Oregon State University
College of Engineering

HIGHWAY COST ALLOCATION STUDY REVIEW: THREE-BIENNIA LOOKBACK STUDY

(2017-2019, 2019-2021, 2021-2023)

FINAL REPORT

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EXECUTIVE SUMMARY

BACKGROUND

The Highway Cost Allocation Study (HCAS) is critical in the State of Oregon's efforts to ensure that highway maintenance, operation, and improvement costs are fairly distributed among various road users. The Oregon HCAS is conducted biennially using projected data for revenue and expenditures.

PURPOSE OF THE REVIEW STUDY

The Oregon's Office of Economic Analysis (OEA) tasked a team of researchers from Oregon State University (OSU) to accomplish the following objectives:

1. **Objective 1**. Verify that the HCAS models for the 2017-2019, 2019-2021, and 2021-2023 biennia can be executed and produce the same output using projected data.
2. **Objective 2**. Examine the differences in the *scaled equity ratios* and *cost responsibility shares* across vehicle classes when using actual revenue and cost data versus projected data.

To fulfill these objectives, the Oregon Department of Transportation (ODOT) provided the OSU research team with revenue and cost data sets (i.e., projected and actual) for all biennia.

Objective 1 Results

Each HCAS model includes an Input Workbook, a Python code file, and an Output Workbook. For all HCAS models, the OSU research team was able to (1) replicate the model environment under which the results of the HCAS Python model were produced, (2) verify that most of the projected data provided by ODOT were included in the HCAS Input Workbook, with a few exceptions (see Section 2.3 for more details), and (3) verify that the outputs generated with the HCAS Input Workbook are the same as (a) the Output Workbook included in the HCAS model, and (b) the Output Workbook provided to ODOT by ECONorthwest (EcoNW).

Objective 2 Results

Tables ES1 through ES3 show the summary of the changes in the scaled equity ratio and the cost responsibility shares for each vehicle class for each biennium, with any difference greater than ± 5% highlighted.

Table ES1. 2017-2019 Biennium using Actual Data.

	Scaled Equity Ratio				Difference in Cost Responsibility Shares (Actual-Projected)	
	Projected		Actual			
	All-Fee	Full-Fee	All-Fee	Full-Fee	All-Fee	Full-Fee
Light (1 to 10,000 lbs)	2.50% Over	0.76% Over	4.71% Over	2.37% Over	0.73%	0.81%
Heavy (10,001 lbs and Up)	4.24% Under	1.35% Under	8.26% Under	4.36% Under	-0.73%	-0.81%

Table ES2. 2019-2021 Biennium using Actual Data.

	Scaled Equity Ratio				Difference in Cost Responsibility Shares (Actual-Projected)	
	Projected		Actual			
	All-Fee	Full-Fee	All-Fee	Full-Fee	All-Fee	Full-Fee
Light (1 to 10,000 lbs)	0.50% Over	1.54% Under	31.01% Under	31.75% Under	30.81%	30.18%
Heavy (10,001 lbs and Up)	0.85% Under	3.14% Over	760.96% Over	1160.05% Over	-30.81%	-30.18%

Table ES3. 2021-2023 Biennium using Actual Data.

	Scaled Equity Ratio				Difference in Cost Responsibility Shares (Actual-Projected)	
	Projected		Actual			
	All-Fee	Full-Fee	All-Fee	Full-Fee	All-Fee	Full-Fee
Light (1 to 10,000 lbs)	5.12% Under	1.54% Under	7.13% Under	9.08% Under	1.61%	1.65%
Heavy (10,001 lbs and Up)	10.70% Over	16.35% Over	16.04% Over	22.45% Over	-1.61%	-1.65%

CONCLUSIONS

Based on the evaluation conducted by the OSU research team, the following conclusions were reached:

1. The HCAS models for all biennia can be run using projected and actual data.
2. The HCAS models for all biennia produce the same outputs as those generated by EcoNW when using the Input Workbook that EcoNW prepared for the Python model. The outputs generated by the OSU research team are the same as those provided to ODOT by EcoNW.
3. The *scaled equity ratios* and *cost responsibility shares* generated using projected versus actual data for each biennium differ. In some cases, the differences in the *cost responsibility shares* for light-weight or heavy-weight vehicles exceed ±5% when comparing actual versus projected data.
   - In the 2019-2021 biennium, these differences are pronounced and are likely due to the effect of the COVID-19 pandemic and the actual data exceeding threshold limitations present in the HCAS's Python.
   - Due to these special circumstances, the validity of the calculated scaled equity ratios and cost responsibility shares using actual revenue and cost data for the 2019-2021 biennium cannot be substantiated nor refuted by the OSU research team as a result of this study.

RECOMMENDATIONS

After completing the evaluation of the HCAS models for the 2017-2019, 2019-2021, and 2021-2023 biennia, the OSU research team recommends the following to OEA: (1) perform further research on the limitations of the HCAS model, (2) streamline the coding of project WorkTypes, and (3) improve the documentation on project WorkType and Bridge Type Coding process.

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1.0 INTRODUCTION

The Oregon Highway Cost Allocation Study (HCAS) plays a critical role in the State of Oregon's efforts to ensure that highway maintenance, operation, and improvement costs are fairly distributed among various road users (Merriss, n.d.). Oregon has conducted highway cost allocation studies since 1937 to ensure fair and proportional road user taxation, as required by the state constitution. Initially managed by the Oregon Department of Transportation (ODOT), these studies have been overseen by the Office of Economic Analysis (OEA) in the Department of Administrative Services (DAS) since 1999, with ODOT providing technical support.

The Oregon HCAS uses a cost-occasioned approach, aligning with prior studies in Oregon and those by the federal government and other states. This method allocates costs based on the road usage by different vehicle classes, ensuring each user pays proportionally to the costs they impose. Conducted biennially, the HCAS analyzes projected revenue and cost data for a comprehensive view of cost allocation and revenue attribution.

1.1 PROJECT OBJECTIVE

The OEA tasked a team of researchers from Oregon State University (OSU) to (1) verify that the HCAS models for the 2017-2019, 2019-2021, and 2021-2023 biennia can be executed and produce the same output using projected data, and (2) to examine the differences in the *scaled equity ratios* and *cost responsibility shares* across vehicle classes when using actual revenue and costs data versus projected data.

Figure 1 depicts the workflow involved in the HCAS and identifies the responsibilities of each organization involved. In this study, the OSU research team conducted an independent, in-depth evaluation of the HCAS models (see red-dashed outline in Figure 1) utilized in the 2017-2019, 2019-2021, and 2021-2023 biennia. This review included a thorough examination of the results generated by each HCAS model, assessing their validity and reliability.

