The Importance of Highways to U.S. Agriculture

APPENDIX C

Methodology

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http://dx.doi.org/10.9752/TS295.12-2020

Methodology

This appendix describes the methods and data used to develop the report *The Importance of Highways to U.S. Agriculture.* This appendix contains four sections, each describing a separate methodology used in this report:

High-Volume Domestic Agriculture Highways (HDAH) Identification and Analysis Corridors Development

The U.S. highway network is extensive and contains hundreds of thousands of highway miles. Conducting the level of analysis intended for this study on the full highway network is both time and resource prohibitive. Instead, the project team identified High-Volume Domestic Agriculture Highways (HDAH), the highways that carry the highest volumes of the commodities studied for this report in terms of tonnage and market value, as well as 17 analysis corridors.

Identify Baseline Network

The project team used 2018 domestic agricultural commodity flow data from the IHS Markit Transearch database to define the full highway network from which the HDAH were identified. The full network of highways in the United States includes several designated networks, including the National Highway System (NHS), Interstate System, National Highway Freight Network, and several others.

The Transearch database is extensive concerning mode, operations, and commodities, and provides advantages over the publicly available U.S. Census Commodity Flow Survey (CFS) and the Federal Highway Administration (FHWA) Freight Analysis Framework version 4 (FAF4).

The CFS is a shipper survey of domestic establishments from the mining, manufacturing, and wholesale sectors industries. The CFS includes data on the type of commodities shipped, their origin and destination, their value and weight, and the mode(s) of transport.[1] CFS provides the building blocks for FAF4, accounting for 70% of the FAF4 flow by value, and defining the 132 domestic FAF4 regions and mode classifications. The remaining 30% of FAF4 flows are constructed using a variety of public and industry data including foreign trade statistics and economic census data, the 2012 Census of Agriculture, and Port Import/Export Reporting Service (PIERS).[2]

This report uses FAF4 data and projections to provide context about overall agricultural highway freight and multimodal freight transportation in Sections 1 and 2. Transearch is used for the more detailed agricultural commodity flows and performance analysis in Section 4.

Similar to the FAF4 and CFS, IHS Markit's Transearch database provides commodity flow volumes, but more recently updated, at greater detail and assigned to a highway network. Some advantages of the Transearch data for this analysis include:

- County-to-county commodity flow and truck volume data is available in Transearch at the four-, and in some cases, five-digit Standard Transportation Commodity Code (STCC) level.
    - FAF4 uses two-digit commodity code flows, estimated by mode, for origin-destination pairs between 132 domestic regions, as defined by the CFS.
        - FAF4 and CFS use two-digit Standard Classification of Transported Goods (SCTG) codes, which are high-level (e.g., 02 = "cereal grains (including seed)") as compared with more detailed STCC (e.g., 01144 = "soybeans").
        - FAF4 regions typically contain many counties, as compared with individual counties in the Transearch database.
- FAF4 incorporates data from the 2012 Census of Agriculture, while Transearch includes 2017 Census of Agriculture data (the latest available).

Analysis in this report is based on a highway network defined by the following parameters:

- Domestic (non-imports) truck flows only;
- U.S. county-to-county flows (inbound, outbound, and through);
- Commodity flow per segment by volume (tonnage), market value (in dollars), and shipment units (truck units); AND
- A representative sample of agricultural commodities. These commodities are listed in Table 1, with the STCC which identifies them in the Transearch data.

