the unique position of generating enough State revenue without the recent need for significant special legislative actions. This demonstrates a very proactive approach within FDOT for funding Statewide highway infrastructure projects, because its existing funding systems are structured such that they align well with projected or anticipated needs over time.

States with actions or policies that can be considered predominantly as reactive are generally those States that have enacted policies in response to a high rate of infrastructure deterioration, damage, or newly anticipated deficiencies (e.g., widespread seismic vulnerabilities). The contributing factors differ from State to State—for example, a lack of historical funding, the occurrence or threat of significant natural disasters—but nonetheless affect the State’s ability to properly maintain its highways and bridges, and in some cases anticipate future needs. In California, while a number of policies were enacted to effectively manage funds for general transportation purposes, a significant amount of funding in recent years has been invested in the State’s seismic retrofit programs. This program was funded in direct response to a series of unanticipated seismic event, and the realization that the current design and State of California’s bridges were particularly vulnerable to seismic events. The widespread nature of these vulnerabilities necessitated significant additional funding, well above the level necessary to manage and maintain State bridges under historic circumstances. ODOT has produced a number of reports outlining the current deficit in State bridge funding that has adversely affected the state of repair on highway bridges. Although major earthquake events on the scale of those seen in California have not yet occurred in Oregon, anticipated seismic events (i.e., a Cascadia Subduction Zone earthquake) clarify the need for significant additional investment in Statewide bridges.

While it is difficult to characterize one approach as superior without a better understanding of broader policy environments and decisionmaking contexts in each State, there are some tradeoffs between the proactive and reactive approaches that can be noted. In general, States with a predominantly proactive policy-making approach seem to maintain a higher percentage of bridges in good repair than those whose policies are defined as reactive. Policies in these States, as summarized above, generally reflect broad funding initiatives for general transportation or infrastructure investment, many of which are part of State statutes (e.g., Florida). Broader, more consistent, or more stable annual transportation and infrastructure funding may enable better long-term planning for infrastructure management, and better position DOTs to set and achieve more realistic performance goals. In comparison, States with predominantly reactive policies have demonstrated effectiveness in taking action aimed at funding specific programs to alleviate the crisis of the significant number of bridges in disrepair. In these cases, such reactive policies

are necessarily more targeted towards appropriating funding for specific initiatives, but not for broader system maintenance and performance management. This could lead to greater uncertainty in long-term planning and potentially complicate the ability to both set and achieve longer-term performance goals for transportation infrastructure.

Identifying or analyzing the reasons for some States being reactive while others are proactive was not one of the defined objectives of this study; nonetheless some possible explanations that can be hypothesized for further exploration or testing in future studies. For example, States that are characterized as primarily reactive (California and Oregon) both became increasingly aware of unforeseen or previously unconsidered seismic hazards during, or immediately prior to, the 1995-2014 study period. These hazards may have contributed to an unanticipated need for significant, system-wide infrastructure investment to enhance the resilience of transportation infrastructure to such hazards, and necessarily put both States (and their DOTs) into the position of having to *react* to these hazards. In the proactive States, such system-wide hazards either do not exist (e.g., Illinois), or occur on a somewhat regular basis (e.g., hurricanes in Texas and Florida) such that they can be anticipated and planned for proactively. Similarly, while system-wide hazards in proactive States such as hurricanes in Florida and Texas can have significant impacts, the potential for damage is of a considerably smaller magnitude than that which could occur as a result of a State- or region-wide seismic impacts in States such as Oregon and California.

Another hypothesis for the proactive versus reactive distinction is that it may be a reflection of policies or policy environments that existed prior to the 1995-2014 study period used in this analysis (which, as mentioned, was necessitated by infrastructure data availability), which then either persisted into the current study period, or evolved incrementally into the policies and policy environments of today. Additional qualitative or semi-quantitative policy research over a longer time domain could better clarify such longer-term influences to present day trends in policy making.

When interviewing State DOT representatives, a common sentiment arose regarding funding levels. Many interviewees observed a correlation between factors that directly affect funding (e.g., population density, the diversity of State transportation funding streams) with their State's funding levels. One example is the stark contrast between Oregon and Florida with respect to funding and observed bridge deficiency levels. Unlike Florida, Oregon's State highways have no toll roads. Also, the population densities of motorists who pay user fees and motor fuel taxes are strikingly different; there are far fewer motorists in Oregon than in Florida.

Another notable observation, specifically from Florida, related to that State's success in generating adequate levels of State revenue for funding transportation infrastructure is FDOT's strong approach to top-down decision-making. That is, most of the decisions for programming and funding allocation in Florida for bridge repair, replacement, construction, and maintenance projects are made at the FDOT level; in contrast, many other States often delegate such decisions to individual DOT maintenance regions, counties, or city governments. This may partially explain Florida's ability to proactively generate sufficient revenue without special legislation; however, a more detailed analysis of DOT management approaches across States is needed to confirm this.

In addition to the proactive/reactive dichotomy noted in State funding policies, many of the State DOT representatives whom researchers interviewed expressed their concern with the additional sources of funding not being steady revenue sources. Specifically, in lieu of providing funding from bonds and other project financing options, there is an almost unanimous call for establishing more stable revenue sources, such as increased taxes and other user-based fees that are adjusted to inflation. Such changes can help the States to avoid the “boom and bust” situations caused by financing mechanisms that are built on unsustainable long-term funding mechanism, and thereby provide the ability to more consistently maintain their transportation infrastructure.

Lastly, motor fuel tax is one of the main sources of revenue for the States as well as the Federal Highway Trust Fund. While increasing the motor fuel taxes or adjusting them to inflation has the potential alleviate the near-term funding gap, most State DOTs felt that in the long term, it may be necessary to develop alternative sources of highway infrastructure revenue. As petroleum fueled vehicles becoming more fuel efficient, as the proliferation of electric or alternative-fuel vehicles broadens, or as populations and individual attitudes towards personal mobility shift in the coming years, motor fuel tax may become an increasingly unreliable source of funding for Statewide transportation infrastructure.

4. Statistical Modeling Results

Compiled Bridge and Funding Data

Researchers compiled annualized data on bridge characteristics using the NBI from 1995 to 2014 in five primary States of interest: California, Florida, Illinois, Oregon, and Texas. This resulted in data for approximately 116,000 to 126,000 bridges each year of data across all five States. Similarly, bridge funding data (see Appendix B for full list of variables) were compiled on an annualized basis for each State. Figure 11 shows the number of bridges in each of the five States during the study period.

Figure 11: Number of Bridges per State During Study Period 1995-2014

Data quality required some post-processing; for example, excluding any bridge data that was associated with a structure prior to the date it was built (e.g., a bridge is recorded as being built in 1999, but is included in the 1995 data). Duplicate structure numbers (i.e., any row of data for a particular bridge that was a duplicate within each year) were also excluded.

The NBI assigns bridges the designation as “eligible for rehabilitation” if their Sufficiency Rating is below 80, and “eligible for replacement” if their Sufficiency Rating is below 50. This analysis utilizes these designations on a proportional basis (e.g., the proportion of bridges in a State with a sufficiency rating below 80, or below 50), in addition to average Statewide Sufficiency Rating. Using the proportion of bridges with sufficiency ratings below the rehabilitation and replacement thresholds better accounts for differences among States in the number of bridges each must maintain, as well as the distribution of sufficiency ratings from 0 to 100 among bridges in a given State.

Figures 12 and 13 show the percentage of bridges in each State each year that were eligible for replacement or rehabilitation, excluding any bridge that did not have a sufficiency rating provided in the NBI. Examination of the data suggests that the incidence of eligibility for rehabilitation was relatively flat in California and Oregon and had a slight downward trend in Florida, Illinois, and Texas. Incidence of eligibility for replacement showed downward trends, with more variability in Oregon over the 20-year period. Texas showed the most improvement, reducing the percentage of bridges eligible for replacement from nearly 11 percent to 2.5 percent over the 20-year period. These trends are somewhat consistent with findings from the structured policy analysis that showed generally robust, proactive funding policies in Florida, Illinois, and Texas to pay for bridge replacement and rehabilitation projects (thus reducing the proportion of bridges eligible for, or requiring such actions). Similarly, these trends support the policy findings for California, where policy actions have been reactive in nature, but have nonetheless seen significant investment through policies funding the State's Bridge Seismic Retrofit Program. In Oregon, the policy analysis found that ODOT's budget does not provide an adequate amount of money for bridge preservation and replacement projects which prevents that State from meeting performance goals and improving upon the current state of repair of Statewide bridges. This then may partially explain the flat trend in the proportion of Statewide bridges in Oregon eligible for rehabilitation, as well as the generally higher proportion of bridges eligible for both rehabilitation and replacement in Oregon, as compared with other States.

Figure 12: Proportion of Bridges Eligible for Rehabilitation (Sufficiency Rating < 80)

Figure 13: Proportion of Bridges Eligible for Replacement (Sufficiency Rating < 50)

Figure 14 shows the average sufficiency rating across all bridges in each State. As may be expected given the trends of proportional sufficiency ratings given above, Oregon was the only State in which the average bridge sufficiency rating was relatively flat; all other States show a slight increase in average Statewide bridge sufficiency ratings over time.

Figure 14: Average Statewide Bridge Sufficiency Ratings

Statewide Bridge Funding and Policy Analysis Outcomes

To characterize the connection between State policies and funding levels, researchers plotted several bridge funding variables to identify any coincidence in the funding programs identified in Section 3, with changes in State DOT expenditures on bridge projects over time. Figures 15 to 19 show the State capital outlays for bridge replacement, in both rural and urban locations. Note that values are stacked or additive in these figures, therefore the top of the Urban Bridges trend line represents the cumulative outlay for both urban and rural bridges.

The data shown in Figure 15 show relatively strong temporal correlation with the enactment of State funding policies. In California, the Transportation Congestion Relief Act (2000) created \$4.9 billion in funding, which may correspond with a significant increase in spending on bridge projects a year later from 2001-2002. Similarly, Proposition 1B (2006) in California authorized the sale of \$19 billion in general obligation bonds for a list of projects of which, to date, only 75 percent are complete. This may explain the significant increase in spending after 2006, which has remained relatively higher in comparison with previous years.

Figure 15: California State Capital Outlay (2014 Dollars): Rural and Urban Bridge Expenditures

Funding policies that affect bridge funding in Florida have remained relatively consistent over the past 20 years, with periodic updates to Florida Statutes that affect the State SIS or the STTF. This relative stability in funding policy may explain the relatively consistent funding over time in Florida for bridge projects from 1995 to 2015 levels. The increase in funding in Florida from approximately 2003 through 2008 may be partially attributed to the establishment of the SIS in 2003.

Figure 16: Florida State Capital Outlay (2014 Dollars): Rural and Urban Bridge Expenditures

Illinois exhibits a possible trend of increased bridge spending, particularly from 2005 moving forward. This may reflect the State's recent series of funding programs that increased

transportation funding in 2009 (Jumpstart Illinois Capital Plan, \$8 billion), 2013 (Public Act 98-94, \$3.223 billion), and 2014 (IJN! \$1.1 billion), each of which coincide with an increase in bridge expenditure. Additionally, the ongoing MYP process that described a significant need for future funding—the FY2017 to 2022 Bridge Maintenance Program calls for \$1.962 billion in funding—may reflect the attitude of increased spending at IDOT, which may be associated with the increase in bridge expenditures over the past decade.

Figure 17: Illinois State Capital Outlay (2014 Dollars): Rural and Urban Bridge Expenditures

Oregon bridge expenditure exhibits a significant increase starting in approximately 2003 and lasting through 2014, particularly in rural locations. These increases coincide with the OTIA of 2003 that provides \$1.3 billion for bridge replacement and rehabilitation, and the Oregon JTA of 2009 that provides a \$300 million annual increase in funding for transportation project, of which \$10 million annually was designated for bridges.

Figure 18: Oregon State Capital Outlay (2014 Dollars): Rural and Urban Bridge Expenditures

Texas bridge expenditures exhibits a strong increasing trend in spending from 1999 to the present. These increases coincide with a series of State policies aimed at increasing transportation funding within the State. These include the creation of the TMF under Proposition 15 in 2001, Proposition 14 in 2003 (\$6 billion), Proposition 12 in 2007 (\$5 billion) and Proposition 1 in 2014 (\$1.7 billion).