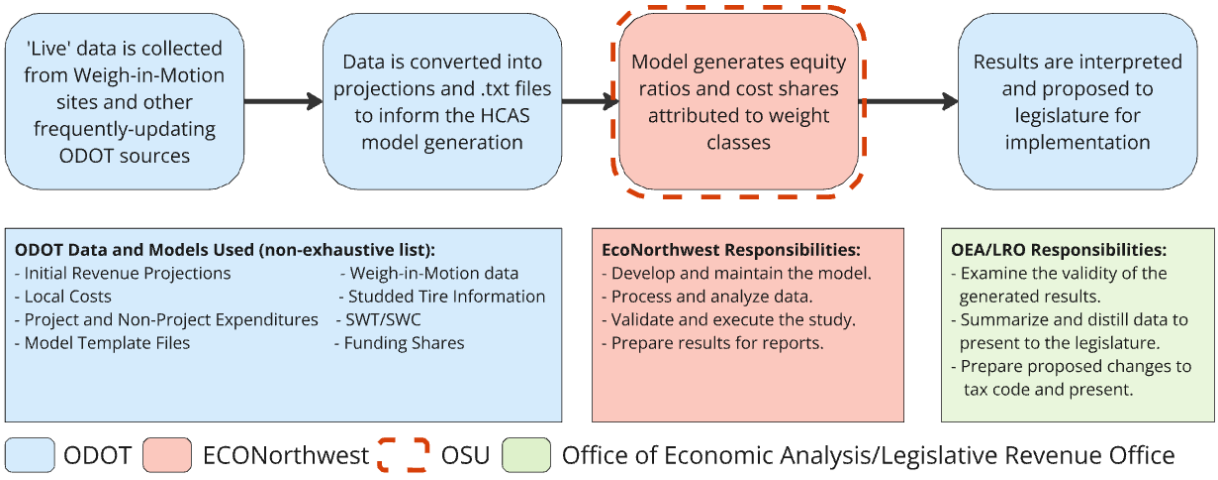

Figure 1. HCAS Workflow and Responsible Parties.

2.0 METHODOLOGY

This chapter details the OSU research team's methodology for verifying and validating three HCAS models. The methodology encompasses several key steps including data preparation, environment replication, model execution, and analysis. The primary objectives were to:

1. Replicate the model environment under which EcoNW results were produced,
2. Verify the inputs used and the outputs produced by each HCAS model,
3. Generate *scaled equity ratios* and *cost responsibility shares* using actual data, and
4. Compare the *scaled equity ratios* and *cost responsibility shares* produced by each model with projected versus actual data.

Figure 2 is an overview of the methodology. The analyses conducted by the OSU research team to execute the verification and validation processes are detailed in the remaining sections of this chapter.

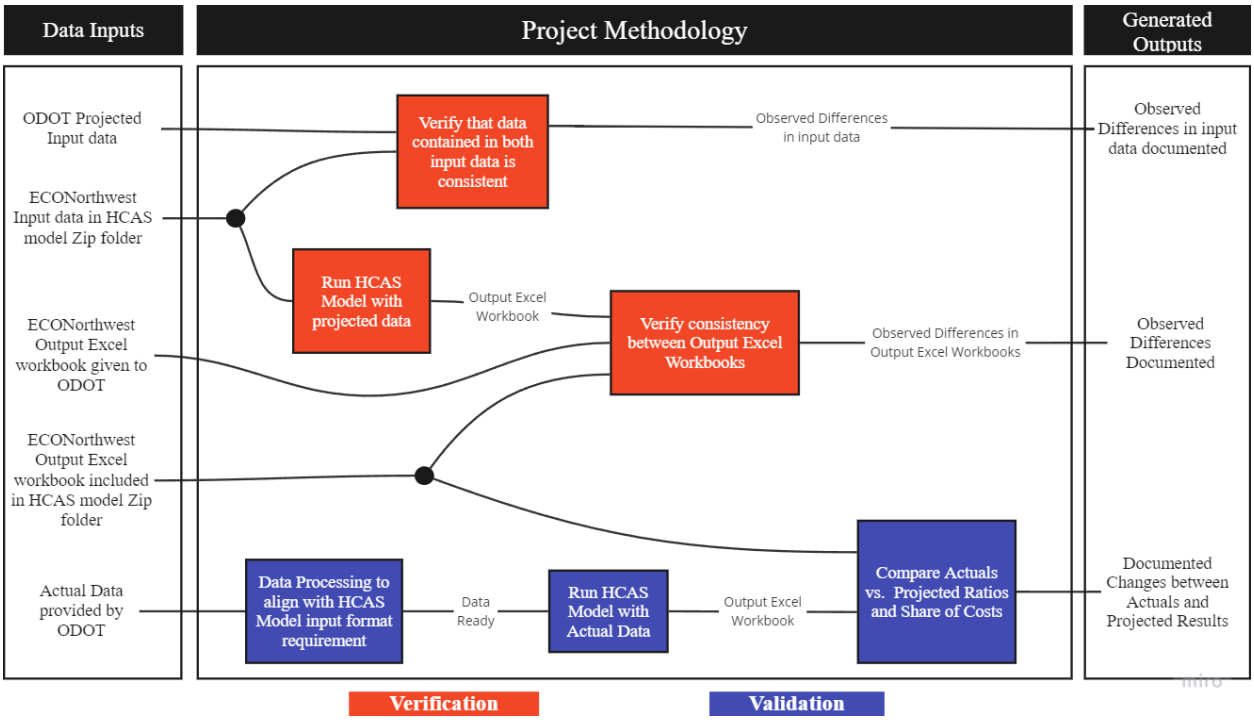

Figure 2. Overview of the Methodology.

2.1 HCAS Models Evaluated

ODOT provided the OSU research team with three HCAS models developed by EcoNW for the biennia 2017-2019, 2019-2021, and 2021-2023.

Each HCAS model was packaged as a ZIP file containing a Python model and several Microsoft® (MS) Excel and text files containing the data needed to run and validate the Python model. This study utilized the following files:

1. **HCAS Model**. A computer program developed in Python that processes different input data categories to produce a cost allocation based on road usage by different vehicle classes.
2. **HCAS Input Workbook**. An MS Excel workbook prepared by EcoNW containing all the input data processed by the Python model.
3. **HCAS Output Workbook**. An MS Excel workbook generated by the Python model containing output data.

2.2 HCAS Model Environment Replication

To replicate the outputs produced by the HCAS models, the OSU research team utilized two versions of Python across different biennia, each running on separate environments to ensure the accuracy and integrity of the replication process. Python 2.7.18 was used for the 2017-2019 and 2019-2021 HCAS models and Python 3.12.4 was used for the 2021-2023 HCAS model, as shown in Table 1. In addition to different Python versions, each HCAS model required specific versions of OpenPyXL, an open-source library for reading and writing MS Excel files in Python. The versions of the OpenPyXL library used were 2.0.5 for the 2017-2019 HCAS model, 2.4.2 for the 2019-2021 HCAS model, and 3.0.4 for the 2021-2023 HCAS model.

Table 1. Versions of Python and OpenPyXL Used by each HCAS Model.

HCAS Model	Python Environment Version	OpenPyXL Version
2017-2019	2.7.18	2.0.5
2019-2021		2.4.2
2021-2023	3.12.4	3.0.4

The different versions of the Python environments and OpenPyXL libraries were managed using Anaconda 3 (see Figure 3) to create isolated environments, which avoided conflicts with other Python environment versions or dependencies. Anaconda 3 facilitated the installation and management of separate Python environments for each biennium, thus ensuring that each environment was identical to those originally used by EcoNW and effectively replicating the conditions under which EcoNW results were produced.

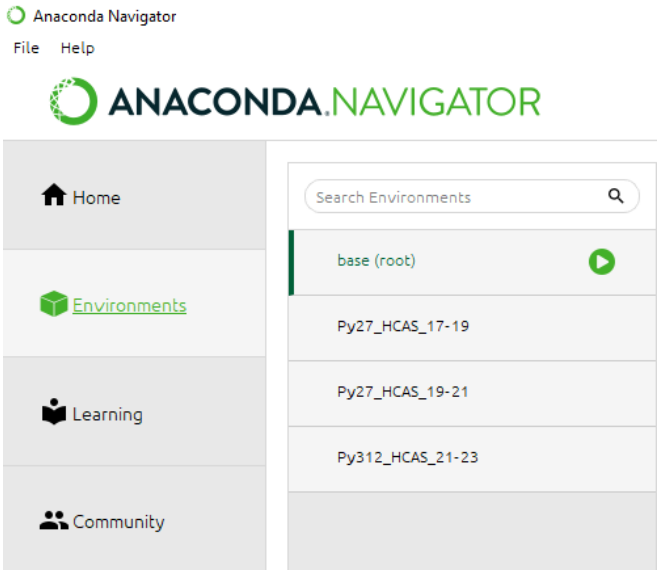

Figure 3. Anaconda Navigator Environments for the Different HCAS Models.