1 Commodity Flow Survey. Bureau of Transportation Statistics and U.S. Census Bureau (2017). https://www.bts.gov/cfs

2 Freight Analysis Framework. Bureau of Transportation Statistics and Federal Highway Administration (2019). https://www.bts.gov/explore-topics-and-geography/freight-analysis-framework-version-4-faf4-frequently-asked-questions

Table 1: Focus Agricultural Commodities		
Commodity Group	**Commodity**	**STCC**
Grain	Corn	01132
	Soybeans	01144
	Wheat	01137
Fruits	Apples	01221
	Strawberries	01293
	Oranges	01214
	Watermelons	01392
Vegetables	Lettuce	01335
	Dry Onions	01318
	Potatoes other than sweet	01195
Milk & Dairy Products	Dairy farm products	0142
	Processed whole milk, skim, cream or fluid products	2026
Meat Perishables	Meat, fresh or chilled	2011
	Meat, fresh-frozen	2012
	Dressed Poultry, fresh or chilled	2015
	Dressed Poultry, fresh-frozen	2016
Livestock	Livestock	0141
Poultry	Live poultry	0151

Source: Volpe Center

Identify High-Volume Domestic Agriculture Highways (HDAH)

The highway network defined above was subset to identify HDAH using the following parameters:

- Subset highway segments into two categories based on functional class: “Interstates” and “non-Interstates.”
    - Given that Interstates tend to carry higher volumes than non-Interstates, distinguishing between the two allowed for non-Interstates with high volumes of the focus commodities to be included in the analysis while excluding the less important Interstates.

- For each category, Interstates and non-Interstates, calculate the cumulative percentage for market value and tonnage across all segments for each commodity type.
  - Market value and tonnage were both considered, as these are both important measures of commodity flows.
- For each category, select the segments within the top 80% (cumulative) for either market value **or** tonnage for **at least one** commodity group.
  - This results in four identified sets of segments, each accounting for 80% of the relevant flows within each commodity group:
    - ♦ Interstates by tonnage,
    - ♦ Interstates by market value,
    - ♦ non-Interstates by tonnage, and
    - ♦ non-Interstates by market value.
  - Individual segments were included in HDAH if they fell within any one (or more) of these sets.

Identify Analysis Corridors

Seventeen corridors were identified for more detailed analysis. These corridors represent discrete sets of contiguous segments included in HDAH, generally stretching across one or more States. They were selected from the HDAH using the following process:

- Exclude HDAH segments[3] not part of the NHS because performance data from the National Performance Management Research Dataset (NPMRDS) are only available for NHS segments.
- Identify the top 5% of HDAH segments by volume, for each commodity type, and then compiled all of these sets of segments across all commodities. This combined set was then overlaid on a single map, which generated areas that are highly dense in agricultural commodity flows but disconnected from one another.
- Connect dense commodity flows manually into logical corridors using other HDAH segments.
- Add two additional corridors which do not include segments in the top 5%:
  - Corridor #7 (I-95 from Florence, South Carolina to Jacksonville, Florida): added to incorporate better geographic balance in the full array of analysis corridors.
  - Corridor #15 (California State Route-99 from Stockton, California to Los Angeles, California): added due to Caltrans comment which indicated that this was a critical corridor for agricultural freight transportation.

3 HDAH consist of numerous smaller highway segments which may vary from less than a mile to a dozen or more miles in length. These segments are the basic unit of analysis used to identify the corridors.

Corridor Conditions and Performance Analysis

To analyze infrastructure condition and agricultural freight performance for each of the 17 corridors, the project team used the following datasets and associated attributes:

- **Highway Performance Monitoring System (HPMS) – Federal Highway Administration (FHWA) (2017-2018)**
  - Average Annual Daily Traffic (AADT), urban/rural designation, pavement condition
- **All Road Network of Linear Referenced Data (ARNOLD) - FHWA (2017-2018)**
  - Shapefile which HPMS data is attached to
- **National Performance Management Research Data Set (NPMRDS) – FHWA (2018)**
  - Travel Time Index (TTI), Truck Travel Time Reliability (TTTR)
- **Transearch Database – IHS Markit (2018)**
  - Commodity flow data including tonnage, market value, and truck units
- **National Bridge Inventory (NBI) – FHWA (2019)**
  - Bridge location and condition
- **Fatality Analysis Reporting System (FARS) – National Highway Transportation Safety Administration (2014-2018)**
  - Fatalities involving trucks

All steps used to calculate and analyze corridor conditions and performance were automated in Python, which allowed for repeatability and scalability.