Figure 19: Texas State Capital Outlay (2014 Dollars): Rural and Urban Bridge Expenditures

This semi-quantitative analysis of State transportation funding policies with State-level bridge expenditures shows that there is an acceptable level of correlation between funding policy data and State-level bridge-related expenditures. State-level bridge funding and expenditure, however, must also be taken in the context of Federal funding of bridge-related projects at the State-level. Although Federal funds are dispersed to the States for allocation and spending, the source of funds from the USDOT is an important consideration in overall State bridge funding. Figure 20 shows the total Federal transportation funding spent by each of the five States (the summation of Federal funds spent on bridge replacement, interstate system, NHS, surface transportation, and interstate maintenance), as well as the proportion of that funding that was spent specifically on bridge replacement projects. Note that in most States, the level of Federal funding provided to the States for all highway projects is an order of magnitude greater than the State capital bridge outlays shown in Figures 15 to 19.

Figure 20: Federal Funds Expenditures (2014 dollars): Proportion Spent on Bridge Replacement

Linear Model with Correlated Errors

This study fitted linear models to the time series data for each State, structuring the covariance of the error terms using autoregressive moving average models to account for non-independence as follows. Suppose that y_t and x_t are time series variables. A simple linear regression model with autoregressive (AR) errors, for example, can be written as

$$y_t = \beta_0 + \beta_1 x_t + \epsilon_t$$

with $\epsilon_t = \phi_1 \epsilon_{t-1} + \phi_2 \epsilon_{t-2} + \dots + w_t$, such that $w_t \sim iid N(0, \sigma^2)$.
If we let $\Phi(B) = 1 - \phi_1 B - \phi_2 B^2 - \dots$, then we can write the AR model for the errors as $\Phi(B)\epsilon_t = w_t$. If we assume that an inverse operator, $\Phi^{-1}(B)$, exists, then $\epsilon_t = \Phi^{-1}(B)w_t$. So the linear model can be written

$$y_t = \beta_0 + \beta_1 x_t + \Phi^{-1}(B)w_t,$$

where w_t is the usual white noise series.

This study then estimated each linear model using ordinary least squares and checked the usual model assumptions of normality and linearity. Researchers then examined the autocorrelation and partial autocorrelation of the residuals to determine the correlation structure for each outcome variable. Using this information, they fitted a linear model using generalized least squares, in which the errors are allowed to be correlated and/or have unequal variances.

Control Variables

In addition to the intercept, representing either the average proportion of bridges eligible for rehabilitation, the average proportion of bridges eligible for replacement, or the average bridge sufficiency rating at the start of the 20-year period, numerous other data variables were included in the statistical models to account for variation among both transportation system and non-transportation State-level characteristics across the five States in this study. These control variables include, for example, GDP, population density, lane-miles of highway, and vehicle miles traveled (VMT). These variables were included to account for differences in the relative economic productivity of each State (GDP), the relative size and dispersion of roadway users (population density), the relative size and extent of the State's transportation infrastructure system (lane-miles of highway), and the relative level of usage of the State's transportation infrastructure (VMT). A number of these variables were directly available from the FHWA HSS dataset; other more general data were obtained from the U.S. Census Bureau, which conducts an annual survey of State and local government finances to gather data on revenue, expenditure, debt, and financial assets.⁶⁶ A full listing of these other control variables are given in Appendix B.

For the purposes of statistical modeling, this study aggregates the bridge characteristics to State-level variables. For example, the proportion of bridges in each State that are eligible for rehabilitation or replacement, the average daily traffic averaged across all bridges in each State, or total lane-miles of bridges in each State.

Linear Model Results: California

Outcome Variable: Average Sufficiency Rating

	Est.	SE	p-value	
(Intercept)	-5.41430	28.49435	0.857	
Time	-0.39400	0.26410	0.196	
Proportion of Bridges with Maintenance: Local Hwy	-19.11570	26.80664	0.508	
Proportion of Bridges with Maintenance: State Hwy	-157.39320	43.89027	0.016	**
Proportion of Bridges on Interstate System	480.70850	80.02014	0.002	***
State Population Density (Persons/Square Mile of Land)	0.28210	0.11131	0.052	*
State GDP (\$Millions)*	0.00000	0.00000	0.992	
Lane-Miles of NHS Roads (1,000's of miles)	-0.04870	0.01123	0.007	***
Total VMT (1,000's of miles)	-0.05600	0.03142	0.135	
Federal Funds: Expenditures for Interstate System (1-year lag; \$Millions)*	0.01340	0.00399	0.020	**
Federal Funds: Expenditures for NHS; Surface Transportation; and Interstate Maintenance (1-year lag; \$Millions)*	0.00110	0.00028	0.011	**
Federal Funds: Expenditures for Bridge Replacement (1-year lag; \$Millions)*	0.00070	0.00099	0.530	
State Funds: Capital Outlay for Rural Bridges (1-year lag; \$Millions)*	-0.00070	0.00043	0.161	
State Funds: Capital Outlay for Urban Bridges (1-year lag; \$Millions)*	-0.00030	0.00038	0.478	

* Significant at 0.10 level

** Significant at 0.05 level

*** Significant at 0.01 level

‡ Adjusted to 2014 dollars

The results for the linear model in California with the outcome variable of Average Sufficiency Rating show that, holding all else constant, a \$1 billion increase in Federal Fund Expenditures for the Interstate System is associated with an average increase of 13.4 points in average bridge sufficiency rating in California the following year. Similarly, Federal Expenditures for NHS, Surface Transportation, and Interstate Maintenance are also significantly related to average bridge sufficiency rating in California. Holding all else constant, a \$1 billion increase in these funds is associated with an average increase of 1.1 points in average bridge sufficiency rating the following year. The Interstate System funds were primarily directed at a large interstate construction program that was near or at completion in 2008. The Interstate System funds also indicate funding for some interstate construction, interstate discretionary funds, and interstate gap closing funds. Conversely, the funding for NHS, Surface Transportation, and Interstate Maintenance were consistently funded during the 20-year study period. Though these results may appear to indicate a large difference in the relationships between expenditures for the interstate system and expenditures for NHS, surface transportation, and interstate maintenance with average bridge sufficiency rating, in terms of effect size based on the amount of variance explained, the two predictors are relatively similar: Cohen's $d = 3.4$ and 3.9 , respectively. Additionally, the models indicated that there not enough evidence exists to conclude that there are significant effects of other funding variables (i.e., Federal Expenditures for Bridge Replacement, State Capital Outlay for Rural Bridges, and State Capital Outlay for Urban Bridges).

These results suggest that in California the Federal disbursement of funds to the State for the use of the State DOT on transportation projects have greater influence on improving the Statewide

average sufficiency rating of bridges, whereas State capital outlays of funding for bridges were not found to be statistically significant.

Outcome variable: Proportion of Bridges Eligible for Rehabilitation

	Est.	SE	p-value	
(Intercept)	2.17747	0.40	0.003	***
Time	0.00845	0.00	0.071	*
Proportion of Bridges with Maintenance: Local Hwy	0.63339	0.37	0.148	
Proportion of Bridges with Maintenance: State Hwy	1.67130	0.61	0.041	**
Proportion of Bridges on Interstate System	-7.21173	1.09	0.001	***
State Population Density	-0.00567	0.00	0.015	**
State GDP	0.00000	0.00	0.728	
Lane-Miles of NHS Roads (1,000's of miles)	0.00062	0.00	0.011	**
Total VMT (1,000's of miles)	0.00071	0.00	0.155	
Federal Funds: Expenditures for Interstate System (1-year lag)	-0.00025	0.00	0.007	***
Federal Funds: Expenditures for NHS; Surface Transportation; and Interstate Maintenance (1-year lag)	-0.00002	0.00	0.004	***
Federal Funds: Expenditures for Bridge Replacement (1-year lag)	0.00001	0.00	0.676	
State Funds: Capital Outlay for Rural Bridges (1-year lag)	0.00002	0.00	0.023	**
State Funds: Capital Outlay for Urban Bridges (1-year lag)	0.00001	0.00	0.337	

In examining the influence of various factors on the proportion of bridges within California that are eligible for rehabilitation (i.e., a sufficiency rating < 80), there are significant effects of Federal Fund Expenditures for the Interstate System ($p < 0.01$); Federal Expenditures for NHS, Surface Transportation, and Interstate Maintenance ($p < 0.01$); and State Capital Outlay for Rural Bridges ($p < 0.05$) on the proportion of bridges eligible for rehabilitation in the following year, on average. Holding all else constant, a \$100 million increase in Federal Fund Expenditures for the Interstate System is associated with a 2.5 percentage point decrease in the percentage of California bridges that are eligible for rehabilitation the following year, on average. (For example, if 50 percent of bridges were eligible for rehabilitation in the current year, only 47.5 percent would be considered eligible for rehab the following year, on average.) Similarly, holding all else constant, a \$100 million increase in Federal Fund Expenditures for NHS, Surface Transportation, and Interstate Maintenance is associated with a 0.2-percentage point decrease in the percentage of California bridges that are eligible for rehabilitation the following year, on average.

An unanticipated result showed a significant increase of 0.2 percentage points, on average, in bridges eligible for rehab for each additional \$100 million in State Capital Outlay for Rural Bridges. It is important to note that statistical significance is not the same as practical significance. Results like this may be due to lack of data or poor data reliability. A larger sample size would increase statistical power (i.e., the probability that we detect a significant relationship given one exists), and higher quality data could be necessary to provide a representative sample. It is also possible that this result reflects a bias in investment trends towards urban bridges as opposed to rural bridges at the expense of rural bridge sufficiency ratings, or that the additional

investment in rural bridges is insufficient to keep up with normal wear and tear or deterioration of those bridges, resulting in a negative trend despite investment. At this point, such suggestions are speculative at best; additional research is required to better understand this trend.

Outcome variable: Proportion of Bridges Eligible for Replacement

	Est.	SE	p-value	
(Intercept)	0.74620	0.13	0.002	***
Time	0.01339	0.00	0.015	**
Proportion of Bridges with Maintenance: Local Hwy	0.42262	0.17	0.052	*
Proportion of Bridges with Maintenance: State Hwy	4.63016	0.62	0.001	***
Proportion of Bridges on Interstate System	-7.01013	0.53	0.000	***
State Population Density	-0.00657	0.00	0.006	***
State GDP	0.00000	0.00	0.455	
Lane-Miles of NHS Roads (1,000's of miles)	0.00106	0.00	0.001	***
Total VMT (1,000's of miles)	0.00036	0.00	0.181	
Federal Funds: Expenditures for Interstate System (1-year lag)	-0.00025	0.00	0.001	***
Federal Funds: Expenditures for NHS; Surface Transportation; and Interstate Maintenance (1-year lag)	-0.00001	0.00	0.002	***
Federal Funds: Expenditures for Bridge Replacement (1-year lag)	-0.00001	0.00	0.171	
State Funds: Capital Outlay for Rural Bridges (1-year lag)	0.00001	0.00	0.009	***
State Funds: Capital Outlay for Urban Bridges (1-year lag)	-0.00001	0.00	0.090	*

In examining the influence of various factors on the proportion of bridges within California that are eligible for replacement (i.e., a sufficiency rating < 50), there are significant effects of Federal Expenditures for the Interstate System ($p < 0.01$); Federal Expenditures for NHS, Surface Transportation, and Interstate Maintenance ($p < 0.01$); and State Capital Outlay for Rural Bridges ($p < 0.01$); and State Capital Outlay for Urban Bridges ($p < 0.05$) on the proportion of California bridges eligible for replacement in the following year, on average. Holding all else constant, a \$1 billion increase in Federal Fund Expenditures for the Interstate System is associated with a 25 percentage point decrease in the percentage of California bridges that are eligible for replacement the following year, on average. Similarly, holding all else constant, a \$1 billion increase in Federal Fund Expenditures for NHS, Surface Transportation, and Interstate Maintenance is associated with a 1-point decrease in the percentage of California bridges that are eligible for replacement the following year, on average. State funding levels showed conflicting results: holding all else constant, a \$1 billion increase in State Capital Outlay for urban bridges is associated with a 1 point decrease in the percentage of California bridges that are eligible for replacement the following year, on average. However, a \$1 billion increase in State Capital Outlay for *rural* bridges is associated with a 1 point *increase* in the percentage of California bridges that are eligible for replacement the following year, on average. These unanticipated results are likely due to issues with data reliability.