2.3 VERIFICATION OF INPUTS TO HCAS MODEL

ODOT provided EcoNW with the necessary input data for the HCAS model. EcoNW transformed the input data into an MS Excel workbook (i.e., the HCAS Input Workbook). ODOT provided the OSU research team with the same set of input data provided to EcoNW, which includes the following data sets for each biennium:

1. Projected project cost.
2. Projected non-project cost.
3. Local cost.
4. Projected revenue.

The OSU research team compared the input data provided by ODOT against the input data contained in EcoNW's HCAS Input Workbook. Sections 2.3.1, 0, 0, and 2.3.4 present the results of this comparison.

2.3.1 Projected Project Costs

The OSU research team compared the following information for projected project costs between the ODOT-provided input and EcoNW's HCAS Input Workbook:

1. Projected projects by key number and project name.
2. Expenditures for each project (i.e., dollar amount), broken down by funding sources (e.g., Federal, State, Other, etc.)

2.3.1.1 2017-2019 Biennium

For the 2017-2019 biennium, the comparison showed that all projected project expenditures (broken down by the funding sources) provided by ODOT were the same as those included in EcoNW's HCAS Input Workbook.

2.3.1.2 2019-2021 Biennium

For the 2019-2021 biennium, 14 projects were duplicated in the projected project cost data set provided by ODOT. These 14 projects were also duplicated in EcoNW's HCAS Input Workbook. Table 2 lists the duplicated projects included in EcoNW's HCAS Input Workbook. The 14 duplicated projects amount to $12,525,782, representing 0.86% of the projected project costs for the 2019-2021 biennium.

Table 2. Duplicate Projects in EcoNW's HCAS Input Workbook for the 2019-2021 Biennium.

Key Number	Project Name	Construction Cost
K19962	District 3 West ADA Improvements	$610,992.00
K20367	FIX-IT ADA FUNDING FFY19-21	$483,997.00
K20404	AGENCY PRIORITY PROGRAM - STATEWIDE ADA FFY19	$3,177,365.00
K20405	AGENCY PRIORITY PROGRAM - STATEWIDE ADA FFY20	$2,339,766.00
K20406	AGENCY PRIORITY PROGRAM - STATEWIDE ADA FFY21	$252,623.00
K21144	maintenance triggered curb ramps and pedestrian si	$2,222,752.00
K21145	PRIORITY CURB RAMP & PEDESTRIAN SIGNALS	$558,790.00
K21239	US30 priority curb ramps	$174,403.00
K21243	OR126B: 35th St - 40th St (Springfield)	$58,708.00
K21251	OR126: Mohawk Blvd (Springfield)	$99,829.00
K21252	OR237: Bryan St-Oregon St & OR203 @ College St	$753,282.00
K21253	OR82:W. Walter St-SE School St & OR3:NW Flora St-N	$753,282.00
K21254	OR140: N. 10th St - S. F St & N. O St - N. H St	$753,282.00
K21282	US101: SE 8th Street-SE 14th Street (Lincoln City)	$286,711.00
	Total	**$12,525,782**

2.3.1.3 2021-2023 Biennium

For the 2021-2023 biennium, EcoNW's HCAS Input Workbook omitted the JTA State Construction Cost for four projects. These four projects, along with their funding sources and the dollar amount omitted, are listed in Table 3. The JTA State Construction Cost for the four projects amounts to $8,888,380, which represents 0.51% of the total projected project costs for the 2021-2023 biennium.

Table 3. Funding Source and Amount Omitted from the 2021-2023 HACS Input.

Key Number	Funding Source omitted	Construction Cost Omitted
K19490	JTA State Funding	$6,254,993.00
K21511	JTA State Funding	$1,652,208.00
K19763	JTA State Funding	$981,179.36
K21083	JTA State Funding	$79,579.00
	Total	**$8,888,380**

2.3.2 Projected Non-Project Costs

ODOT provided the OSU research team with the same projected non-project costs given to EcoNW in a “Cost to Allocate Report.” The "Cost to Allocate Report" outlines various cost categories subjected to allocation within the HCAS model.

In the "Cost to Allocate Report", expense categories are organized into different maintenance and operational activities, including “OPS/SpPgms/Permits”, “State Radio System”, and “Surface/Shoulder/Contract”, to name a few. Each expense category lists the corresponding costs across multiple funding sources (e.g., state, federal, bond, local, etc.) For each expense category, the “Cost to Allocate Report” provides detailed monetary values allocated to each funding source followed by the total amount allocated (i.e., “ARB Total”). This comprehensive breakdown ensures that all non-project-related expenses are accounted for in the overall cost allocation process. The “Check Values” column in the “Cost to Allocate Report” appears to be used to verify or balance the totals against other financial metrics. Overall, the “Cost to Allocate Report” is a detailed financial summary consolidating various operational and maintenance costs, preparing them for inclusion in the broader HCAS analysis.

The comparison of the values included in the “Cost to Allocate Report” against those appearing in EcoNW’s HCAS Input Workbook revealed some discrepancies regarding non-project costs across all biennia, as shown in Table 4, Table 5, and Table 6. These discrepancies arise primarily from differences in categorization (i.e., naming conventions) and missing data (i.e., omitted expense categories).

In the 2017-2019 biennia, the discrepancies amounted to $51,845,692.68 or 2.33% of total non-project costs. In the 2019-2021 biennia, the discrepancies amounted to $623,320,873.53 or 15.79% of total non-project costs. Finally, in the 2021-2023 biennia, the discrepancies amounted to $203,813,543.18 or 6% of total non-project costs.

Table 4. Observed Differences in Non-Project Cost for the 2017-2019 Biennium.

Expense	Observed Differences	Dollar Amount
Fleet Outside Billing	Not listed in 2017 HCAS Input Workbook	$31,452,566.68
Project Preliminary Engineering	Listed as "Other project-related (PE)" *Excluded from Total Calculation*	$121,716,239.91
Reimbursables (excluded from Special Programs)	Not listed in 2017 HCAS Input Workbook	$16,192,857.00
Snowmobile/WinterRec (excluded from Special Programs)	Not listed in 2017 HCAS Input Workbook	$4,200,269.00
	Total	**$51,845,692.68**

Table 5. Observed Differences in Non-Project Cost for the 2019-2021 Biennium.

Expense	Observed Differences	Dollar Amount
Fleet Outside Billing	Not listed in 2019 HCAS Input Workbook	$16,528,283.37
Reg Fee Collection Costs - Light Only (includes CS)	Listed as "Reg Fee Collection Costs - Basic Only (includes CS)" *Excluded from Total Calculation*	$27,508,391.95
Reg Fee Collection Costs - Non-Light Only (includes CS)	Listed as "Reg Fee Collection Costs - Non-Basic Only (includes CS)" *Excluded from Total Calculation*	$1,116,044.16
Repl. Stickers, Dup Veh Reg, Veh Restore PLT Fee	Not listed in 2019 HCAS Input Workbook	$29,605,371.20
Light Driver	Not listed in 2019 HCAS Input Workbook	$155,876,738.22
Heavy Driver	Not listed in 2019 HCAS Input Workbook	$15,628,655.74
Debt Service (Highway Fund portion)	Not listed in 2019 HCAS Input Workbook	$405,681,825.00
	Total	**$623,320,873.53**

Table 6. Observed Differences in Non-Project Cost for the 2021-2023 Biennium.