Process HPMS, ARNOLD, and NPMRDS

Since corridors span multiple States and ARNOLD/HPMS and NPMRDS data are provided at the State level, each corridor was processed by State and then later merged.

Linear-referenced HPMS data were joined to the ARNOLD shapefiles and then subset within 500 meters of the corridor to omit roads which are not traversed as part of the corridor. Corridor endpoints within the State were defined and then ArcGIS network tools were used to determine the route between the two corridor endpoints, favoring higher functional classes. The resultant route was checked for accuracy and refined if necessary. This yielded an ordered list of the segments along the route along with their attributes. This was also done for the reverse direction. A similar process was used to determine the NPMRDS features along the corridor.

Due to real variations in divided highways and differences in the Geographic Information System (GIS) layers, route distances can vary by direction (e.g., southbound versus northbound) and across networks (HPMS vs NPMRDS). For this reason, it was necessary to go through a process to calibrate the GIS geometries so that they could be accurately compared to each other.

Process NBI and FARS

Bridges within 500 meters of each corridor were then reviewed and subset based on the route number and to only include bridges that would be driven on (i.e., ignoring bridges passing over the highway). This subset of bridges, along with locations of fatal crashes from FARS, were then snapped to the corridor to determine their distance along the corridor.

With all this data in place, pavement condition, TTI, and TTTR were all calculated at the segment level, and bridge condition was calculated for the bridges.

Identify TTI and TTTR Thresholds

TTTR values were reviewed, and it was observed that roughly 5% of segments by mileage had a TTTR value of approximately 2.0 or above. The project team selected out segments within the 17 analysis corridors with a TTTR value greater than 2.0 and then applied a clustering process with a 15km clustering tolerance. A similar approach was also used for TTI where a cutoff of 1.2 was used to identify the 3% of segments by mileage with the highest TTI values. This process identified clusters of TTTR values greater than 2.0 and clusters of TTI values greater than 1.2, which are shaded in the strip charts in Appendix B.

Generate Final Products

With all datasets imported, processed, and calibrated, the project team was able to generate the analytical products needed for this analysis. This included strip charts to graphically depict various condition and performance characteristics along the corridor (Appendix B), corridor level summary statistics (used to inform corridor narratives), and GIS layers for displaying results on maps (used throughout the report).

State Freight Plan Investments Analysis

The *Fixing America's Surface Transportation Act* ("FAST Act," Pub. L. No. 114-94) was enacted in 2015 and established, for the first time, a freight-specific funding source within the larger Federal-Aid Highway Program – the National Highway Freight Program (NHFP). The NHFP requires each State, the District of Columbia, and Puerto Rico to develop a State Freight Plan (SFP) that includes a fiscally constrained list of freight infrastructure projects that use NHFP funds. Some States also choose to include additional funding sources used to improve freight infrastructure in these plans.

The project team used the most recent SFPs available at the time of the study to characterize how and where States are investing in highway freight infrastructure projects. This section describes the methodology used to develop the georeferenced project list used to generate the maps, charts, and figures in this report that reference SFP projects.

Develop a Comprehensive SFP Project List

The project team collected each of the fifty-one SFPs as published in December 2019. Many State DOTs treat their freight plans as living documents and make periodic updates, in particular to the freight investment plan section, to reflect updated project timelines and funding availability. Each State DOT uses its own process to make these updates, which can result in inconsistencies from one plan to the next. For example, some State DOTs remove projects that have already been completed, while others keep those projects in the plan for the entirety of the funding period. As updates are made to the individual plans, previous versions of the documents are not typically available to the public, and any projects that were removed from the investment programs are not easily researched. The dataset compiled for this analysis contains the projects that were included in the publicly available SFPs as of December 2019; however, as described above, this is not representative of all projects funded throughout the lifespan of the NHFP.