Linear Model Results: Florida

Outcome variable: Average Sufficiency Rating

	Est.	SE	p-value	
(Intercept)	120.3000	23.8600	0.004	***
Time	0.4398	0.1648	0.044	**
Proportion of Bridges with Maintenance: Local Hwy	13.5600	42.4000	0.762	
Proportion of Bridges with Maintenance: State Hwy	-9.1250	15.1400	0.573	
Proportion of Bridges on Interstate System	-137.1000	40.9300	0.020	**
State Population Density	-0.0386	0.0297	0.250	
State GDP	3.88E-06	3.82E-06	0.357	
Lane-Miles of NHS Roads (1,000's of miles)	-0.0521	0.0222	0.066	*
Total VMT (1,000's of miles)	0.0114	0.0158	0.504	
Federal Funds: Expenditures for Interstate System (1-year lag)	-0.0114	0.0080	0.215	
Federal Funds: Expenditures for NHS; Surface Transportation; and Interstate Maintenance (1-year lag)	0.0004	0.0004	0.361	
Federal Funds: Expenditures for Bridge Replacement (1-year lag)	0.0006	0.0024	0.803	
State Funds: Capital Outlay for Rural Bridges (1-year lag)	0.0049	0.0018	0.040	**
State Funds: Capital Outlay for Urban Bridges (1-year lag)	-0.0003	0.0010	0.787	

* significant at 0.10 level

** significant at 0.05 level

*** significant at 0.01 level

The results for the linear model in Florida with the outcome variable of Average Sufficiency Rating show that, holding all else constant, a \$1 billion increase in State Capital Outlay for Rural Bridges is associated with an increase in average sufficiency rating among Florida bridges by 4.9-points, on average. These results suggest that in Florida, State-level funding—at least in the case of rural bridges—has the greater influence on improving the Statewide average sufficiency ratings, whereas Federal funding disbursements to the States were not found to be statistically significant.

Outcome variable: Proportion of Bridges Eligible for Rehabilitation

	Est.	SE	p-value	
(Intercept)	-0.6808	0.6234	0.325	
Time	-0.0103	0.0045	0.070	*
Proportion of Bridges with Maintenance: Local Hwy	-0.1198	1.1128	0.918	
Proportion of Bridges with Maintenance: State Hwy	0.3492	0.3844	0.405	
Proportion of Bridges on Interstate System	3.2574	0.9889	0.022	**
State Population Density	0.0009	0.0008	0.312	
State GDP	0.0000	1.00E-07	0.234	
Lane-Miles of NHS Roads (1,000's of miles)	0.0014	0.0006	0.053	*
Total VMT (1,000's of miles)	-0.0002	0.0004	0.597	
Federal Funds: Expenditures for Interstate System (1-year lag)	0.0003	0.0002	0.154	
Federal Funds: Expenditures for NHS; Surface Transportation; and Interstate Maintenance (1-year lag)	-7.00E-06	8.20E-06	0.411	
Federal Funds: Expenditures for Bridge Replacement (1-year lag)	-1.20E-05	6.71E-05	0.860	
State Funds: Capital Outlay for Rural Bridges (1-year lag)	-0.0001	4.12E-05	0.045	**
State Funds: Capital Outlay for Urban Bridges (1-year lag)	9.00E-06	2.49E-05	0.733	

In examining the influence of various factors on the proportion of bridges within Florida that are eligible for rehabilitation (i.e., a sufficiency rating < 80), holding all else constant, a \$1 billion increase in State Capital Outlay for Rural Bridges is associated with a 10-point decrease in the percentage of Florida bridges that are eligible for rehabilitation, on average. This is consistent with the results above for the average sufficiency rating outcome variable, suggesting that State-level funding has the greater influence on Statewide bridge sufficiency ratings.

Outcome variable: Proportion of Bridges Eligible for Replacement

	Est.	SE	p-value	
(Intercept)	-0.0238	0.2508	0.928	
Time	-0.0033	0.0017	0.118	
Proportion of Bridges with Maintenance: Local Hwy	-0.5462	0.4457	0.275	
Proportion of Bridges with Maintenance: State Hwy	-0.0830	0.1591	0.624	
Proportion of Bridges on Interstate System	1.3470	0.4303	0.026	**
State Population Density	2.10E-04	3.12E-04	0.530	
State GDP	-5.89E-08	4.02E-08	0.203	
Lane-Miles of NHS Roads (1,000's of miles)	0.0006	0.0002	0.058	*
Total VMT (1,000's of miles)	0.0000	0.0002	0.780	
Federal Funds: Expenditures for Interstate System (1-year lag)	4.15E-05	8.45E-05	0.644	
Federal Funds: Expenditures for NHS; Surface Transportation; and Interstate Maintenance (1-year lag)	-7.34E-06	3.70E-06	0.104	
Federal Funds: Expenditures for Bridge Replacement (1-year lag)	-1.64E-07	2.49E-05	0.995	
State Funds: Capital Outlay for Rural Bridges (1-year lag)	-4.60E-05	1.87E-05	0.058	*
State Funds: Capital Outlay for Urban Bridges (1-year lag)	3.66E-06	1.10E-05	0.754	

In examining the influence of various factors on the proportion of bridges within Florida that are eligible for replacement (i.e., a sufficiency rating < 50), holding all else constant, a \$1 billion increase in State Capital Outlay for Rural Bridges is associated with a 4.6-point decrease in the percentage of Florida bridges that are eligible for replacement, on average. As with the two previous statistical models, these results suggest that State-level funding in Florida have the greatest influence over Statewide bridge sufficiency ratings.

Linear Model Results: Illinois

Model results for all three linear models generated for Illinois indicate that there is insufficient evidence to conclude that either State or Federal funding had a significant effect on Illinois bridge sufficiency ratings in the following year. Additional data would provide a clearer picture of these relationships.

Outcome variable: Average Sufficiency Rating

	Est.	SE	p-value	
(Intercept)	-640.5000	852.2000	0.486	
Time	-0.0347	0.9333	0.972	
Proportion of Bridges with Maintenance: Local Hwy	685.4000	920.6000	0.490	
Proportion of Bridges with Maintenance: State Hwy	522.6000	912.0000	0.591	
Proportion of Bridges on Interstate System	1292.0000	1461.0000	0.417	
State Population Density	-0.1373	0.6579	0.843	
State GDP	2.52E-05	3.35E-05	0.486	
Lane-Miles of NHS Roads (1,000's of miles)	-0.3386	0.2945	0.302	
Total VMT (1,000's of miles)	0.1090	0.1995	0.608	
Federal Funds: Expenditures for Interstate System (1-year lag)	0.3165	0.6397	0.642	
Federal Funds: Expenditures for NHS; Surface Transportation; and Interstate Maintenance (1-year lag)	0.0032	0.0025	0.267	
Federal Funds: Expenditures for Bridge Replacement (1-year lag)	-0.0083	0.0192	0.683	
State Funds: Capital Outlay for Rural Bridges (1-year lag)	-0.0014	0.0054	0.800	
State Funds: Capital Outlay for Urban Bridges (1-year lag)	-0.0051	0.0061	0.439	

* significant at 0.10 level

** significant at 0.05 level

*** significant at 0.01 level

Outcome variable: Proportion of Bridges Eligible for Rehabilitation

	Est.	SE	p-value	
(Intercept)	26.8300	26.0100	0.350	
Time	0.0038	0.0285	0.898	
Proportion of Bridges with Maintenance: Local Hwy	-25.8400	28.1000	0.400	
Proportion of Bridges with Maintenance: State Hwy	-19.4900	27.8300	0.515	
Proportion of Bridges on Interstate System	-49.2400	44.5800	0.320	
State Population Density	0.0073	0.0201	0.730	
State GDP	-9.56E-07	1.02E-06	0.393	
Lane-Miles of NHS Roads (1,000's of miles)	0.0122	0.0090	0.232	
Total VMT (1,000's of miles)	-0.0013	0.0061	0.838	
Federal Funds: Expenditures for Interstate System (1-year lag)	-0.0125	0.0195	0.550	
Federal Funds: Expenditures for NHS; Surface Transportation; and Interstate Maintenance (1-year lag)	-0.0001	0.0001	0.208	
Federal Funds: Expenditures for Bridge Replacement (1-year lag)	0.0002	0.0006	0.724	
State Funds: Capital Outlay for Rural Bridges (1-year lag)	0.0001	0.0002	0.733	
State Funds: Capital Outlay for Urban Bridges (1-year lag)	0.0002	0.0002	0.447	

Outcome variable: Proportion of Bridges Eligible for Replacement

	Est.	SE	p-value	
(Intercept)	2.6480	2.7290	0.377	
Time	-6.51E-05	0.0030	0.984	
Proportion of Bridges with Maintenance: Local Hwy	-1.9960	2.9480	0.528	
Proportion of Bridges with Maintenance: State Hwy	-1.9830	2.9200	0.527	
Proportion of Bridges on Interstate System	-2.7520	4.6770	0.582	
State Population Density	-0.0010	0.0021	0.663	
State GDP	-5.02E-08	1.07E-07	0.660	
Lane-Miles of NHS Roads (1,000's of miles)	0.0007	0.0009	0.484	
Total VMT (1,000's of miles)	-0.0014	0.0006	0.077	*
Federal Funds: Expenditures for Interstate System (1-year lag)	-0.0003	0.0020	0.886	
Federal Funds: Expenditures for NHS; Surface Transportation; and Interstate Maintenance (1-year lag)	-6.00E-06	8.11E-06	0.493	
Federal Funds: Expenditures for Bridge Replacement (1-year lag)	4.04E-05	6.15E-05	0.540	
State Funds: Capital Outlay for Rural Bridges (1-year lag)	-6.19E-06	1.72E-05	0.734	
State Funds: Capital Outlay for Urban Bridges (1-year lag)	6.74E-06	1.94E-05	0.742	

Linear Model Results: Oregon

Outcome variable: Average Sufficiency Rating

	Est.	SE	p-value	
(Intercept)	114.1556	8.9485	0.000	***
Time	0.4398	0.1038	0.008	***
Proportion of Bridges with Maintenance: Local Hwy	200.3429	35.2837	0.002	***
Proportion of Bridges with Maintenance: State Hwy	-339.0314	52.1247	0.001	***
Proportion of Bridges on Interstate System	63.6885	11.4875	0.003	***
State Population Density	0.3798	0.1894	0.101	
State GDP	-0.0001	0.0000	0.004	***
Lane-Miles of NHS Roads (1,000's of miles)	-0.5663	0.0420	0.000	***
Total VMT (1,000's of miles)	-0.7325	0.0549	0.000	***
Federal Funds: Expenditures for Interstate System (1-year lag)	-0.5293	0.0647	0.000	***
Federal Funds: Expenditures for NHS; Surface Transportation; and Interstate Maintenance (1-year lag)	0.0105	0.0015	0.001	***
Federal Funds: Expenditures for Bridge Replacement (1-year lag)	-0.0153	0.0028	0.003	***
State Funds: Capital Outlay for Rural Bridges (1-year lag)	0.0006	0.0014	0.695	
State Funds: Capital Outlay for Urban Bridges (1-year lag)	-0.0074	0.0017	0.007	***

* significant at 0.10 level

** significant at 0.05 level

*** significant at 0.01 level

The results for the linear model in Oregon with the outcome variable of Average Sufficiency Rating show that there are significant effects of Federal Expenditures for the Interstate System ($p < 0.01$); Federal Expenditures for NHS, Surface Transportation, and Interstate Maintenance ($p < 0.01$); and Federal Expenditures for Bridge Replacement ($p < 0.01$); and State Capital Outlay for Urban Bridges ($p < 0.01$) on the average Oregon bridge sufficiency rating in the following year, on average.