Expense	Observed Differences	Dollar Amount
Fleet Outside Billing	Not listed in 2021 HCAS Input Workbook	$26,448,846.88
Project Construction	Local Funding is not listed in 2021 HCAS Input Workbook	$126,374,155.71
Project Preliminary Engineering	Listed as "Other Project-Related (PE)" *Excluded from Total Calculation*	$253,776,675.20
Project Preliminary Engineering	Local Funding is not listed in 2021 HCAS Input Workbook	$19,818,379.49
Project Right of Way & Utility	Local Funding is not listed in 2021 HCAS Input Workbook	$6,676,959.62
Reimbursables (excluded from Special Programs)	Not listed in 2021 HCAS Input Workbook	$19,652,382.48
Snowmobile/WinterRec (excluded from Special Programs)	Not listed in 2021 HCAS Input Workbook	$4,802,819.00
	Total	**$203,813,543.18**

2.3.3 Local Costs

The "Local Road and Street Questionnaire" provided by ODOT confirmed local cost data inputs included in EcoNW's HCAS Input Workbook. The local cost data provided by ODOT and the local cost data included in EcoNW's HCAS Input Workbook were consistent for all biennia.

2.3.4 Revenues

The revenue data provided by ODOT was used to confirm revenue data inputs in EcoNW's HCAS Input Workbook. The data provided by ODOT and the data included in EcoNW's HCAS Input Workbook were consistent for all biennia. It is important to highlight that eight revenue sources tracked by ODOT are not included in EcoNW's HCAS Input Workbook for any of the three biennia. However, these eight revenue sources are provided in the actual revenue data provided by ODOT. The eight omitted revenue sources are:

1. Mobile Home Toter Reg
2. DMV Trip Permits
3. Salvage Titles
4. Plate MFG - Light
5. Plate MFG - Heavy
6. Other DMV
7. Light Driver - Non-Commercial
8. Heavy Driver - Commercial

For consistency, the OSU research team also omitted these eight revenue sources when analyzing the output of the HCAS model using actual revenue data. For the 2017-2019 biennium, the eight revenue sources represent 4.61% of actual revenues collected, or $130,874,949.34. For the 2019-2021 biennium, the eight revenue sources represent 4.47% of actual revenues collected, or $132,044,631.79. For the 2021-2023 biennium, the eight revenue sources represent 4.33% of actual revenues collected, or $141,755,755.63.

2.4 Verification of Outputs from the HCAS Model

The verification of the HCAS model outputs entails comparing the following (in MS Excel format):

1. The output file included in the HCAS Zip folder provided by EcoNW.
2. The output file provided to EcoNW by ODOT.
3. The output file generated by the OSU research team by running the appropriate Python code, and the HCAS Input Workbook included in the HCAS Zip folder provided by EcoNW.

WinMerge, an open-source file comparison and merging tool, was used to examine and compare the MS Excel files line-by-line within a Windows 10 Pro operating system environment to identify any differences. WinMerge's graphical user interface is depicted in Figure 4, whereas Figure 5 shows a screen capture of the WinMerge results.

The comparisons showed that the output files generated by the OSU research team and those provided by EcoNW were identical.

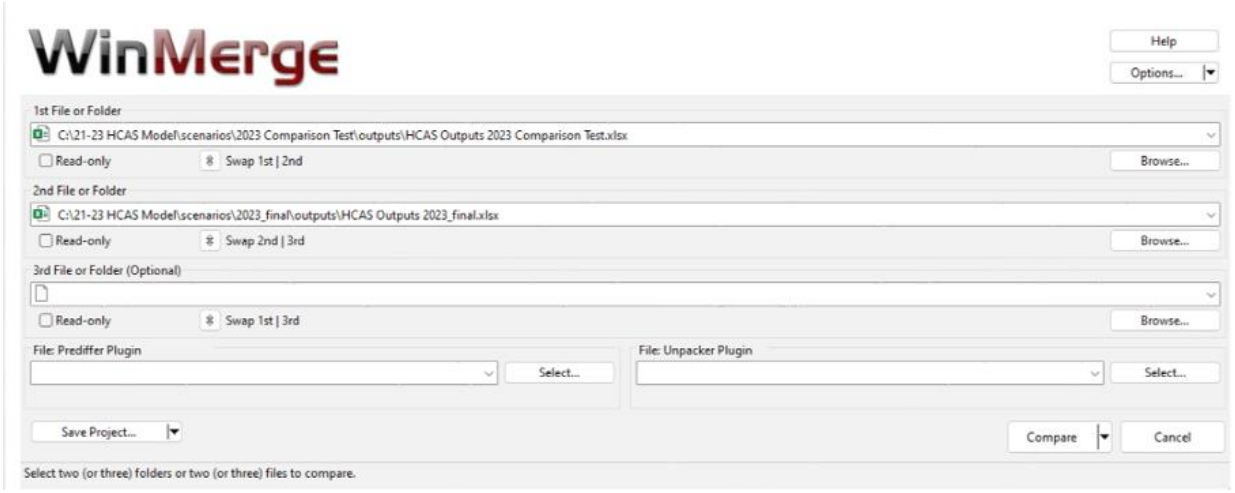

Figure 4. WinMerge's Graphical User Interface.

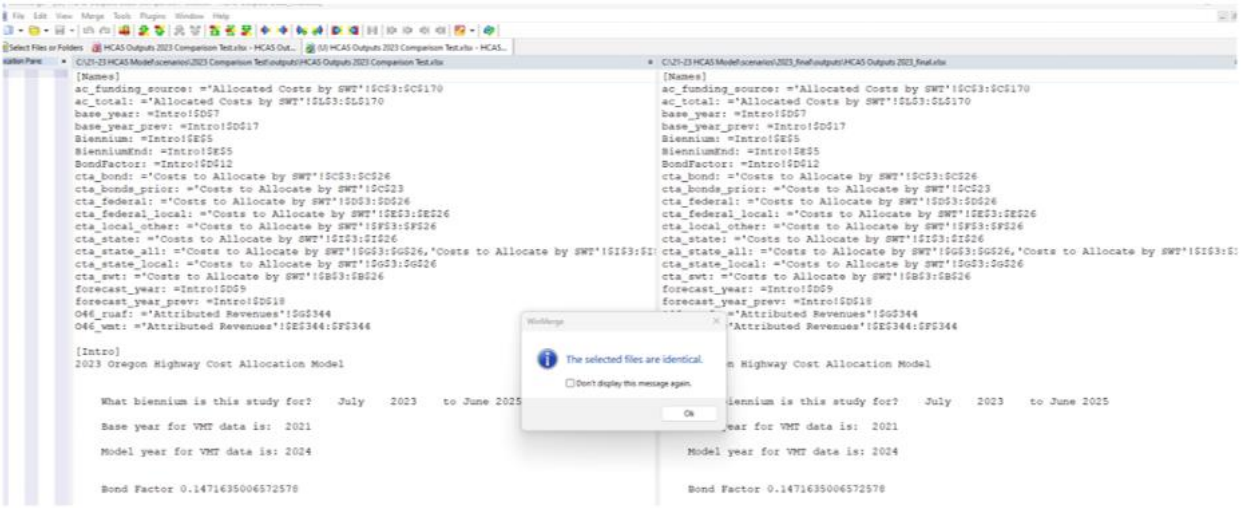

Figure 5. Comparison Results for the 2021-2023 HCAS Output Files Using WinMerge.