The project team used the following process to compile project information from SFPs:

- Recorded project information reported in each SFP into a single database, including:
    - Project description;
    - Fiscal year of programmed project expenditure;[4,5]
    - Total project funding;

4 Several projects were funded across multiple fiscal years, with each year's expenditure listed as a separate project in the fiscally constrained program of projects. Projects which are programmed over multiple years have their costs aggregated and reported in the final planned year as a single project. For example, if a project was programmed for 2015, 2016, and 2017, all three years of expenditures are summed together and reported as being a single project delivered in 2017.

5 The dataset should not be used to determine exact delivery dates of individual projects. State DOTs program funds by fiscal year in their State Freight Plans, though not all State DOTs operate on the same calendar. This analysis reports on a generic fiscal year that aggregates all States into a single fiscal year (e.g., if one State DOT's fiscal year 2017 was from June 1, 2017 – May 31, 2018 and another's was from October 1, 2016 – September 31, 2017, both would be reported as "fiscal year 2017."

- NHFP funds programmed;
- State transportation funds programmed (if reported); and
- Local transportation funds programmed (if reported).

- Using the project description provided in the plan, assigned each project a 'project type' from one of the following broad categories:

Table 2: Project Types Assigned to SFP Projects

Project Type	Description
Bridge Improvement	Projects that improve the condition of a bridge, either through reconstruction, resurfacing, or other general improvements.[6]
Capacity Expansion	Projects which add lanes to a highway or in some other way increase the total possible volume of a route.
Intelligent Transportation Systems (ITS)	Installation or upgrades to software or hardware that improves operations on freight routes, including truck counting devices and the installation of variable messaging systems.
Interchange Improvements	Projects which in any way involve an interchange (which must later be modeled separate from highways); may include geometry improvements, resurfacing of the interchange, or total reconstruction of the interchange.
New Segment Construction	The building of a new highway that did not previously exist, primarily to serve as a more direct route between two critical freight routes.
Non-Highway	Up to ten percent of a states' NHFP funding may be used on non-highway projects, including maritime, railway, air and space cargo, or other non-highway freight improvements.
Resurfacing and Reconstruction	Projects which, once completed, improves the condition of the highway but do not change its capacity.
Safety	Projects that have the primary goal of reducing crashes, injuries, and fatalities.
Truck Parking Improvements	The construction of new truck parking facilities, or upgrading amenities/capacity of existing facilities.

Source: Volpe Center

6 If a bridge project's primarily impact is increasing the clearance for the highway underneath the bridge, the project is considered a capacity expansion project for the highway passing under the bridge. If the bridge project adds lanes to the bridge, it is primarily considered a capacity expansion project for the highway of which the bridge is a part; "bridge projects" category project are primarily comprised of rebuilding or reconstructing deteriorating bridges to their former condition/capacity.

- Removed projects programmed beyond fiscal year 2020. Programming projects beyond 2020 is not required under the FAST Act, though some State DOTs choose to plan beyond the required time horizon.
- Removed projects that used no NHFP funding. Some State DOTs reported only projects leveraging NHFP funding, while others chose to also include projects funded with other Federal, State, and local sources.
    - Total programmed funding in the SFPs for fiscal years 2016-2020 in December 2019 was $35.56 billion; projects programmed with at least $1 of NHFP funding through fiscal year 2020 totaled $17.08 billion (48% of total).

Georeference Projects

The SFPs did not all include information about the specific location of each project. To complete additional analysis for the report, the team:

- Approximated the geographic location of each project using the project descriptions provided in the plans.
- Georeferenced projects to a single point in space. Although many projects were comprised of several miles of highway, the spatial representation of a project was a single point located approximately at the mid-point.[7]

Map Projects and Conflate with HPMS Network and Attributes

The project team supplemented SFP project data by mapping the projects and appending additional physical and infrastructure characteristics. The team:

- Snapped each project to the Highway Performance Monitoring System (HPMS) highway network using GIS software,
- Assigned each project a functional class based on the functional class of the associated HPMS segment, and
- Assigned each project an urban/rural designation based on the highway segment's HPMS urban/rural designation.