Holding all else constant, a \$100 million increase in Federal Fund Expenditures for the Interstate System spent by Oregon is associated with an average decrease of 52.9 points in average bridge sufficiency rating in Oregon the following year. Holding all else constant, a \$100 million increase in Federal funds for NHS in Oregon, Surface Transportation, and Interstate Maintenance is associated with an average increase of 1.1 points in average bridge sufficiency rating the following year. Holding all else constant, a \$100 million increase in Federal expenditures for bridge replacement is associated with a decrease of 1.5 points, on average, in Oregon's average bridge sufficiency rating the following year. A similar, unanticipated result was found with respect to State Capital Outlay for urban bridges: holding all else constant, a \$100 million increase in these funds are associated with a 0.74 point decrease in average sufficiency rating the following year.

These results suggest that in Oregon the Federal disbursement of funds to the State for the use of the State DOT on transportation projects have greater influence on improving the Statewide average sufficiency rating of bridges. It is notable, however, that in contrast to the similar results found for California, the level of investment is an order of magnitude different in Oregon versus

California (\$100 million versus \$1 billion, respectively) to see a change in average Statewide bridge sufficiency ratings. Similarly, the magnitude of the change in sufficiency ratings (e.g., a decrease of 52.9 points) associated with this smaller \$100 million change in investment, is notably larger than in other States with a \$1 billion change in investment (e.g., 13.4 points in California and 4.9 points in Florida). The results for Oregon also show that although State capital outlays of funding for bridges were found to be statistically significant, yet in the opposite direction as expected given observed effects in other States. This slight and counter-intuitive effect may be attributed to issues data quality, which while capable of yielding statistically significant results, may nonetheless not reflect the actual effect; additional data or better quality data may help to resolve this counter-intuitive result.

Outcome variable: Proportion of Bridges Eligible for Rehabilitation

	Est.	SE	p-value	
(Intercept)	0.2698	0.1900	0.215	
Time	-0.0092	0.0024	0.012	**
Proportion of Bridges with Maintenance: Local Hwy	-3.7397	0.4198	0.000	***
Proportion of Bridges with Maintenance: State Hwy	5.6314	0.6563	0.000	***
Proportion of Bridges on Interstate System	-0.9383	0.1121	0.000	***
State Population Density	-0.0098	0.0035	0.040	**
State GDP	0.000002	2E-07	0.000	***
Lane-Miles of NHS Roads (1,000's of miles)	0.0078	0.0012	0.001	***
Total VMT (1,000's of miles)	0.0087	0.0010	0.000	***
Federal Funds: Expenditures for Interstate System (1-year lag)	0.0046	0.0011	0.009	***
Federal Funds: Expenditures for NHS; Surface Transportation; and Interstate Maintenance (1-year lag)	-0.0002	3.24E-05	0.002	***
Federal Funds: Expenditures for Bridge Replacement (1-year lag)	0.0003	4.57E-05	0.002	***
State Funds: Capital Outlay for Rural Bridges (1-year lag)	-7.8E-05	2.83E-05	0.041	**
State Funds: Capital Outlay for Urban Bridges (1-year lag)	0.0001	2.63E-05	0.044	**

In examining the influence of various factors on the proportion of bridges within Oregon that are eligible for rehabilitation (i.e., a sufficiency rating < 80), there are significant effects of all funding variables on the proportion of bridges eligible for rehabilitation in the following year, on average ($p < 0.05$). Holding all else constant, a \$10 million increase in Federal Fund Expenditures for the Interstate System is associated with a 4.6-point *increase* in the percentage of Oregon bridges that are eligible for rehabilitation the following year, on average. Similarly, holding all else constant, a \$10 million increase in Federal Expenditures for Bridge Replacement is associated with a 0.3-point increase in the percentage of Oregon bridges that are eligible for rehabilitation the following year, on average. Another result in the opposite direction than originally hypothesized was found for State Capital Outlay for Urban Bridges: a \$10 million increase in these funds was associated with a 0.1-point increase in the percentage of bridges that are eligible for rehab in the following year, on average.

Other significant relationships were found in the expected direction: holding all else constant, an additional \$10 million in Federal Expenditures for NHS, Surface Transportation, and Interstate Maintenance is associated with a 0.2 point decrease in the percentage of bridges eligible for

rehab in the following year, on average. Similarly, an additional \$10 million in State Capital Outlay for Rural Bridges is associated with a 0.08-point decrease in the percentage of bridges eligible for rehab in the following year, on average.

Outcome variable: Proportion of Bridges Eligible for Replacement

	Est.	SE	p-value	
(Intercept)	-0.6591	0.0523	0.000	***
Time	-0.0093	0.0007	0.000	***
Proportion of Bridges with Maintenance: Local Hwy	-2.9247	0.2605	0.000	***
Proportion of Bridges with Maintenance: State Hwy	5.1290	0.3949	0.000	***
Proportion of Bridges on Interstate System	-1.1355	0.0679	0.000	***
State Population Density	-0.0012	0.0013	0.378	
State GDP	1.00E-06	1E-07	0.000	***
Lane-Miles of NHS Roads (1,000's of miles)	0.0075	0.0004	0.000	***
Total VMT (1,000's of miles)	0.0130	0.0004	0.000	***
Federal Funds: Expenditures for Interstate System (1-year lag)	0.0091	0.0004	0.000	***
Federal Funds: Expenditures for NHS; Surface Transportation; and Interstate Maintenance (1-year lag)	-0.0002	1.11E-05	0.000	***
Federal Funds: Expenditures for Bridge Replacement (1-year lag)	0.0002	2.14E-05	0.000	***
State Funds: Capital Outlay for Rural Bridges (1-year lag)	1.20E-05	1.03E-05	0.307	
State Funds: Capital Outlay for Urban Bridges (1-year lag)	0.0001	1.19E-05	0.000	***

In examining the influence of various factors on the proportion of bridges within Oregon that are eligible for replacement (i.e., a sufficiency rating < 50), there are significant effects of all Federal funding variables and State funding for urban bridges on the proportion of bridges eligible for replacement in the following year, on average ($p < 0.05$). Holding all else constant, a \$10 million increase in Federal Fund Expenditures for the Interstate System is associated with a 9.1-point *increase* in the percentage of Oregon bridges that are eligible for replacement the following year, on average. Similarly, holding all else constant, a \$10 million increase in Federal Expenditures for Bridge Replacement is associated with a 0.2-point *increase* in the percentage of Oregon bridges that are eligible for replacement the following year, on average. Another result in the opposite direction than originally hypothesized was found for State Capital Outlay for Urban Bridges: a \$10 million increase in these funds was associated with a 0.1-point increase in the percentage of bridges that are eligible for replacement in the following year, on average.

A significant relationship in the expected direction as found for the remaining Federal funds: holding all else constant, an additional \$10 million in Federal Expenditures for NHS, Surface Transportation, and Interstate Maintenance is associated with a 0.2 point *decrease* in the percentage of bridges eligible for replacement in the following year, on average.

In both of the models examining the proportion of bridges eligible for rehabilitation and for replacement in Oregon, many of the significant relationships between funding and Oregon bridge sufficiency is in the opposite direction of what researchers originally hypothesized. The plotted trends showing average sufficiency ratings for Oregon bridges over time show that Statewide average bridge sufficiency was relatively flat across the 20-year study period. In addition,

Figure 11 shows that Oregon has a substantially smaller number of bridges than the other four States, resulting in a smaller bridge dataset upon which to build statistical models. These two factors may explain, to some extent, the unexpected results of the statistical models for Oregon, where increases in funding are associated with increases in sufficiency ratings. The relatively smaller size of the bridge dataset, as well as a less distinct trend of changing bridge sufficiency ratings over time, may also explain the difference in the magnitudes of investment in Oregon as compared with other States (e.g., \$10 million versus \$100 million) that are associated with changes in sufficiency ratings. Additional data for Oregon for the current study period, or a longer study period than 20 years, may help to clarify or explain these unexpected outcomes.

There are also potential policy-oriented explanations for these unexpected results. First, it is possible that given the comparatively smaller number of bridges in Oregon (~8,000) as compared with other States, funds were directed to projects elsewhere in the State's transportation system. An alternative is that bridges, particularly in rural locations, were not prioritized for investment in comparison with other bridges or other transportation infrastructure. Nonetheless, these potential policy explanations are speculative at best; additional research is required to better understand, clarify, or correct these findings.

Linear Model Results: Texas

Outcome variable: Average Sufficiency Rating

	Est.	SE	p-value	
(Intercept)	2.9430	111.5000	0.980	
Time	-0.0802	0.4336	0.861	
Proportion of Bridges with Maintenance: Local Hwy	68.3900	115.7000	0.580	
Proportion of Bridges with Maintenance: State Hwy	55.9900	114.6000	0.646	
Proportion of Bridges on Interstate System	9.2840	37.3200	0.813	
State Population Density	0.3849	0.1513	0.052	*
State GDP	4.750E-07	2.89E-06	0.876	
Lane-Miles of NHS Roads (1,000's of miles)	-0.0242	0.0228	0.337	
Total VMT (1,000's of miles)	-0.0589	0.0221	0.044	**
Federal Funds: Expenditures for Interstate System (1-year lag)	-0.0175	0.0118	0.197	
Federal Funds: Expenditures for NHS; Surface Transportation; and Interstate Maintenance (1-year lag)	0.0007	0.0003	0.052	*
Federal Funds: Expenditures for Bridge Replacement (1-year lag)	0.0011	0.0056	0.856	
State Funds: Capital Outlay for Rural Bridges (1-year lag)	-0.0038	0.0051	0.484	
State Funds: Capital Outlay for Urban Bridges (1-year lag)	-0.0041	0.0032	0.252	

* significant at 0.10 level

** significant at 0.05 level

*** significant at 0.01 level

The results for the linear model in Texas with the outcome variable of Average Sufficiency Rating show that, holding all else constant, a \$100 million increase in Federal Expenditures for NHS, Surface Transportation, and Interstate Maintenance is associated with an increase in average sufficiency rating among Texas bridges by 0.07 units, on average.

Outcome variable: Proportion of Bridges Eligible for Rehabilitation

	Est.	SE	p-value	
(Intercept)	0.9988	4.5170	0.834	
Time	0.0185	0.0176	0.342	
Proportion of Bridges with Maintenance: Local Hwy	-0.0292	4.6910	0.995	
Proportion of Bridges with Maintenance: State Hwy	-0.2015	4.6450	0.967	
Proportion of Bridges on Interstate System	0.7841	1.5130	0.626	
State Population Density	-0.0141	0.0061	0.069	*
State GDP	-1.07E-07	1.17E-07	0.405	
Lane-Miles of NHS Roads (1,000's of miles)	0.0013	0.0009	0.207	
Total VMT (1,000's of miles)	0.0019	0.0009	0.088	*
Federal Funds: Expenditures for Interstate System (1-year lag)	0.0007	0.0005	0.208	
Federal Funds: Expenditures for NHS; Surface Transportation; and Interstate Maintenance (1-year lag)	-2.94E-05	1.04E-05	0.037	**
Federal Funds: Expenditures for Bridge Replacement (1-year lag)	0.0001	0.0002	0.819	
State Funds: Capital Outlay for Rural Bridges (1-year lag)	0.0001	0.0002	0.566	
State Funds: Capital Outlay for Urban Bridges (1-year lag)	0.0001	0.0001	0.670	

In examining the influence of various factors on the proportion of bridges within Texas that are eligible for rehabilitation (i.e., a sufficiency rating < 80), the results indicate that holding all else constant, a \$100 million increase in Federal Expenditures for NHS, Surface Transportation, and Interstate Maintenance is associated with a 0.29 point decrease in the percentage of Texas bridges that are eligible for rehabilitation, on average.