2.5 CREATION OF NEW SCENARIOS USING ACTUAL DATA

The methodology for running a test scenario with the HCAS model using actual data as input is outlined in the appendix section titled "Set Up a New Scenario" of the documentation prepared by EcoNW. The OSU research team followed this exact methodology to align with the documented procedures for setting up and running new scenarios using the HCAS model.

The initial setup involved unzipping the 20XX HCAS model ZIP archive, creating the necessary folder structure, and including all required input files. The base model folder contains four primary directories: `src`, `processed scenarios`, `scenarios`, and `template_outputs`. The `src` folder contains the Python file (i.e., `HCASModule.py`) to perform model calculations and must remain unaltered. New scenarios are created and managed in the `scenarios` folder, while completed scenarios are stored in the `processed scenarios` folder. The `template_outputs` folder includes a template MS Excel workbook (i.e., `HCAS Outputs.xlsx`) for formatting output data.

Next, a new folder is created within the `scenarios` folder to set up a test scenario. The folder is named appropriately, such as "Test Scenario with Actual Data." The simplest way to establish a new scenario is to duplicate the `20XX_final` folder and rename the copy to the new scenario name. The `HCAS Inputs.xlsx` file in the new scenario's `inputs` folder is opened and assumptions and input data are updated to reflect the actual revenue data. The original names of the input text files and the MS Excel workbook must not be changed to ensure consistency with the HCAS model's requirements.

Running the HCAS model involves several steps. First, a graphical Python user interface called the *Integrated Development and Learning Environment* (IDLE) is opened by typing "IDLE" in the Start menu search box and selecting the appropriate listing. Next, the `HCASModule.py` file from the `src` folder is opened in the IDLE. The model is run by selecting "Run Module" from the "Run" menu in the IDLE, generating output files in the scenario's `outputs` folder. After verifying the model outputs, the scenario's folder is moved from the `scenarios` folder to the `processed scenarios` folder. If further modifications are necessary, the scenario's folder can be moved back to the `scenarios` folder, and the steps are repeated.

2.6 GENERATING OUTPUTS WITH THE HCAS MODEL USING ACTUAL DATA

While the data provided by ODOT largely matched the data used in EcoNW's HCAS Input Workbook, EcoNW's HCAS Input Workbook had formatting structures and underlying assumptions that differed from the information presented in ODOT's summary files.

To replicate the formatting of EcoNW's HCAS Input Workbook using actual data, the OSU research team translated ODOT's information into the format used by EcoNW's HCAS Input Workbook for data included in the Project Costs, Non-Project Costs, Local Costs, and Revenues workbook tabs. The processes and assumptions used for each of these data subdivisions are detailed in Sections 2.6.1, 2.6.2, 2.6.3, and 2.6.4.

2.6.1 Project Costs

The organization of the project cost data supplied by ODOT is depicted in Figure 6. However, EcoNW's HCAS Input Workbook only accepts project cost data organized as depicted in Figure 7.

	A	B	D	E	F	G	H	R	S	T	U
1	Data Source:	Budget Prep Fiel 02-22-16 (c).xlsx; Tab: HCAS-Projects (Values P									
2	2nd Data Source:	YYHCAS11 (run06-20-16).xlsx; Column 69 SXYR-WKDESX; Insertec									
3	Expend Date:	July 1, 2017 through June 30, 2019									
4											
5	Project ID	Hwy Name	WRK TYP	WRK TYP PCT	WRK TYP2	WRK TYP PCT2	WRK TYP3	Construction Amount	Fed CONST $'s	State CONST $'s	Other CONST $'s
6	K09679	US97 @ WICKIUP JCT. (LA PINE)	MODERN	96.00	SAFETY	4.00		4,299,260.00	3,678,446.86	384,783.77	236,029.37
7	K12518	FFO-I-5 @ OR214 INTERCHANGE (WOODBURN) DEVELOPMENT	MODERN	100.00		0.00		136,345.00	111,284.79	9,871.38	15,188.83
8	K12723	FFO-I-5: FERN VALLEY INTERCHANGE, UNIT 2	MODERN	92.00	BRSO	8.00		1,371,180.00	1,225,012.21	132,455.99	13,711.80
9	K13762	SELLWOOD BRIDGE	BRLO	100.00		0.00		114,212,401.00	7,994,868.07	2,284,248.02	90,227,796.79
10	K13994	OR62: CORRIDOR SOLUTIONS UNIT 2 (MEDFORD)	MODERN	92.00	OPERAT	8.00		22,065,404.00	-	441,308.08	-
11	K14077	AGNESS ROAD (CURRY COUNTY)	MODERN	100.00		0.00		804,401.00	721,789.02	-	82,611.98
12	K14269	SALMON RIVER (ELK PARK ROAD) BRIDGE	BRSF	100.00		0.00		819,688.00	735,506.04	-	84,181.96
13	K14313	US101 @ OR6 (TILLAMOOK)	MODERN	100.00		0.00		10,418,689.00	-	-	-
14	K14393	NE CLEVELAND AVE:STARK ST - POWELL BLVD (GRESHAM)	MODERN	100.00		0.00		310,326.00	124,999.31	-	185,326.69
15	K14429	KINSMAN RD: SW BOECKMAN - SW BARBER (WILSONVILLE)	MODERN	100.00		0.00		1,486,920.00	700,934.09	-	785,985.91
16	K14438	STARK ST BEAVER CREEK CULVERT	CULVRT	100.00		0.00		300,841.00	254,872.50	-	45,968.50
17	K15116	LOCAL GOVERNMENT STP STATEWIDE BUCKET 2010	SPPROG	100.00		0.00		5,214,480.00	-	5,214,480.00	-
18	K15117	LOCAL GOVERNMENT STP STATEWIDE BUCKET 2011	SPPROG	100.00		0.00		5,214,480.00	-	5,214,480.00	-

Figure 6. Projected Project Cost Data Provided by ODOT.

	A	B	C	D	E	F	G
1	Funding	Work Type	Functional Class	Bridge Type	Dollars	Key Number	Memo
2	federal	5	0	0	3,531,309	K09679	US97 @ WICK
3	federal	21	0	0	147,138	K09679	US97 @ WICK
4	other	5	0	0	226,588	K09679	US97 @ WICK
5	other	21	0	0	9,441	K09679	US97 @ WICK
6	state	5	0	0	369,392	K09679	US97 @ WICK
7	state	21	0	0	15,391	K09679	US97 @ WICK
8	federal	67	0	0	111,285	K12518	FFO-I-5 @ OR:
9	other	67	0	0	15,189	K12518	FFO-I-5 @ OR:
10	state	67	0	0	9,871	K12518	FFO-I-5 @ OR:
11	federal	67	0	0	1,127,011	K12723	FFO-I-5: FERN
12	federal	67	0	0	98,001	K12723	FFO-I-5: FERN
13	other	67	0	0	12,615	K12723	FFO-I-5: FERN

Figure 7. Project Cost Data Required by EcoNW's HCAS Input Workbook.

There are two key differences in how the project cost data is organized in the MS Excel files depicted in Figure 6 and Figure 7.

1. Each line item in EcoNW's HCAS Input Workbook depicted in Figure 7 corresponds to the proportion of each funding source based on a project's WorkType. For example, row 6 in ODOT's MS Excel file in Figure 6 (i.e., Project ID K09679) translates to rows 2-7 in EcoNW's HCAS Input Workbook depicted in Figure 7. The dollar amounts shown in rows 2-7 in EcoNW's HCAS Input Workbook are obtained by multiplying the WorkType percentage listed in column E of Figure 6 by each funding source shown in columns S, T, and U of the same file.
2. The project cost data in ODOT's MS Excel file depicted in Figure 6 lists each WorkType in columns D, F, and H as alphabetic codes, whereas EcoNW's HCAS Input Workbook requires numerical WorkTypes.

