Methodological Appendix

This document explains the methodological approach the authors use to measure various roadway attributes by their ownership. This appendix lists data sources and considerations, explains how data was processed and summarized, and describes the analysis for each section in the main report.

Data sources

For the purposes of our analysis, we primarily rely on the Federal Highway Administration's (FHWA) Highway Statistics Series. This has been the official source of information on the U.S. transportation network—including travel statistics, roadway conditions, and spending—since the 1940s. The series includes tables that break down various topics, such as roadway functional class and ownership. FHWA derives these tables from the Highway Performance Monitoring System (HPMS); states are required to submit roadway data to the federal government via HPMS.

Because our analysis pertains to different roadway characteristics depending on their ownership, we also rely on HPMS data directly. The Highway Statistics Series reports roadway mileage by owner, but it does not do the same for vehicle miles traveled (VMT) or roadway conditions, whether measured through the International Roughness Index (IRI) or Present Serviceability Rating (PSR). HPMS includes more robust information for each roadway. To ensure our foremost reliance on the Highway Statistics Series, we used data from HPMS itself to break down Highway Statistics Series summary data for VMT and condition by roadway ownership. This process is described in further detail below.

In the process of cleaning and preparing the HPMS data, we impute several fields that are not present in HPMS. Those calculations are done, where appropriate, according to the Highway Performance Monitoring System Field Manual (2016).

We use Highway Statistics Series data from 2022 to ensure compatibility with the most recent public version of HPMS. HPMS 2023 data had only been released in beta at the time of publication, while the Highway Statistics Series had published its 2023 vintage.

Processing data from HPMS

We use the following five steps to pull, prepare, analyze, and organize data from HPMS:

1. We retrieve geospatial HPMS data for each state, calculating several additional fields based on the underlying HPMS data.
    a. Mileage: The difference between the end- and begin-point, for each roadway segment.
    b. Vehicle miles traveled (VMT): The product of the segment's mileage, average annual daily traffic, and the number of days in a non-leap year for each roadway segment.
    c. VMT for both combination and single-unit trucks are calculated separately, each using the above formula.

2. We group our data using four criteria. This grouping allows both cross-comparison with Highway Statistics Series tables and more granularity than summary statistics as reported in the Highway Statistics Series. Within each state, roadway segments are grouped by:
    a. Urbanity (urban or rural)
    b. Functional class
    c. Ownership
    d. National Highway System (NHS) status
3. We generate summary statistics of the following metrics for each group.
    a. International Roughness Index (IRI):
        i. Mileage of roadway with an IRI over 170 (considered in "poor" condition)
        ii. Mileage of roadway with an IRI between 95 and 170, inclusive (considered in "fair" condition)
        iii. Mileage of roadway with an IRI under 95 (considered in "good" condition)
        iv. Mileage of roadway where IRI was not reported
    b. Present Serviceability Rating (PSR), where IRI is not available:
        i. Mileage of roadway with a PSR under 2 (considered in "poor" condition)
        ii. Mileage of roadway with a PSR between 2 and 4, inclusive (considered in "fair" condition)
        iii. Mileage of roadway with a PSR over 4 (considered in "good" condition)
        iv. Mileage of roadway where PSR was not reported
    c. Condition
        i. Mileage considered in "good" condition, as measured by either IRI or PSR
        ii. Mileage considered in "fair" condition, as measured by either IRI or PSR
        iii. Mileage considered in "poor" condition, as measured by either IRI or PSR
    d. Vehicle miles traveled
        i. Total VMT
        ii. VMT from combination trucks
        iii. VMT from single-unit trucks
    e. Mileage
        i. Total mileage
4. We take several steps to ensure the quality of the resulting data, including the removal of groups with incomplete data for any of the four criteria (e.g., any VMT on roadways with no identified owner is excluded).
    a. For roadways clearly owned by state and localities—most notably toll roads—we categorize segments as either state-owned or locally owned, whichever is most appropriate. This removes them from the "other" category used in the Highway Statistics Series.
5. Finally, we prepare a copy of the resulting data where functional classes five and six (major collectors and minor collectors) are combined for urban roadways. This allows us to compare condition data as reported in HPMS to Highway Statistics Table HM-63, which aggregates the two classes.

Calculating VMT by ownership

Unlike mileage, the Highway Statistics Series does not report VMT by owner. However, Table VM-2 reports VMT by functional class and urbanity (i.e., it differentiates between urban and rural roadways in each functional class) in each state, which provides a baseline for our calculations.

We then use the post-processed version of HPMS to create VMT shares for each ownership category, subdividing by the urbanity and functional classes that align with Table VM-2. For most functional classes, this starts with a simple sum of all VMT by that ownership category. We then divide that ownership category's total by the national HPMS total, creating a percentage of all HPMS VMT. We then multiply those shares by the VMT totals in Table VM-2 to create estimates that will perfectly align with Highway Statistics Series tables. The exceptions are rural minor collectors, rural local roads, and urban local roads; HPMS does not have valid VMT data for those functional classes. Instead, we make VMT assignments based on ownership's share of national roadway mileage within HPMS. This operation is forced to use the assumption that VMT is the same on every roadway segment, likely penalizing local road owners in most states.

Calculating condition by ownership

The Highway Statistics Series also does not report roadway condition by owner. Table HM-63 reports conditions in each state by functional class and urbanity for urban functional classes four through six and rural functional class five. It aggregates urban functional classes five and six. Table HM-64 reports conditions in each state by functional class and urbanity for urban functional classes one through three and rural functional classes one through four. The Highway Statistics Series does not report condition data for urban and rural functional class seven and rural functional class six.

For each condition rating—good, fair, and poor—as measured by IRI and PSR, we replicate the process used to derive VMT. That is, we calculate a ratio using mileage of roadway in each condition rating in HPMS comparing the group in our data to the total mileage with the same condition rating in all groups that share the same functional class and urbanity. We then use that ratio to break down condition data reported in the Highway Statistics Series by owner for each state.

Calculating spending on locally owned roadways

The Highway Statistics Series provides data on total state disbursements for highways in Table SF-2 and state expenditures and grants-in-aid for local roads in Table SF-6. We calculate the percent that each state suballocates to localities by dividing the total amount spent on locally owned roads (including grants-in-aid) by the state in Table SF-6 by the total disbursement amount in Table SF-2.

Assessing federal gas tax contributions by state

We use the share of a state's VMT generated on locally owned roads as a proxy for the gas tax contributions from driving on those same roads. Where we reference Highway Trust Fund revenues generated on locally owned roads, those are derived from Table HF-1.

There are two variables that may complicate this analysis of gas tax contributions.

The first is freight traffic patterns. Because diesel is taxed at a higher rate than regular gasoline, trucks and other freight traffic contribute more tax revenue per mile than the typical passenger vehicle. Trucks also disproportionately use interstate highways, which are almost entirely owned by states. To mitigate the differences in contributions per VMT of trucks, we sought data for their share of VMT in each group in our data. However, HPMS data on AADT and VMT of trucks was not robust enough to complete the analysis.

The second is roadway design. Since speed limits on many locally owned roads are lower, fuel efficiency of personal vehicles and trucks goes down. This may mean that locally owned roadways would actually generate more gas tax revenue per mile than many state-owned roads, holding VMT constant.

Since these variables are both in opposition to one another and extremely difficult to measure, we elect to use local share of VMT in the state as a simple proxy for gas tax contributions.