Outcome variable: Proportion of Bridges Eligible for Replacement

	Est.	SE	p-value	
(Intercept)	0.7999	0.4255	0.119	
Time	-0.0053	0.0017	0.024	**
Proportion of Bridges with Maintenance: Local Hwy	-0.7223	0.4418	0.163	
Proportion of Bridges with Maintenance: State Hwy	-0.4304	0.4375	0.370	
Proportion of Bridges on Interstate System	-0.4707	0.1425	0.021	**
State Population Density	-0.0014	0.0006	0.064	*
State GDP	4.90E-08	1.10E-08	0.007	***
Lane-Miles of NHS Roads (1,000's of miles)	-1.15E-04	8.71E-05	0.243	
Total VMT (1,000's of miles)	-6.75E-06	8.42E-05	0.939	
Federal Funds: Expenditures for Interstate System (1-year lag)	3.48E-05	4.49E-05	0.473	
Federal Funds: Expenditures for NHS; Surface Transportation; and Interstate Maintenance (1-year lag)	1.48E-07	9.79E-07	0.885	
Federal Funds: Expenditures for Bridge Replacement (1-year lag)	6.51E-07	2.13E-05	0.977	
State Funds: Capital Outlay for Rural Bridges (1-year lag)	-1.72E-05	1.94E-05	0.416	
State Funds: Capital Outlay for Urban Bridges (1-year lag)	1.06E-05	1.22E-05	0.424	

In examining the influence of various factors on the proportion of bridges within Texas that are eligible for replacement (i.e., a sufficiency rating < 50), insufficient evidence exists to conclude that there are significant effects of State or Federal funding on the proportion of Texas bridges that are eligible for replacement.

For all statistical models for Texas, results suggest that Federal funding has a greater influence on bridge average sufficiency ratings across the State, as well as on the proportion of bridges eligible for rehabilitation. The comparatively modest increases in bridge sufficiency given \$100 million investments may be partially attributed to the significantly greater number of bridges in Texas, as compared with other States. Nonetheless, the inconclusive results with respect to the influence of funding on the number of bridges eligible for replacement suggest that data quality may have had an adverse impact on the model outcomes, and that either additional or higher-quality data may improve model outcomes.

5. Conclusions

This study sought to identify and characterize the potential influences of State policies on critical infrastructure resilience. To accomplish this, it examined the specific case of State-level capital transportation policies from five States (California, Florida, Illinois, Oregon and Texas) and the resilience of bridges located on roadways under the management and oversight of State DOTs. This study collected and analyzed State policy data from open-source research, legislative record, and subject-matter expert interviews with State DOT personnel. State capital outlay and expenditure data came from the FHWA's Highway Statistic Series, which collects and aggregates State-level data on an annualized basis in a centralized Federal database. Bridge resilience information utilized the NBI, a federally maintained bridge database containing more than 100 bridge inspection items that State DOTs provide for aggregation and recording. Bridge resilience used an aggregate measure of bridge condition and inspection items from the NBI called the Bridge Sufficiency Rating, which incorporates information related to a bridge's structural deficiency, serviceability and functional obsolescence, essentiality for public use, and other special reductions/restrictions relevant. Bridge Sufficiency Rating is then an assessment of the bridge's overall condition; this study uses a proxy for resilience as related to the mitigation dimension of resilience discussed earlier in the methodology section.

Researchers analyzed these data items using a structured policy analysis approach to identify linkages between individual State-level capital funding policy information and federally aggregated State expenditure and capital outlay data. They then analyzed this expenditure and capital outlay data was using linear regressive statistical models with various measures of sufficiency ratings (e.g., Statewide average, proportion below 80, proportion below 50) as the outcome variables to identify potential linkages between actual bridge capital spending and changes in this measure of bridge resilience.

The results showed that for some States in this study, an apparent linkage exists between State policy information and the State spending information. Furthermore, the structured policy analysis identified that State DOT bridge funding policies can generally be characterized as either *proactive* or *reactive*. That is, *proactive* States enact funding policies to maintain an acceptable or benchmarked state of repair among State highway bridges. Conversely, *reactive* States enact funding policies intended to generate funding to recover or restore from significant deficiencies that exist in the highway bridges due to inefficient previous funding programs or damage and distress caused by natural disasters (or the threat thereof). While it is difficult to characterize one policy approach as more beneficial than another without understanding broader Statewide policy, political, and other contexts, there are some notable tradeoffs and considerations. For example, proactive policy approaches may enable better long-term performance planning due to the more easily anticipated nature of sustained annual funding through proactive actions.

Although only those State policies that occurred during the 20-year analytical timeframe of this study were included in the policy analysis, that timeframe does enable the study to distinguish the dichotomy of recent policies as proactive versus reactive. It is notable, however, that such an analytical timeframe does lack the longer view of State funding policy that may be available if this study period was extended to include earlier decades. Doing so may uncover additional types

or characterizations of State capital investment policies that could prove insightful or beneficial in today's policy environment. Certainly most of the State and Federal level highway systems were initially constructed well before the beginning of this study's analysis timeframe; the State-level policies enacted to support those efforts could add a broader point of view to this study. Nonetheless, the policy analysis outcomes in this study do provide valuable information to decision makers looking to influence critical infrastructure funding in today's capital investment policy environment.

The results of the statistical modeling intended to identify linkages between State bridge capital expenditures and bridge sufficiency ratings as a measure of physical resilience (and therefore indirect linkages between funding policies and physical resilience) are unfortunately less conclusive. The strongest results—those for California and Florida—showed that increased funding for capital investment projects did positively influence bridge resilience outcomes. However, there was a significant distinction between those two States with respect to the source of funding. In California, for every \$1 billion in increased investment in *Federal funding for interstates*, the average bridge sufficiency ratings increased by 13.4 points. In Florida, conversely, for every \$1 billion in increased investment in *State capital outlay for bridges* (and more specifically, for rural bridges), the average bridge sufficiency ratings increased by 4.9 points. This distinction between Federal funding and State-level funding may be reflective of the proactive/reactive dichotomy identified during the policy analysis in that States with reactive policies (which may be necessitated by unforeseen conditions, such as the increased awareness of seismic threats) may rely more heavily on Federal funding to support large, Statewide capital investment programs, such as the Bridge Seismic Retrofit program, or to support other State transportation capital investment so that State-level funding policies can instead focus on these specific capital investment programs. States with proactive policies may be in a better position to anticipate future funding needs (as unanticipated conditions are less common, and therefore do not necessitate reactive policies in respond) and then take action at the State-level to ensure funding for those anticipated investment needs. These conclusions are somewhat contradicted by the results from Texas, a State characterized by proactive policies, but in which the Federal funding variables were shown to be more influential with respect to bridge resilience outcomes. However, in the case of Texas, the magnitude of that influence was shown to be very small, a fact that may instead indicate the need for additional or better data to further clarify those results. A larger sample size increases the statistical power, that is, the probability that a statistically significant relationship is found given that one exists. It is also important to remember that statistical significance is not the same as practical significance. Because evidence of the hypothesized relationship is seen in other models, the possibility that data quality is a potential issue that is resulting in inconclusive and/or unanticipated outcomes must be considered.

In addition to the analytical results, this study yielded notable methodological outcomes. First, the overall methodology of this project (as illustrated in Figure 2) has been shown capable of yielding significant results connecting State policies with critical infrastructure resilience. However, as some outcomes were mixed, further refinement of the methodology could better distinguish if these inconclusive results are attributed to the analytical approach, or the data that was used to support the analysis. This evolution of the study methodology could both strengthen outcomes and ultimately provide greater insight to decision makers. For example, a more systematic connection of funding policies to historical funding records may strengthen the

linkage between those two datasets and enable the expansion of the methodology beyond direct linkages to explore indirect or other exogenous factors. For example, if it were shown that only a weak to moderate connection between bridge capital funding policies and actual bridge investment expenditures existed, a more systematic or detailed characterization of this linkage could better enable the study to identify what factors external to policies themselves (e.g., governmental politics, competing non-transportation priorities, competing non-bridge priorities) affected capital expenditure.

The analytical methodology also demonstrated the importance of both high-quality, reliable and readily available datasets to conduct these analyses. Transportation infrastructure, and more specifically bridge infrastructure, is somewhat unique among critical infrastructure systems in that there are large and detailed datasets collated, aggregated and published at the Federal level containing information that is collected at the State-level for State, county, and locally owned public infrastructure. This ensures not only the availability of data for all States, but also consistency in the data across all States, which more readily enables comparative analyses such as this study. However, despite the greater availability of comparative datasets for bridge infrastructure, issues persist that substantially hamper analysis. First, data are collected on an annualized basis; therefore, longitudinal studies that intend to look at trends over time require substantial post-processing to compile, sort and collate data into a useable dataset. In that respect, the data produced for this study should be viewed as a unique and significant deliverable in its own right.

Second, this study demonstrated that the lack of readily available of data for analyses over longer timeframes may prevent more conclusive outcomes from statistical models. The 20-year timeframe in this study was dictated by the availability of NBI bridge data, which only began to be collected electronically or digitized in 1995. Therefore, while NBI data exists for earlier time periods, there may be diminishing returns on incorporating earlier data as the processing of that data into a useable form would require substantial added effort.

These methodological and data-specific considerations are important when evaluating the deployment of this study methodology to other types of critical infrastructure, where infrastructure data and investment-specific funding data may be either collected at the State or local level, is significantly different in form and detail across jurisdictions, or else is largely unavailable.

The consideration of how State-level policies influence critical infrastructure resilience is increasingly important. For decades the United States has made significant investment in expanding or building new infrastructure systems; as these systems largely approach completion, it may now be time for policymakers to turn their focus on hardening or increasing the resilience of these systems to ensure their longevity and availability for years to come. This study provides a first step in better understanding the connection between State capital funding policies, State capital investment in bridge infrastructure, and the resilience of roadway bridges as but one component of the Nation's critical infrastructure.

Appendix A – Policy Analysis Department of Transportation (DOT) Contacts and Question Set

State DOT	Name	Title
Oregon	Bruce Johnson	State Bridge Engineer
Florida	Lisa Saliba	Director, Office of Work Program & Budget
	Richard Kerr	Bridge Management Inspection Engineer
	Kendra Sheffield	Manager of Work Program Development, Office of Work Program and Budget
	Daniel Cashin	Manager of Finance, Program, and Recourse Allocation, Office of Work Program and Budget
Illinois	Traci Sisk	Section Chief, Office of Program Management, Planning, and Programming
	Missy Doedtmann	Section Chief, Program Development
	Erin Aleman	Director, Office of Program Management, Planning, and Programming
Texas	Gregg Freeby	Director, Bridge Division

* Caltrans did not respond to multiple attempts to contact for interviews, however the multitude of information available from open-sources and published by State offices warranted their continued inclusion

Question Set

- Can you highlight key policies and measures in your State that impact bridge resilience -- preparedness, mitigation, response, and recovery?
 - What are responsibilities at State, local, and Federal level
- How are bridge maintenance, rehabilitation, and new structure construction funded?
 - Funding sources (e.g., taxes, tolls, Federal Highway Administration funding)
 - Authorization process (State, Federal)
 - Schedule for funding levels review/renewal
- What legislative/regulatory conditions impact infrastructure resilience funding?
 - Does any major policy or legislation come to mind (e.g., Federal stimulus, 2014 California Seismic Retrofit Program)?
 - How is infrastructure/bridge resilience funding impacted by State-level budget issues?
 - In a scenario of limited funding, how do tradeoffs play out between maintenance, rehabilitation, and new structure construction?
- What advice would you have for analyzing the impact of State policy on infrastructure resilience in your or other States?
 - Agencies and individuals to contact (DOT, Bridge Engineer, regional/national association)
 - Any additional comments on overall approach?
- Do you use Multi-Year Plans?
 - Why make X-year plan every year? (as opposed one plan every X years) and how often (and why) are projections from a previous year's plan changed?
- How does programming for bridge maintenance/repair take place in terms of the driving factors—do the projects drive the budget or are the projects prioritized based on available (and forecasted) budget?
 - Are there “controls” policies that ensure that the allocated amount for a given year's program benefit only this program?

7. Currently the State's share of funding is about XX percent, and the rest comes from the Federal Government.
 - a. Has this number changed/fluctuated drastically over the past 25 years?
 - i. What has caused such fluctuation?
 - b. Are there State policies that limit/secure a share of the Federal Funding to go towards State Highway Infrastructure?
 - ii. Does the Federal Government have a say in this, or is your State autonomous in making such decisions?
8. Where do the funds go that are collected from State rules (e.g., taxes or motor vehicle registration fees)?
 - a. Have there been State policies enacted that, for example, secure a percentage of funds to be exclusively used for State Highway Infrastructure?
 - b. What about tolls?
 - i. Do the tolls collected on the State Toll Roads only benefit the infrastructure on these roads, or do the other State highways benefit (directly or indirectly) from toll funds?
 - ii. Conversely, do Toll Roads benefit from State funds raised by means other than tolls?
9. How much money did your State receive through American Recovery and Reinvestment Act Transportation Investment Generating Economic Recovery grants to aid the State Highway Infrastructure?
10. Can you comment on the effectiveness of previous State policies (e.g., in Illinois the then Gov. Pat Quinn's policy of increasing taxes on certain products, such as cigarettes, to fund the *Jump Start Capital Plan/Accelerated Construction Program*, or Gov. George Ryan's *Illinois First!* program)?
 - a. Do funds (or a portion of them) collected from these taxes still go towards State highway infrastructure, or were they more of a one-time stimulus package?
11. Can you provide insight into policies as far back as the early 2000's and early 90's that have affected your State's highway infrastructure?
12. How is funding for emergencies (such as a bridge collapse) handled?