Due to these differences, the OSU research team attempted to convert actual project data into a format compatible with the template accepted by EcoNW's HCAS Input Workbook by multiplying the WorkType percentage by each funding source. However, the alphabetic WorkTypes are not a format accepted by the HCAS model. The OSU research team developed a process for translating the alphabetic WorkTypes into numerical WorkTypes that the HCAS model would accept. This is detailed in Sections 2.6.1.1, 2.6.1.2, and 2.6.1.3.

2.6.1.1 Confirmed Project Types via Decoder Ring File Provided by EcoNW

To translate the alphabetic WorkTypes into numerical WorkTypes, the OSU research team requested a list of WorkTypes from EcoNW (which EcoNW calls the "HCAS WorkType Decoder Ring"). A selection of WorkTypes listed in the "HCAS WorkType Decoder Ring" is depicted in Figure 8.

	A	B	C
1	odot_worktype	description	hcas_worktype
2	ADAP	ADA PED PROJECTS	41
3	ADAR	ADA ROAD PROJECTS	41
4	AVIATE	AVIATION PROJECTS	47
5	BIKPED	BIKE/PED GRANT PROGRAM ONLY	41
6	BP-FLX	BIKE/PED FLEXIBLE FUNDS	41
7	BR-CLV	NON-NBI CULVERTS	44
8	BR-MBM	MAJOR BRIDGE MAINTENANCE	15
9	BR-SCR	BRIDGE OVERPASS SCREENING	20
10	BR-RLR	BRIDGE RAIL RETROFIT PROGRAM	42
11	BRIDGE	BRIDGE PROGRAM	bridge
12	BRLF	BRIDGE - LARGE - OFF	bridge
13	BRLO	BRIDGE - LARGE - ON	bridge
14	BRSF	BRIDGE - SMALL - OFF	bridge
15	BRSO	BRIDGE - SMALL - ON	bridge
16	CMAQ	CONGESTN MITIGATN AND AIR QTY	varies
17	CT-MCM	MAJOR CULVERT MAINTENANCE	12
18	CULVRT	CULVERT	12
19	EM-REL	EMERGENCY RELIEF PROJECTS	varies

Figure 8. Sample of WorkType Codes Included in the Decoder Ring File.

It is important to note that the "Decoder Ring" file detailed three categories of WorkTypes:

1. WorkTypes with a direct numerical conversion.
2. WorkTypes that are represented as "bridge".
3. WorkTypes that are represented as "varies".

The proportion of WorkTypes in each "Decoder Ring" category is provided in Table 7, as well as projects that contained WorkTypes relating to both indirect translation categories.

Table 7. Projects Contained in each "Decoder Ring" WorkType Category.

	Biennium					
	2017-2019		2019-2021		2021-2023	
	#	%	#	%	#	%
Total Project Count (reflecting actual data)	551	100%	523	100%	546	100%
Total Project Cost	$914,540,947.95	100%	$786,972,459.70	100%	$1,334,952,681.41	100%
Decoder Ring Confirmed Project Count	286	51.91%	295	56.40%	326	59.70%
Decoder Ring Confirmed Project Total Cost	$306,865,404.45	33.55%	$358,348,975.71	45.54%	$512,401,739.80	38.38%
Projects Containing "Bridge" WorkTypes Count	128	23.23%	129	24.67%	138	25.28%
Projects Containing "Bridge" WorkTypes Total Cost	$376,039,896.56	41.12%	$272,961,019.27	34.68%	$504,526,132.51	37.79%
Projects Containing "Varies" WorkTypes Count	137	24.86%	99	18.93%	82	15.02%
Projects Containing "Varies" WorkTypes Total Cost	$231,635,646.94	25.33%	$155,662,464.72	19.78%	$318,024,809.10	23.83%

After further discussions with ODOT and EcoNW personnel, it was determined that many "bridge" and "varies" numerical WorkTypes could not be mapped to specific projects due to lack of clear documentation. The process of determining these WorkTypes is detailed in Sections 2.6.1.2 and 2.6.1.3.

2.6.1.2 Bridge Projects via Bridge Classification provided by EcoNW

In the HCAS model, the classification of "bridge" WorkTypes is used to reference and classify the scope of work involved in bridge-related projects. The classification of bridge projects is based on two key components:

- **Bridge Type**. Refers to the physical characteristics of the bridge project (i.e., the type of bridge or structure involved in the project). Engineers must assess a project and assign the appropriate bridge type based on these characteristics.
- **WorkType**. Describes work performed on a bridge, including construction, rehabilitation, maintenance, and other related tasks. Engineers must identify the specific WorkType based on the activities outlined in the project plans. Each WorkType is associated with a numeric code, which must be assigned to the bridge project. This code simplifies the categorization process and ensures consistency across different bridge projects.

The bridge type/WorkType classification system reflects the nature of the work and the bridge projects' physical characteristics. Due to incomplete documentation, the OSU team received assistance from ODOT engineers in applying this process to classify bridge-related projects. Below is a step-by-step explanation of how this classification process was implemented:

1. **Identification of Bridge Types**. The first step involves categorizing bridges based on their physical characteristics. ODOT engineers provided the Bridge Type for each project, utilizing EcoNW's Bridge Type numeric codes shown in Table 8. This had to be done by ODOT engineers due to lack of clear documentation to identify a bridge's span.
2. **Assignment of WorkType Codes**. Once the bridge types were identified, ODOT engineers assigned the corresponding numerical WorkType code developed by EcoNW (see Exhibit 3-1 in EcoNW's HCAS reports). Each WorkType was associated with a unique code, which served as an identifier for that work category. For example, "Preliminary and Construction Engineering" was assigned the code "1", while "Right of Way (and Utilities)" was assigned the code "2". This step ensured that each aspect of the bridge project was categorized correctly within the overall framework.

Table 8. HCAS Bridge Types Defined by EcoNW.

Code	Description
1	Single-span under 125 feet
2	Single-span over 125 feet
3	Multi-span
4	Interchange
0	Unknown, not a bridge

2.6.1.3 Unconfirmed Project Types

In the HCAS model, the classification of "varies" WorkTypes is used within the "Decoder Ring" to identify project work that is not attributable to one numerical WorkType specifically. Due to lack of clear documentation, assistance from ODOT engineers was required to code WorkTypes. To clarify these projects and convert them into a format acceptable to EcoNW's HCAS Input

Workbook, ODOT engineers were presented with a list of the projects with the "varies" numerical WorkType. The ODOT engineers then manually assigned the corresponding numerical WorkType code presented in Exhibit 3-1 of the HCAS reports. This step ensured that each aspect of the unconfirmed projects was categorized correctly within the overall framework.

2.6.2 Non-Project Costs

One assumption was made when reconstructing the non-project costs included in EcoNW's HCAS Input Workbook. This assumption pertains to how funding attributed to House Bill 2017 (HB 2017) was allocated. The data used by the HCAS model includes the transfer of non-project costs from ODOT to cities and counties. ODOT provided the OSU research team with non-project cost data separated by funding source for each examined biennium. The funding sources are Federal, State, Bond, Other, Oregon Transportation Investment Act (OTIA), and the Jobs and Transportation Act (JTA).

A funding package allocated to ODOT in the 2017 legislative session, known as HB 2017, was also included as a potential funding source. Following discussions with ODOT personnel, it was decided that any funding attributed to HB 2017 should not be included in the State funding source. Instead, it should be included as part of the "Other Funding" source. This funding source allocation was maintained for each biennium.