Approximate Relationships between Modeling Project Categories and National Highway Freight Program Project Eligibility

Projects found in State Freight Plans (as of December 2019) were assigned to modeling categories based on the descriptions provided in each plan, as described in the previous section. The National Highway Freight Program (NHFP) – the freight-specific funding source in the Federal-Aid Program – is the largest single funding source for freight infrastructure projects. Table 3 describes how modeling categories, as used in the analysis for this report, relate to NHFP project eligibilites described in 23 U.S.C. 167, and may be helpful to States as they consider future investments related to agricultural highway freight. NHFP categories are broad, and specific projects may have been assigned modeling categories other than those below based on their specific proejct descriptions. This table is for illustrative purposes only.

7 Note: All locations should be considered estimations; project descriptions in plans are often described in little detail. In some instances, additional information was researched on State DOT websites or other publicly available sources to assign the location of the project.

Table 3: Modeling Categories in Relation to Freight Project Categories Eligible under the National Highway Freight Program

Category used for Modeling	Categories of NHFP Eligible Projects
Capacity Expansion	• Adding or widening of shoulders. • Additional road capacity to address highway freight bottlenecks. • Any other surface transportation project to improve the flow of freight into and out of an eligible intermodal freight facility. [23 U.S.C. 167(i)(5)(C)] • Climbing and runaway truck lanes. • Development phase activities, including planning, feasibility analysis, revenue forecasting, environmental review, preliminary engineering and design work, and other preconstruction activities. • Traffic signal optimization, including synchronized and adaptive signals. • Truck-only lanes. • Physical separation of passenger vehicles from commercial motor freight. • Railway-highway grade separation.
Resurfacing & Reconstruction	• Construction, reconstruction, rehabilitation, acquisition of real property (including land relating to the project and improvements to land), construction contingencies, acquisition of equipment, and operational improvements directly relating to improving system performance.
New Segment Construction	• Construction, reconstruction, rehabilitation, acquisition of real property (including land relating to the project and improvements to land), construction contingencies, acquisition of equipment, and operational improvements directly relating to improving system performance.
Bridge & Interchange Improvements *(not modeled in this report)*	• A highway or bridge project, other than a project described [elsewhere in this legislation], to improve the flow of freight on the National Highway Freight Network (NHFN). • Geometric improvements to interchanges and ramps.
Non-Highway *(not modeled in this report)*	• 10 percent flex funds for multimodal projects.

(continued) Table 3: Modeling Categories in Relation to Freight Project Categories Eligible under the National Highway Freight Program

Category used for Modeling	Categories of NHFP Eligible Projects
Other (Safety, ITS, Truck Parking, etc.) *(not modeled in this report)*	• Conducting analyses and data collection related to the NHFP, developing and updating freight performance targets to carry out section 167 of title 23, and reporting to the Administrator to comply with the freight performance target under section 150 of title 23. [23 U.S.C. 167(i)(6)] • Diesel retrofit or alternative fuel projects under the Congestion Mitigation and Air Quality Improvement program (CMAQ) for class 8 vehicles. • Efforts to reduce the environmental impacts of freight movement. • Electronic cargo and border security technologies that improve truck freight movement. • Electronic screening and credentialing systems for vehicles, including weigh-in-motion truck inspection technologies. • Environmental and community mitigation for freight movement. • Enhancement of the resiliency of critical highway infrastructure, including highway infrastructure that supports national energy security, to improve the flow of freight. • Highway ramp metering. • Intelligent transportation systems that would increase truck freight efficiencies inside the boundaries of intermodal facilities. • Intelligent transportation systems and other technology to improve the flow of freight, including intelligent freight transportation systems. • Real-time traffic, truck parking, roadway condition, and multimodal transportation information systems. • Truck parking facilities eligible for funding under section 1401 (Jason's Law) of the Moving Ahead for Progress in the 21st Century Act (MAP-21). • Work zone management and information systems.