Appendix B - Bridge Funding and Control Variables

Variable Number	Variable Name	Variable Type	Variable Description	Variable Units	Variable Source Data	Link to Data Source ²
1	State	Indexing	The full name of the U.S. State	Text	N/A	N/A
2	Year	Indexing	The specific study year within the multi-year study period to which the data point is attributed	Year	N/A	N/A
3	ADTTTruck	Bridge Data	The Average Daily Truck Traffic (ADTT) volumes for each bridge in the State averaged across all bridges for that study year	Vehicles/day	National Bridge Inventory (USDOT)	https://www.fhwa.dot.gov/bridge/nbi/ascii.cfm
4	AvgADT	Bridge Data	The Average Daily Traffic (ADT) volumes for each bridge in the State averaged across all bridges for that study year	Vehicles/day	National Bridge Inventory (USDOT)	https://www.fhwa.dot.gov/bridge/nbi/ascii.cfm
5	AvgBridgeAge	Bridge Data	The average age of bridges on public roadways within a State, by study year	Years	National Bridge Inventory (USDOT)	https://www.fhwa.dot.gov/bridge/nbi/ascii.cfm
6	AvgSuffRating	Bridge Data	The average sufficiency ratings for all State bridges, by study year	Unitless value between 0 and 100	National Bridge Inventory (USDOT)	https://www.fhwa.dot.gov/bridge/nbi/ascii.cfm
7	EligibleForRehab	Bridge Data	The total number of bridges within the State that are eligible for rehabilitation, based on a sufficiency rating of less than 80, by year	Count of bridges	National Bridge Inventory (USDOT)	https://www.fhwa.dot.gov/bridge/nbi/ascii.cfm
8	EligibleForReplacement	Bridge Data	The number of bridges (by study year and State) that are eligible for replacement, based on having a Sufficiency Rating of less than 50	Count of bridges	National Bridge Inventory (USDOT)	https://www.fhwa.dot.gov/bridge/nbi/ascii.cfm
9	LocalHwyMaintenance	Bridge Data	The number of miles of highway within the State for which local governments are primarily responsible for highway maintenance, by study year	Count of miles	National Bridge Inventory (USDOT)	https://www.fhwa.dot.gov/bridge/nbi/ascii.cfm
10	MedianSuffRating	Bridge Data	The median sufficiency rating for all State bridges, by study year	Unitless value between 0 and 100	National Bridge Inventory (USDOT)	https://www.fhwa.dot.gov/bridge/nbi/ascii.cfm

² Where source data is year specific, single-year Bridge Data links for 2014 are given as example

Variable Number	Variable Name	Variable Type	Variable Description	Variable Units	Variable Source Data	Link to Data Source ²
11	PropLocalHwyMain tenance	Bridge Data	The proportion of the total highway miles within the State for which local governments are primarily responsible for highway maintenance, by study year	Decimal percentage of miles	National Bridge Inventory (USDOT)	https://www.fhwa.dot.gov/bridge/nbi/ascii.cfm
12	PropRuralInterstate	Bridge Data	The proportion of the total number of interstate highway miles within the State that are located in rural areas, by year	Decimal percentage of total miles	National Bridge Inventory (USDOT)	https://www.fhwa.dot.gov/bridge/nbi/ascii.cfm
13	PropServiceTypeOnHwy	Bridge Data	The proportion of the total number of bridges within the State for which the Service Type of roadway carried by the bridge is identified as a highway, as opposed to non-highway roadways	Decimal percentage of total bridges	National Bridge Inventory (USDOT)	https://www.fhwa.dot.gov/bridge/nbi/ascii.cfm
14	PropServiceTypeUnderHwy	Bridge Data	The proportion of the total number of bridges within the State for which the Service Type of roadway carried by the bridge is identified as a highway, as opposed to non-highway roadways or non-roadways (e.g., rivers)	Decimal percentage of total bridges	National Bridge Inventory (USDOT)	https://www.fhwa.dot.gov/bridge/nbi/ascii.cfm
15	PropStateHwyMain tenance	Bridge Data	The proportion of the total highway miles within the State for which State government is primarily responsible for highway maintenance, by study year	Decimal percentage of miles	National Bridge Inventory (USDOT)	https://www.fhwa.dot.gov/bridge/nbi/ascii.cfm
16	PropSuffRating50	Bridge Data	The proportion of the total number of bridges within the State with a Sufficiency Rating below 50, by study year	Decimal percentage of bridges	National Bridge Inventory (USDOT)	https://www.fhwa.dot.gov/bridge/nbi/ascii.cfm
17	PropSuffRating80	Bridge Data	The proportion of the total number of bridges within the State with a Sufficiency Rating below 80, by study year	Decimal percentage of bridges	National Bridge Inventory (USDOT)	https://www.fhwa.dot.gov/bridge/nbi/ascii.cfm
18	PropUrbanInterstate	Bridge Data	The proportion of the total number of interstate highway miles within the State that are located in urban areas, by year	Decimal percentage of total miles	National Bridge Inventory (USDOT)	https://www.fhwa.dot.gov/bridge/nbi/ascii.cfm

Variable Number	Variable Name	Variable Type	Variable Description	Variable Units	Variable Source Data	Link to Data Source ²
19	RuralInterstate	Bridge Data	The number of interstate highway miles within the State that are located in rural areas, by year	Count of miles	National Bridge Inventory (USDOT)	https://www.fhwa.dot.gov/bridge/nbi/ascii.cfm
20	ServiceTypeOnHwy	Bridge Data	The number of bridges within the State for which the Service Type of roadway carried by the bridge is identified as a highway	Count of bridges	National Bridge Inventory (USDOT)	https://www.fhwa.dot.gov/bridge/nbi/ascii.cfm
21	ServiceTypeUnderHwy	Bridge Data	The number of bridges within the State for which the Service Type of roadway carried by the bridge is identified as a highway, as opposed to non-highway roadways or non-roadways (e.g., rivers)	Count of bridges	National Bridge Inventory (USDOT)	https://www.fhwa.dot.gov/bridge/nbi/ascii.cfm
22	StateHwyMaintenance	Bridge Data	The number of miles of highway within the State for which State government is primarily responsible for highway maintenance, by study year	Count of miles	National Bridge Inventory (USDOT)	https://www.fhwa.dot.gov/bridge/nbi/ascii.cfm
23	SumBridgeLaneMiles	Bridge Data	The total number of lane miles of public roadway carried upon bridges (i.e., length of bridge surface multiplied by the number of lanes), by study year	Count of lane miles	National Bridge Inventory (USDOT)	https://www.fhwa.dot.gov/bridge/nbi/ascii.cfm
24	TotalBridgeCount	Bridge Data	The total number of bridges on public roadways within the State, by study year	Count of bridges	National Bridge Inventory (USDOT)	https://www.fhwa.dot.gov/bridge/nbi/ascii.cfm
25	UrbanInterstate	Bridge Data	The number of interstate highway miles within the State that are located in urban areas, by year	Count of miles	National Bridge Inventory (USDOT)	https://www.fhwa.dot.gov/bridge/nbi/ascii.cfm
26	GDP	Control / Index	The Statewide gross domestic product for study year	U.S. Dollars	US Census	
27	Index	Control / Index	The State Index Number as assigned in the US Census	Text	US Census	
28	LandSqMiles	Control / Index	The total land area of the State during the study year, excluding the surface area of water features (e.g., lakes)	Square miles	US Census	
29	Pop	Control / Index	The total population of the U.S. State, by study year	Count of persons	US Census	
30	PopDensity	Control / Index	The Statewide population density by study year	Persons per square mile	US Census	

Variable Number	Variable Name	Variable Type	Variable Description	Variable Units	Variable Source Data	Link to Data Source ²
31	PopDensityAvg	Control / Index	The average Statewide population density for the multi-year study period	Persons per square mile	US Census	
32	PopDensityPctChange	Control / Index	The annual percentage change in the Statewide population density as compared with the previous study year	Decimal percentage	US Census	
33	PopDensityPctChangeAvg	Control / Index	The average percentage change in Statewide population density for the multi-year study period	Decimal percentage	US Census	
34	state_abbrev	Control / Index	The State name abbreviation	Text	US Census	
35	state_names	Control / Index	The full name of the U.S. State	Text	US Census	
36	TotalSqMiles	Control / Index	The total area of the State during the study year, including the surface area of water features (e.g., lakes)	Square miles	US Census	
37	LaneMiles_NationalHwySystem	State Highway System	The number of lane miles of roadway in the State that are part of the National Highway System, by study year	Count of lane miles	FHWA Office of Highway Policy Information - Highway Statistics Table HM43 "NATIONAL HIGHWAY SYSTEM LANE-LENGTH - 2014, LANE-MILES BY FUNCTIONAL SYSTEM"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/hm43.cfm
38	LaneMiles_NHS1000s	State Highway System	The number of lane miles of roadway in the State that are part of the National Highway System, by study year, divided by 1000	Count of lane miles / 1000	FHWA Office of Highway Policy Information - Highway Statistics Table HM43 "NATIONAL HIGHWAY SYSTEM LANE-LENGTH - 2014, LANE-MILES BY FUNCTIONAL SYSTEM"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/hm43.cfm
39	LaneMiles_NHSAvg	State Highway System	The average number of lane miles of roadways in the State that are part of the National Highway System for the multi-year study period	Count of lane miles	FHWA Office of Highway Policy Information - Highway Statistics Table HM43 "NATIONAL HIGHWAY SYSTEM LANE-LENGTH - 2014, LANE-MILES BY FUNCTIONAL SYSTEM"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/hm43.cfm

Variable Number	Variable Name	Variable Type	Variable Description	Variable Units	Variable Source Data	Link to Data Source ²
40	LaneMiles_Total	State Highway System	The total number of lane miles of public roadways within the State, by study year	Count of lane miles	FHWA Office of Highway Policy Information - Highway Statistics Table HM10 "NATIONAL HIGHWAY SYSTEM ROAD LENGTH - 2014, MILES BY OWNERSHIP"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/hm40.cfm
41	LaneMiles_Total1000s	State Highway System	The total number of lane miles of public roadways within the State, by study year, divided by 1000	Count of lane miles / 1000	FHWA Office of Highway Policy Information - Highway Statistics Table HM10 "NATIONAL HIGHWAY SYSTEM ROAD LENGTH - 2014, MILES BY OWNERSHIP"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/hm40.cfm
42	VehicleMilesTraveled_NationalHwySystem	State Highway System	The number of Vehicle Miles Traveled (VMT) on roadways within the State that are part of the National Highway System, by study year	Count of miles	FHWA Office of Highway Policy Information - Highway Statistics Table VM3 "FEDERAL - AID HIGHWAY TRAVEL - 2014, ANNUAL VEHICLE - MILES"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/vm3.cfm
43	VehicleMilesTraveled_Total	State Highway System	The total number of VMT on public roadways in the State, by study year	Count of miles	FHWA Office of Highway Policy Information - Highway Statistics Table VM2 "FUNCTIONAL SYSTEM TRAVEL - 2014, ANNUAL VEHICLE - MILES"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/vm2.cfm
44	VMT_NHS1000s	State Highway System	The number of VMT on roadways within the State that are part of the National Highway System, by study year, divided by 1000	Count of miles / 1000	FHWA Office of Highway Policy Information - Highway Statistics Table VM3 "FEDERAL - AID HIGHWAY TRAVEL - 2014, ANNUAL VEHICLE - MILES"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/vm2.cfm
45	VMT_NHSAvg	State Highway System	The average number of VMT on roadways within the State that are part of the National Highway System, for multi-year study period	Count of miles	FHWA Office of Highway Policy Information - Highway Statistics Table VM3 "FEDERAL - AID HIGHWAY TRAVEL - 2014, ANNUAL VEHICLE - MILES"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/vm3.cfm