2.6.3 Local Costs

Another assumption was made when reconstructing the local costs included in EcoNW's HCAS Input Workbook. This assumption pertains to using a single fiscal year (FY) to calculate local costs. To generate an output, the HCAS model utilizes Local Cost data based on one FY of Local Road and Street Survey (LRSS) data, most of which occurs two FYs before the beginning of each biennium. For example, the 2017-2019 HCAS model utilizes 2015 FY LRSS data. Therefore, an HCAS model would not recognize an input file reconstructed using two FYs of actual data.

Following a discussion with ODOT personnel, the decision was made to generate Local Cost data using the average of the two FYs occurring within a biennium. For example, the Local Cost data for the 2017-2019 HCAS model used the average of the 2018 FY data and the 2019 FY data. All HCAS models ran using actual data generated using this averaging process.

2.6.4 Revenues

ODOT provided actual revenue data for all biennia. Except for the revenue sources not utilized in EcoNW's HCAS Input Workbook (see Section 2.3.4), the actual revenue data was added to the EcoNW's HCAS Input Workbook to generate the simulated outputs.

3.0 RESULTS

3.1 MODEL OUTPUT FOR THE 2017-2019 BIENNIUM

Following the data preparation procedure described in Section 0, the OSU research team used the 2017-2019 HCAS model to produce separate HCAS Output Workbooks using projected data (provided by EcoNW) and actual data (provided by ODOT). These HCAS Output Workbooks contain values for the *scaled equity ratios* and *cost responsibility shares* for different vehicle categories.

The results presented in Section 3.1.1 highlight the differences between the *scaled equity ratios* and the *cost responsibility shares* obtained with the 2017-2019 HCAS model.

3.1.1 Differences in Scaled Equity Ratios and Cost Responsibility Shares

Table 9 shows the values for the scaled equity ratios obtained by running the 2017-2019 HCAS model with projected data (i.e., All-Fee and Full-Fee) and actual data (i.e., All-Fee and Full-Fee). The last four columns of Table 9indicate the percentage by which a vehicle category overpaid (e.g., 2.5% Over) or underpaid (e.g., 0.71% Under). Any cell in Table 9 in which the observed overpayment/underpayment percentage was larger/smaller than ±5% is highlighted in light gray. Table 10 shows the values for the *scaled equity ratios* with the heavy vehicle class encompassing all weight classes greater than 10,000 lbs.

Table 11 shows the cost responsibility shares obtained by running the 2017-2019 HCAS model with projected data (i.e., All-Fee and Full-Fee) and actual data (i.e., All-Fee and Full-Fee). The last two columns of Table 11 show the percent difference between the values obtained with projected data and actual data for both the All-Fee and Full-Fee categories. Any cell in Table 11 in which the percent difference was larger/smaller than ±5% is highlighted in light gray. Table 12 shows the values of the *cost responsibility shares* for the heavy vehicle class encompassing all weight classes greater than 10,000 lbs.

Table 9. Differences in Scaled Equity Ratios for the 2017-2019 Biennium.

	Projected		Actual		Projected		Actual	
	All-Fee	**Full-Fee**	**All-Fee**	**Full-Fee**	**All-Fee**	**Full-Fee**	**All-Fee**	**Full-Fee**
Light (1 to 10,000 lbs)	1.0250	1.0076	1.0471	1.0237	2.50% Over	0.76% Over	4.71% Over	2.37% Over
Medium (10,001 to 26,000 lbs)	0.9929	1.0993	0.9935	1.1878	0.71% Under	***9.93% Over***	0.65% Under	***18.78% Over***
Heavy (26,001 lbs and Up)	0.9520	0.9712	0.9045	0.9226	4.80% Under	2.88% Under	***9.55% Under***	***7.74% Under***

Table 10. Differences in Scaled Equity Ratios with Adjusted Light and Heavy Vehicle Classes for the 2017-2019 Biennium.

	Projected		Actual		Projected		Actual	
	All-Fee	**Full-Fee**	**All-Fee**	**Full-Fee**	**All-Fee**	**Full-Fee**	**All-Fee**	**Full-Fee**
Light (1 to 10,000 lbs)	1.0250	1.0076	1.0471	1.0237	2.50% Over	0.76% Over	4.71% Over	2.37% Over
Heavy (10,001 lbs and Up)	0.9576	0.9865	0.9174	0.9564	4.24% Under	1.35% Under	***8.26% Under***	4.36% Under

Table 11. Differences in Cost Responsibility Shares for the 2017-2019 Biennium.

	Projected		Actual		Difference (Actual - Projected)	
	All-Fee	Full-Fee	All-Fee	Full-Fee	All-Fee	Full-Fee
Light (1 to 10,000 lbs)	62.93%	63.98%	63.66%	64.78%	0.73%	0.81%
Medium (10,001 to 26,000 lbs)	5.09%	4.30%	5.29%	4.48%	0.20%	0.18%
Heavy (26,001 lbs and Up)	31.98%	31.72%	31.05%	30.74%	-0.93%	-0.99%

Table 12. Differences in Cost Responsibility Shares with Adjusted Light and Heavy Vehicle Classes for the 2017-2019 Biennium.

	Projected		Actual		Difference (Actual - Projected)	
	All-Fee	Full-Fee	All-Fee	Full-Fee	All-Fee	Full-Fee
Light (1 to 10,000 lbs)	62.93%	63.98%	63.66%	64.78%	0.73%	0.81%
Heavy (10,001 lbs and Up)	37.07%	36.02%	36.34%	35.22%	-0.73%	-0.81%

Figure 9 and Figure 10 depict graphically the differences observed in *scaled equity ratios* by running the 2017-2019 HCAS model with projected data (i.e., All-Fee and Full-Fee) and actual data (i.e., All-Fee and Full-Fee). As Figure 9 and Figure 10 show, no trends or pronounced differences were observed in the *scaled equity ratios* in the 2017-2019 biennium.

Figure 11 and Figure 12 depict graphically the differences observed in *cost responsibility shares* by running the 2017-2019 HCAS model with projected data (i.e., All-Fee and Full-Fee) and actual data (i.e., All-Fee and Full-Fee). As Figure 11 and Figure 12 show, no trends or pronounced differences were observed in the *cost responsibility shares* values in the 2017-2019 biennium.

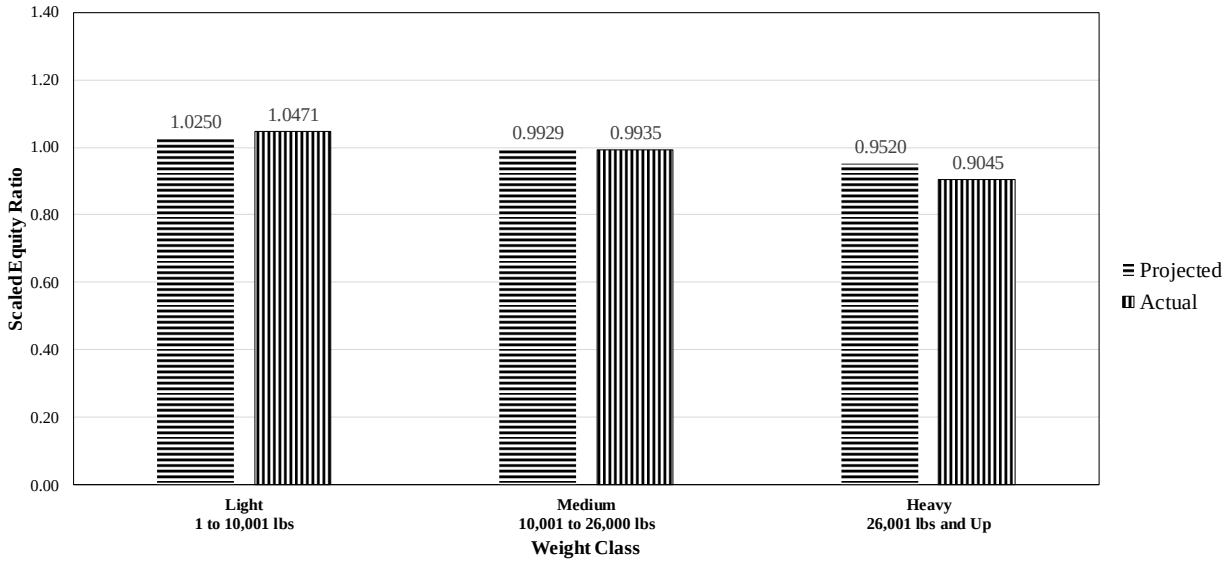

Figure 9. Graphical Comparison of the All-Fee Scaled Equity Ratios for the 2017-2019 Biennium.