Source: National Highway Freight Program, 23 U.S.C. 167

Future Conditions Modeling

Highway Economic Requirements System (HERS) is a software model used for investment analysis by FHWA and State DOTs. HERS estimates the level of investment required to make all economically beneficial highway improvements (i.e., projects where benefits exceed costs). Alternatively, HERS can model budget-constrained scenarios, assessing the cost-effectiveness and potential impacts of alternative investment levels.

The HERS model uses data on existing conditions, other input data and forecasts, and a set of equations to model impacts such as speeds, fuel economy, and emissions. In fiscally constrained analyses, this information is combined with the target spending level to create an estimate of the future highway conditions and performance based on that spending level, along with associated changes in user and non-user costs.

For more technical detail on the HERS model, please see Appendix A: Highway Investment Analysis Methodology in the most recent Conditions and Performance Report.[8]

The project team used the following approach to develop estimates for the Future Conditions chapter of this report.

Prepare Model Inputs

The project team used the State Freight Plan (SFP) project list dataset (described above) to inform scenario runs in HERS. Aggregate project totals reported in SFPs were used as inputs for HERS modeling to approximate the benefits that investments of this magnitude would provide to highway users.

However, HERS can only model certain types of projects (capacity expansion, reconstruction/ resurfacing, and new segment construction). To prepare the model inputs using the SFP data, the project team:

- Filtered projects from the SFP project list dataset which were assigned the following project types and cannot be modeled by HERS:
    - Bridge Improvements;
    - Interchange Improvements;
    - Non-highway; and
    - Other (including ITS, Safety, and Truck Parking projects).
- Found results totaling $18.91 billion over a 5-year period (fiscal years 2016-2020).
    - Of the $18.91 billion total, projects classified as new capacity comprised just over two-thirds ($13.4 billion) while resurfacing and reconstruction projects were $5.5 billion.
    - An average value of $3.782 billion per year was modeled rather than using the specific years associated with each project.

8 Status of the Nation’s Highways, Bridges, and Transit, Conditions & Performance, 23rd Edition. FHWA (2019). https://www.fhwa.dot.gov/policy/23cpr/

Complete HERS Model Runs Based on the "Sustain" Scenario and SFP Spending Levels

The "Sustain" scenario in the Conditions and Performance report represents a case in which State and local governments continue to invest in highways at the same level as they do now. Using the most recent Conditions and Performance Report, this is approximately $60 billion per year in HERS-modeled spending. (The true total of State and local spending is higher due to additional "non-modeled" spending, i.e., highway investments that cannot be modeled in HERS because of the project type and/or highway type.)

Two fiscally constrained HERS model runs were completed using 2016 base year data:

- The "Sustain" scenario from the most recent Conditions and Performance Report, which includes approximately $60 billion per year in modeled highway spending, and
- An investment level of the Sustain scenario less the $18.9 billion (over 5 years) in SFP projects.

With this approach, the difference between these two modeled outcomes is an approximation of the incremental impact of the planned State spending – in other words, the improvements to highway condition and performance that would be forgone if these investments were not made.

It is also worth noting that for the portion of the output where HERS is able to decompose the metrics specifically for trucks, the project team extracted those values and used them for the analysis. The truck-specific metrics include: truck vehicle miles traveled (VMT), truck vehicle hours traveled (VHT), truck travel time savings, operating costs per truck, and fuel costs. These values can be used to estimate the truck-specific operating cost and travel time savings associated with the State-planned investment levels.

An alternative approach would be to estimate the impact of the State-planned projects *in addition* to the Sustain scenario. However, that would be equivalent to assuming that the SFP projects are new, additional spending, rather than simply one component of the overall planned investment level. Based on the available information, it appears much more likely that the SFP projects are a portion of their overall planned spending, rather than a new addition that is over and above current levels.