Variable Number	Variable Name	Variable Type	Variable Description	Variable Units	Variable Source Data	Link to Data Source ²
46	VMT_Total1000s	State Highway System	The total number of VMT on public roadways in the State, by study year, divided by 1000	Count of miles / 1000	FHWA Office of Highway Policy Information - Highway Statistics Table VM2 "FUNCTIONAL SYSTEM TRAVEL - 2014, ANNUAL VEHICLE - MILES"	https://www.fhwa.dot.gov/policyinformation/statistics/2015/vm2.cfm
47	FedFundsExpenditures_BridgeReplacement	Capital Investment	The expenditure of Federal funds within the State on roadway projects for bridge replacement	Thousands of U.S. Dollars	FHWA Office of Highway Policy Information - Highway Statistics Table FA3 "EXPENDITURE OF FEDERAL FUNDS ADMINISTERED BY THE FEDERAL HIGHWAY ADMINISTRATION, DURING FISCAL YEAR 2014"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/fa3.cfm
48	FedFundsExpenditures_BridgeReplacementProp	Capital Investment	Proportion of Federal funds expenditures for bridge replacement, as calculated = FedFundsExpenditures_BridgeReplacement / sum(FedFundsExpenditures variables 45 through 49)	U.S. Dollars	FHWA Office of Highway Policy Information - Highway Statistics Table FA10 "OBLIGATION OF FEDERAL FUNDS FOR HIGHWAY IMPROVEMENTS FISCAL YEAR 2014, (INTENDED TO SHOW ONLY PROJECTS AUTHORIZED IN FY 2014)"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/fa10.cfm
49	FedFundsExpenditures_InterstateMaintenance	Capital Investment	The expenditure of Federal funds within the State on roadway maintenance projects that are part of the Interstate Highway System	Thousands of U.S. Dollars	FHWA Office of Highway Policy Information - Highway Statistics Table FA3 "EXPENDITURE OF FEDERAL FUNDS ADMINISTERED BY THE FEDERAL HIGHWAY ADMINISTRATION, DURING FISCAL YEAR 2014"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/fa3.cfm
50	FedFundsExpenditures_InterstateSystem	Capital Investment	The expenditure of Federal funds within the State on roadway construction projects that are part of the Interstate Highway System, including Interstate Construction, Interstate Discretionary funds, and Interstate Gap Closing funds	Thousands of U.S. Dollars	FHWA Office of Highway Policy Information - Highway Statistics Table FA3 "EXPENDITURE OF FEDERAL FUNDS ADMINISTERED BY THE FEDERAL HIGHWAY ADMINISTRATION, DURING FISCAL YEAR 2014"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/fa3.cfm

Variable Number	Variable Name	Variable Type	Variable Description	Variable Units	Variable Source Data	Link to Data Source ²
51	FedFundsExpenditures_NationalHighwaySystem	Capital Investment	The expenditure of Federal funds within the State on roadway projects that are part of the National Highway System	Thousands of U.S. Dollars	FHWA Office of Highway Policy Information - Highway Statistics Table FA3 "EXPENDITURE OF FEDERAL FUNDS ADMINISTERED BY THE FEDERAL HIGHWAY ADMINISTRATION, DURING FISCAL YEAR 2014"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/fa3.cfm
52	FedFundsExpenditures_SurfaceTransportationProgram	Capital Investment	The expenditure of Federal funds within the State on roadway projects under the Surface Transportation Program	Thousands of U.S. Dollars	FHWA Office of Highway Policy Information - Highway Statistics Table FA3 "EXPENDITURE OF FEDERAL FUNDS ADMINISTERED BY THE FEDERAL HIGHWAY ADMINISTRATION, DURING FISCAL YEAR 2014"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/fa3.cfm
53	Inflation2014	Capital Investment	Inflation rate as compared with 2014 dollars	Decimal percentage	Bureau of Labor Statistics	
54	RuralCollectors_BridgeReplacement_StateCapitalOutlay	Capital Investment	The capital outlay of expenditures for construction and system preservation projects related to bridge replacement on rural collectors (excludes local roadways)	Thousands of U.S. Dollars	FHWA Office of Highway Policy Information - Highway Statistics Table SF12a "State Highway Agency Capital Outlay - 2014, For Arterial Systems in Rural Areas, Classified by Improvement Types"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/sf12a.cfm
55	RuralCollectors_MajorBridgeRehab_StateCapitalOutlay	Capital Investment	The capital outlay of expenditures for construction and system preservation projects related to major bridge rehabilitation on rural collectors (excludes local roadways)	Thousands of U.S. Dollars	FHWA Office of Highway Policy Information - Highway Statistics Table SF12a "State Highway Agency Capital Outlay - 2014, For Arterial Systems in Rural Areas, Classified by Improvement Types"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/sf12a.cfm

Variable Number	Variable Name	Variable Type	Variable Description	Variable Units	Variable Source Data	Link to Data Source ²
56	RuralCollectors_MinorBridgeRehab_StateCapitalOutlay	Capital Investment	The capital outlay of expenditures for construction and system preservation projects related to minor bridge rehabilitation on rural collectors (excludes local roadways)	Thousands of U.S. Dollars	FHWA Office of Highway Policy Information - Highway Statistics Table SF12a "State Highway Agency Capital Outlay - 2014, For Arterial Systems in Rural Areas, Classified by Improvement Types"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/sf12a.cfm
57	RuralCollectors_NewBridge_StateCapitalOutlay	Capital Investment	The capital outlay of expenditures for construction and system preservation projects related to new bridge construction on rural collectors (excludes local roadways)	Thousands of U.S. Dollars	FHWA Office of Highway Policy Information - Highway Statistics Table SF12a "State Highway Agency Capital Outlay - 2014, For Arterial Systems in Rural Areas, Classified by Improvement Types"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/sf12a.cfm
58	RuralInterstate_BridgeReplacement_StateCapitalOutlay	Capital Investment	The capital outlay of expenditures for construction and system preservation projects related to bridge replacement on rural interstates	Thousands of U.S. Dollars	FHWA Office of Highway Policy Information - Highway Statistics Table SF12a "State Highway Agency Capital Outlay - 2014, For Arterial Systems in Rural Areas, Classified by Improvement Types"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/sf12a.cfm
59	RuralInterstate_MajorBridgeRehab_StateCapitalOutlay	Capital Investment	The capital outlay of expenditures for construction and system preservation projects related to major bridge rehabilitation on rural interstates	Thousands of U.S. Dollars	FHWA Office of Highway Policy Information - Highway Statistics Table SF12a "State Highway Agency Capital Outlay - 2014, For Arterial Systems in Rural Areas, Classified by Improvement Types"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/sf12a.cfm
60	RuralInterstate_MinorBridgeRehab_StateCapitalOutlay	Capital Investment	The capital outlay of expenditures for construction and system preservation projects related to minor bridge rehabilitation on rural interstates	Thousands of U.S. Dollars	FHWA Office of Highway Policy Information - Highway Statistics Table SF12a "State Highway Agency Capital Outlay - 2014, For Arterial Systems in Rural Areas, Classified by Improvement Types"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/sf12a.cfm

Variable Number	Variable Name	Variable Type	Variable Description	Variable Units	Variable Source Data	Link to Data Source ²
61	RuralInterstate_NewBridge_StateCapitalOutlay	Capital Investment	The capital outlay of expenditures for construction and system preservation projects related to new bridge construction on rural interstates	Thousands of U.S. Dollars	FHWA Office of Highway Policy Information - Highway Statistics Table SF12a "State Highway Agency Capital Outlay - 2014, For Arterial Systems in Rural Areas, Classified by Improvement Types"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/sf12a.cfm
62	RuralOtherArterial_BridgeReplacement_StateCapitalOutlay	Capital Investment	The capital outlay of expenditures for construction and system preservation projects related to bridge replacement on rural arterials (excludes local roadways)	Thousands of U.S. Dollars	FHWA Office of Highway Policy Information - Highway Statistics Table SF12a "State Highway Agency Capital Outlay - 2014, For Arterial Systems in Rural Areas, Classified by Improvement Types"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/sf12a.cfm
63	RuralOtherArterial_MajorBridgeRehab_StateCapitalOutlay	Capital Investment	The capital outlay of expenditures for construction and system preservation projects related to major bridge rehabilitation on rural arterials (excludes local roadways)	Thousands of U.S. Dollars	FHWA Office of Highway Policy Information - Highway Statistics Table SF12a "State Highway Agency Capital Outlay - 2014, For Arterial Systems in Rural Areas, Classified by Improvement Types"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/sf12a.cfm
64	RuralOtherArterial_MinorBridgeRehab_StateCapitalOutlay	Capital Investment	The capital outlay of expenditures for construction and system preservation projects related to minor bridge rehabilitation on rural arterials (excludes local roadways)	Thousands of U.S. Dollars	FHWA Office of Highway Policy Information - Highway Statistics Table SF12a "State Highway Agency Capital Outlay - 2014, For Arterial Systems in Rural Areas, Classified by Improvement Types"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/sf12a.cfm
65	RuralOtherArterial_NewBridge_StateCapitalOutlay	Capital Investment	The capital outlay of expenditures for construction and system preservation projects related to new bridge construction on rural arterials (excludes local roadways)	Thousands of U.S. Dollars	FHWA Office of Highway Policy Information - Highway Statistics Table SF12a "State Highway Agency Capital Outlay - 2014, For Arterial Systems in Rural Areas, Classified by Improvement Types"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/sf12a.cfm

Variable Number	Variable Name	Variable Type	Variable Description	Variable Units	Variable Source Data	Link to Data Source ²
66	StateCapitalOutlay_RuralCollectors_Bridges	Capital Investment	The total capital outlay of expenditures for construction and system preservation projects related to Rural Collector Bridges, as calculated = Sum of State Capital Outlay bridge variables 66 through 69	U.S. Dollars	FHWA Office of Highway Policy Information - Highway Statistics Table SF12a "State Highway Agency Capital Outlay - 2014, For Arterial Systems in Rural Areas, Classified by Improvement Types"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/sf12a.cfm
67	StateCapitalOutlay_RuralCollectors_BridgesAVG	Capital Investment	The average capital outlay of expenditures for construction and system preservation projects related to Rural Collector Bridges, as calculated = Sum of State Capital Outlay bridge variables 66 through 69	U.S. Dollars	FHWA Office of Highway Policy Information - Highway Statistics Table SF12a "State Highway Agency Capital Outlay - 2014, For Arterial Systems in Rural Areas, Classified by Improvement Types"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/sf12a.cfm
68	StateCapitalOutlay_RuralInterstate_Bridges	Capital Investment	The total capital outlay of expenditures for construction and system preservation projects related to Rural Interstate Bridges, as calculated = Sum of State Capital Outlay bridge variables 50 through 53	U.S. Dollars	FHWA Office of Highway Policy Information - Highway Statistics Table SF12a "State Highway Agency Capital Outlay - 2014, For Arterial Systems in Rural Areas, Classified by Improvement Types"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/sf12a.cfm
69	StateCapitalOutlay_RuralInterstate_BridgesAVG	Capital Investment	The average capital outlay of expenditures for construction and system preservation projects related to Rural Interstate Bridges, as calculated = Sum of State Capital Outlay bridge variables 50 through 53	U.S. Dollars	FHWA Office of Highway Policy Information - Highway Statistics Table SF12a "State Highway Agency Capital Outlay - 2014, For Arterial Systems in Rural Areas, Classified by Improvement Types"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/sf12a.cfm
70	StateCapitalOutlay_RuralOtherArterial_Bridges	Capital Investment	The total capital outlay of expenditures for construction and system preservation projects related to Rural Other Arterial Bridges, as calculated = Sum of State Capital Outlay bridge variables 54 through 57	U.S. Dollars	FHWA Office of Highway Policy Information - Highway Statistics Table SF12a "State Highway Agency Capital Outlay - 2014, For Arterial Systems in Rural Areas, Classified by Improvement Types"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/sf12a.cfm