Complete Additional HERS Model Runs Using Alternative Spending Levels

The project team conducted additional model runs to forecast the outcomes of alternative levels of investment. The project team:

- Completed two model runs:
  - Investment levels 2x the amount of the SFP-defined highway freight investment levels (approximately $37.8 billion over five years), and
  - Investment levels of 4x the amount of the SFP-defined highway freight investment levels (approximately $75.6 billion over five years).
- As with the main scenario described above, the project team compared these against a baseline of the Sustain scenario minus current planned spending of $18.9 billion over 5 years.

About HERS

Investment analysis in HERS includes the following activities:

- Forecasting future deficiencies (pavement, capacity, and/or alignment);
- Identifying a list of improvement options to correct these deficiencies;
- Estimating the costs and benefits of implementing each improvement option and calculating benefit/cost ratios for each; and
- Ranking the project improvements by their benefit/cost ratios.

HERS utilizes incremental benefit-cost analysis to evaluate a potential improvement on a particular highway section. Such an analysis compares the benefits and costs of a candidate improvement relative to a less aggressive alternative. For example, reconstructing and adding lanes to a section may be compared with reconstruction alone.

The HERS model defines benefits as reductions in:

- Direct highway user costs, such as reductions in travel time costs, crash costs, and vehicle operation costs (e.g., fuel, oil, and maintenance);
- Agency costs, including reduced routine maintenance costs (plus the residual value of projects with longer expected service lives than the alternative); and
- Societal costs, such as reduced vehicle emissions.

Increases in any of these costs resulting from a highway improvement (such as higher emissions rates at high speeds or the increased delay associated with a work zone) factors into the analysis as a negative benefit.

Dividing these improvement benefits by the capital costs associated with implementing the improvement results in a benefit-cost ratio (BCR) used to evaluate potential projects on different highway sections. The HERS model implements improvements with the highest BCR first. Thus, as each additional project is implemented into the model, the marginal BCR declines, resulting in a decline in the average BCR for all implemented projects. However, until the point where the marginal BCR falls below 1.0 (i.e., costs exceed benefits), total net benefits continue to increase as additional projects are implemented. Investment beyond this point is not economically justified because it would result in a decline in total net benefits. The process is similar in budget-constrained analyses; however, projects are selected only up to the point where total project costs equal the investment level specified in the scenario.

Limitations of the HERS Model

In HERS, highway capital expenditures can be divided among three types of improvements: system rehabilitation, system expansion, and system enhancements. All improvements selected by HERS that do not add lanes to a facility are classified as part of system rehabilitation, and highway projects that add lanes to a facility normally include resurfacing or reconstructing the existing lanes. HERS allocates the costs of such projects between system rehabilitation and system expansion. As a result of these constraints on project types in the model, there are a number of state-planned non-highway projects, and even some highway project categories, that cannot be modeled in HERS (e.g., interchanges). The analysis is this report thus does not include the benefits or costs of those projects.

HERS is fundamentally rooted to its primary data source, the national sample of independent highway sections contained in the HPMS. In other words, HERS is a national model with a sampling-based approach designed to analyze national-level investment needs, not individual projects. Because the HERS model analyzes each highway section independently rather than the entire transportation system, it cannot fully evaluate the network effects of individual highway improvements, such as the effects of traffic diversion from nearby alternative routes or synergies from a set of complementary projects.

The HERS model is also non-spatial and does not model the effects of entirely new highway links. For this analysis, such projects were treated more generally as a form of capacity expansion. As such, the benefits of these types of projects may be over- or under-estimated by the model.

To fully recognize network effects and/or the impacts of new segments, it would be necessary to develop significant new data sources and significantly revise the HERS model. In addition, the HERS model cannot identify impacts on particular commodities (such as agriculture) within freight trucking. This means that the modeled benefit levels are not specific to agricultural trucking. However, because agriculture constitutes a large share of overall trucking demand, it is likely that there will be a strong correspondence between overall impacts and agriculture-specific impacts.

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http://dx.doi.org/10.9752/TS295.12-2020

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