Variable Number	Variable Name	Variable Type	Variable Description	Variable Units	Variable Source Data	Link to Data Source ²
71	StateCapitalOutlay_RuralOtherArterial_BridgesAVG	Capital Investment	The average capital outlay of expenditures for construction and system preservation projects related to Rural Other Arterial Bridges, as calculated = Sum of State Capital Outlay bridge variables 54 through 57	U.S. Dollars	FHWA Office of Highway Policy Information - Highway Statistics Table SF12a "State Highway Agency Capital Outlay - 2014, For Arterial Systems in Rural Areas, Classified by Improvement Types"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/sf12a.cfm
72	StateCapitalOutlay_UrbanCollectors_Bridges	Capital Investment	The total capital outlay of expenditures for construction and system preservation projects related to Urban Collector Bridges, as calculated = Sum of State Capital Outlay bridge variables 70 through 73	U.S. Dollars	FHWA Office of Highway Policy Information - Highway Statistics Table SF12a "State Highway Agency Capital Outlay - 2014, For Arterial Systems in Rural Areas, Classified by Improvement Types"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/sf12a.cfm
73	StateCapitalOutlay_UrbanCollectors_BridgesAVG	Capital Investment	The average capital outlay of expenditures for construction and system preservation projects related to Urban Collector Bridges, as calculated = Sum of State Capital Outlay bridge variables 70 through 73	U.S. Dollars	FHWA Office of Highway Policy Information - Highway Statistics Table SF12a "State Highway Agency Capital Outlay - 2014, For Arterial Systems in Rural Areas, Classified by Improvement Types"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/sf12a.cfm
74	StateCapitalOutlay_UrbanInterstate_Bridges	Capital Investment	The total capital outlay of expenditures for construction and system preservation projects related to Urban Interstate Bridges, as calculated = Sum of State Capital Outlay bridge variables 58 through 61	U.S. Dollars	FHWA Office of Highway Policy Information - Highway Statistics Table SF12a "State Highway Agency Capital Outlay - 2014, For Arterial Systems in Rural Areas, Classified by Improvement Types"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/sf12a.cfm
75	StateCapitalOutlay_UrbanInterstate_BridgesAVG	Capital Investment	The average capital outlay of expenditures for construction and system preservation projects related to Urban Interstate Bridges, as calculated = Sum of State Capital Outlay bridge variables 58 through 61	U.S. Dollars	FHWA Office of Highway Policy Information - Highway Statistics Table SF12a "State Highway Agency Capital Outlay - 2014, For Arterial Systems in Rural Areas, Classified by Improvement Types"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/sf12a.cfm

Variable Number	Variable Name	Variable Type	Variable Description	Variable Units	Variable Source Data	Link to Data Source ²
76	StateCapitalOutlay_UrbanOtherArterial_Bridges	Capital Investment	The total capital outlay of expenditures for construction and system preservation projects related to Urban Other Arterial Bridges, as calculated = Sum of State Capital Outlay bridge variables 62 through 65	U.S. Dollars	FHWA Office of Highway Policy Information - Highway Statistics Table SF12a "State Highway Agency Capital Outlay - 2014, For Arterial Systems in Rural Areas, Classified by Improvement Types"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/sf12a.cfm
77	StateCapitalOutlay_UrbanOtherArterial_BridgesAVG	Capital Investment	The average capital outlay of expenditures for construction and system preservation projects related to Urban Other Arterial Bridges, as calculated = Sum of State Capital Outlay bridge variables 62 through 65	U.S. Dollars	FHWA Office of Highway Policy Information - Highway Statistics Table SF12a "State Highway Agency Capital Outlay - 2014, For Arterial Systems in Rural Areas, Classified by Improvement Types"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/sf12a.cfm
78	UrbanCollectors_BridgeReplacement_StateCapitalOutlay	Capital Investment	The capital outlay of expenditures for construction and system preservation projects related to bridge replacement on urban collectors (includes both small urban and urbanized areas, excludes local roadways)	Thousands of U.S. Dollars	FHWA Office of Highway Policy Information - Highway Statistics Table SF12a "State Highway Agency Capital Outlay - 2014, For Arterial Systems in Rural Areas, Classified by Improvement Types"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/sf12a.cfm
79	UrbanCollectors_MajorBridgeRehab_StateCapitalOutlay	Capital Investment	The capital outlay of expenditures for construction and system preservation projects related to major bridge rehabilitation on urban collectors (includes both small urban and urbanized areas, excludes local roadways)	Thousands of U.S. Dollars	FHWA Office of Highway Policy Information - Highway Statistics Table SF12a "State Highway Agency Capital Outlay - 2014, For Arterial Systems in Rural Areas, Classified by Improvement Types"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/sf12a.cfm
80	UrbanCollectors_MinorBridgeRehab_StateCapitalOutlay	Capital Investment	The capital outlay of expenditures for construction and system preservation projects related to minor bridge rehabilitation on urban collectors (includes both small urban and urbanized areas, excludes local roadways)	Thousands of U.S. Dollars	FHWA Office of Highway Policy Information - Highway Statistics Table SF12a "State Highway Agency Capital Outlay - 2014, For Arterial Systems in Rural Areas, Classified by Improvement Types"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/sf12a.cfm

Variable Number	Variable Name	Variable Type	Variable Description	Variable Units	Variable Source Data	Link to Data Source ²
81	UrbanCollectors_NewBridge_StateCapitalOutlay	Capital Investment	The capital outlay of expenditures for construction and system preservation projects related to new bridge construction on urban collectors (includes both small urban and urbanized areas, excludes local roadways)	Thousands of U.S. Dollars	FHWA Office of Highway Policy Information - Highway Statistics Table SF12a "State Highway Agency Capital Outlay - 2014, For Arterial Systems in Rural Areas, Classified by Improvement Types"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/sf12a.cfm
82	UrbanInterstate_BridgeReplacement_StateCapitalOutlay	Capital Investment	The capital outlay of expenditures for construction and system preservation projects related to bridge replacement on urban interstates (includes both small urban and urbanized areas)	Thousands of U.S. Dollars	FHWA Office of Highway Policy Information - Highway Statistics Table SF12a "State Highway Agency Capital Outlay - 2014, For Arterial Systems in Rural Areas, Classified by Improvement Types"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/sf12a.cfm
83	UrbanInterstate_MajorBridgeRehab_StateCapitalOutlay	Capital Investment	The capital outlay of expenditures for construction and system preservation projects related to major bridge rehabilitation on urban interstates (includes both small urban and urbanized areas)	Thousands of U.S. Dollars	FHWA Office of Highway Policy Information - Highway Statistics Table SF12a "State Highway Agency Capital Outlay - 2014, For Arterial Systems in Rural Areas, Classified by Improvement Types"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/sf12a.cfm
84	UrbanInterstate_MinorBridgeRehab_StateCapitalOutlay	Capital Investment	The capital outlay of expenditures for construction and system preservation projects related to minor bridge rehabilitation on urban interstates (includes both small urban and urbanized areas)	Thousands of U.S. Dollars	FHWA Office of Highway Policy Information - Highway Statistics Table SF12a "State Highway Agency Capital Outlay - 2014, For Arterial Systems in Rural Areas, Classified by Improvement Types"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/sf12a.cfm
85	UrbanInterstate_NewBridge_StateCapitalOutlay	Capital Investment	The capital outlay of expenditures for construction and system preservation projects related to new bridge construction on urban interstates (includes both small urban and urbanized areas)	Thousands of U.S. Dollars	FHWA Office of Highway Policy Information - Highway Statistics Table SF12a "State Highway Agency Capital Outlay - 2014, For Arterial Systems in Rural Areas, Classified by Improvement Types"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/sf12a.cfm

Variable Number	Variable Name	Variable Type	Variable Description	Variable Units	Variable Source Data	Link to Data Source ²
86	UrbanOtherArterial_BridgeReplacement_StateCapitalOutlay	Capital Investment	The capital outlay of expenditures for construction and system preservation projects related to bridge replacement on urban arterials (includes both small urban and urbanized areas, excludes local roadways)	Thousands of U.S. Dollars	FHWA Office of Highway Policy Information - Highway Statistics Table SF12a "State Highway Agency Capital Outlay - 2014, For Arterial Systems in Rural Areas, Classified by Improvement Types"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/sf12a.cfm
87	UrbanOtherArterial_MajorBridgeRehab_StateCapitalOutlay	Capital Investment	The capital outlay of expenditures for construction and system preservation projects related to major bridge rehabilitation on urban arterials (includes both small urban and urbanized areas, excludes local roadways)	Thousands of U.S. Dollars	FHWA Office of Highway Policy Information - Highway Statistics Table SF12a "State Highway Agency Capital Outlay - 2014, For Arterial Systems in Rural Areas, Classified by Improvement Types"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/sf12a.cfm
88	UrbanOtherArterial_MinorBridgeRehab_StateCapitalOutlay	Capital Investment	The capital outlay of expenditures for construction and system preservation projects related to minor bridge rehabilitation on urban arterials (includes both small urban and urbanized areas, excludes local roadways)	Thousands of U.S. Dollars	FHWA Office of Highway Policy Information - Highway Statistics Table SF12a "State Highway Agency Capital Outlay - 2014, For Arterial Systems in Rural Areas, Classified by Improvement Types"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/sf12a.cfm
89	UrbanOtherArterial_NewBridge_StateCapitalOutlay	Capital Investment	The capital outlay of expenditures for construction and system preservation projects related to new bridge construction on urban arterials (includes both small urban and urbanized areas, excludes local roadways)	Thousands of U.S. Dollars	FHWA Office of Highway Policy Information - Highway Statistics Table SF12a "State Highway Agency Capital Outlay - 2014, For Arterial Systems in Rural Areas, Classified by Improvement Types"	https://www.fhwa.dot.gov/policyinformation/statistics/2014/sf12a.cfm

Glossary:

ADT	Average Daily Traffic (ADT) is the volume of traffic (in vehicles per day) carried by a roadway, as measured at a specific location for a period of time less than one year; it is assumed to represent bi-directional traffic volumes unless the roadway or bridge only carries traffic in one direction, or unless otherwise noted.
Functional Classification	A designation given to all roadways by the Federal Highway Administration that “defines the role that a particular roadway segment plays in serving this flow of traffic through the network. Roadways are assigned to one of several possible functional classifications within a hierarchy according to the character of travel service each roadway provides.” ³ Roadways are classified as, Interstates, Other Freeways & Expressways, Other Principal Arterials, Minor Arterials, Major and Minor Collectors, and Local Roads; a distinction is also made between these roadways in Rural versus Urban settings.
Highway	A term generally applied to higher-volume roadways in accordance with the USDOT Functional Classification system, including roadways that are interstates, part of the National Highway System, or State highways; it generally excludes county roads, arterial roadways, collector roadways, and local roadways.
Interstate Highway System	A Federal designation given by the USDOT to roadways that are part of the Dwight D. Eisenhower National System of Interstate and Defense Highways, which is a network of highways with controlled access that form part of the National Highway System.
Lane-Mile	A measurement of roadway extent that is calculated as the length of a section of roadway (in miles) times the width of that section of roadway (in lanes, traveling in both directions).
National Highway System	The National Highway System (NHS) is a Federal designation given by the USDOT to roadways that form a network of strategically significant highways that provide access to airports, maritime ports, rail facilities, military installations and other important facilities.
Sufficiency Rating	As defined by FHWA (1995) ⁴ , it is “a method of evaluating highway bridge data by calculating four separate factors to obtain a numeric value which is indicative of bridge s sufficiency to remain in service. The result of this method is a percentage in which 100 percent would represent an entirely sufficient bridge and zero percent would represent an entirely insufficient or deficient bridge;” it is used here as an aggregate measure of bridge condition and resilience

³ FHWA, 2013. “Highway Functional Classification Concepts, Criteria and Procedures,” U.S. Department of Transportation, Washington D.C.

⁴ FHWA (1995) “Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation’s Bridges,” US Department of Transportation, Washington, D.C., <https://www.fhwa.dot.gov/bridge/mtguide.pdf>

Surface Transportation Program

A Federal funding program that that provides funding to States for projects that “preserve and improve the conditions and performance on any Federal-aid highway, bridge and tunnel projects on any public road, pedestrian and bicycle infrastructure, and transit capital projects, including intercity bus terminals.”⁵

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