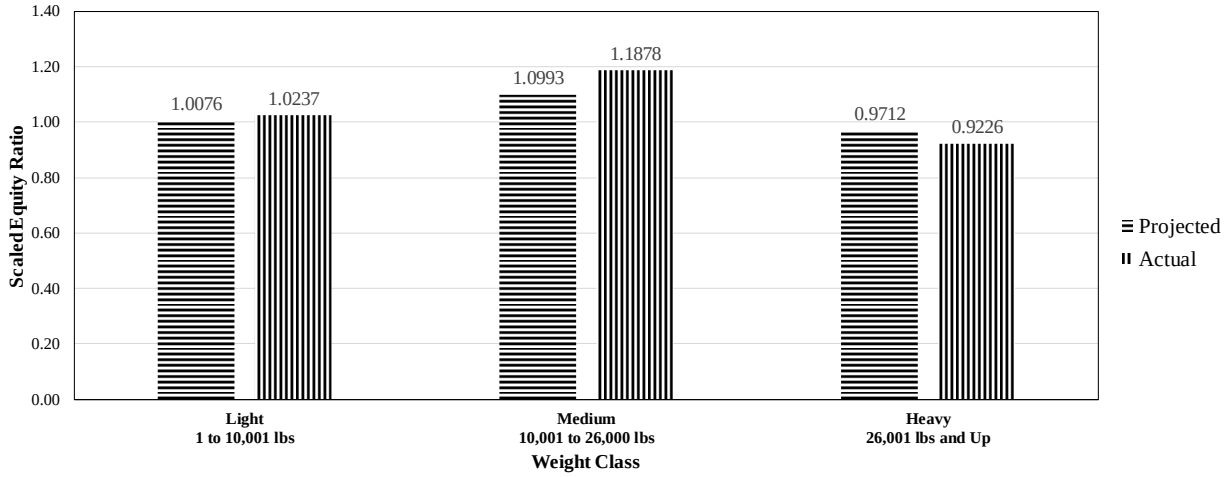

Figure 10. Graphical Comparison of the Full-Fee Scaled Equity Ratios for the 2017-2019 Biennium.

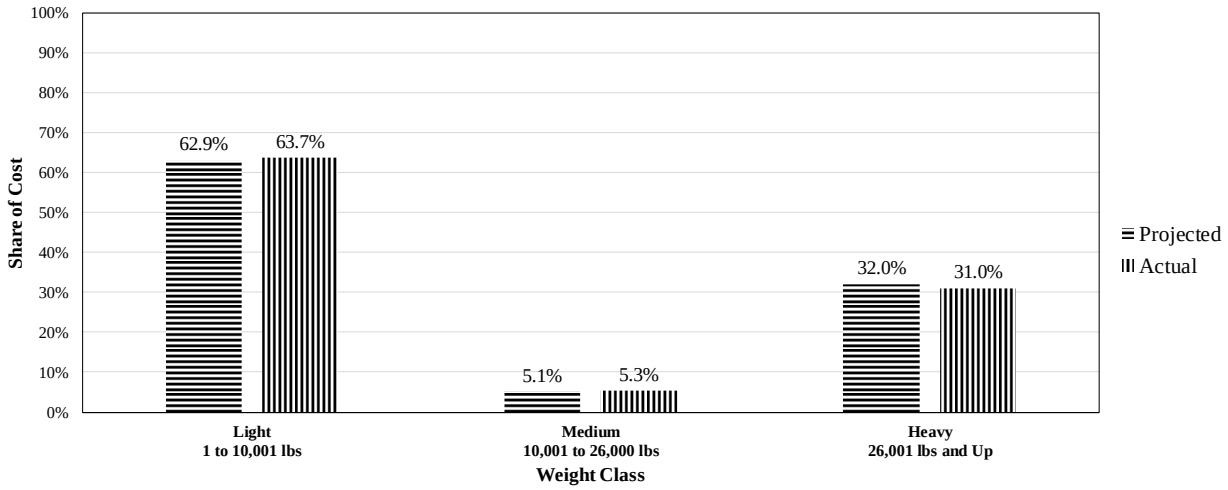

Figure 11. Graphical Comparison of All-Fee Cost Responsibility Shares for the 2017-2019 Biennium.

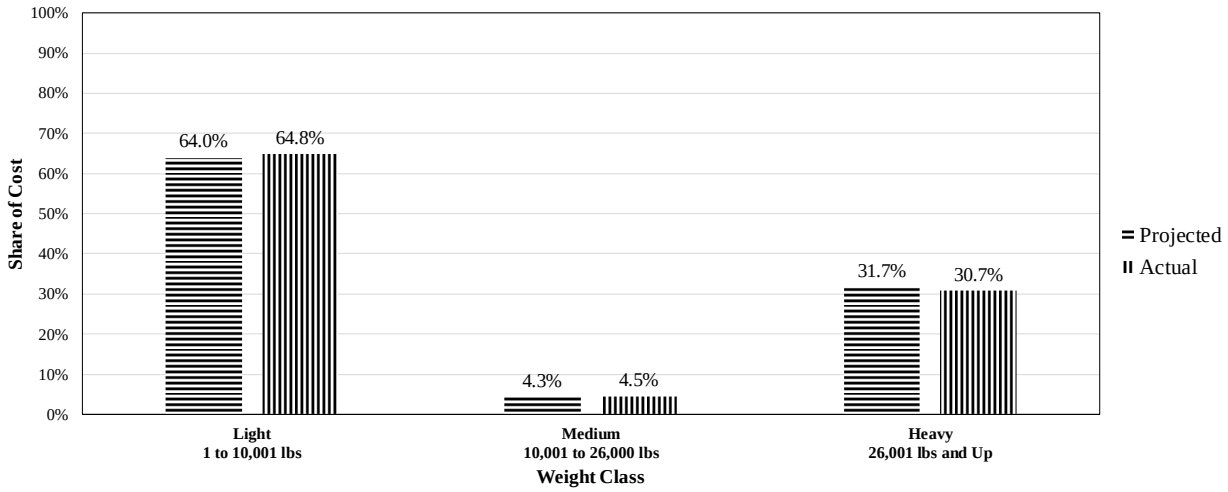

Figure 12. Graphical Comparison of the Full-Fee Cost Responsibility Shares for the 2017-2019 Biennium.

3.2 MODEL OUTPUT FOR THE 2019-2021 BIENNIUM

Following the data preparation procedure described in Section 0, the OSU research team used the 2019-2021 HCAS model to produce separate HCAS Output Workbooks using projected data (provided by EcoNW) and actual data (provided by ODOT). These HCAS Output Workbooks contain values for the *scaled equity ratios* and *cost responsibility shares* for different vehicle categories.

The results presented in Section 3.2.1 highlight the differences between the *scaled equity ratios* and the *cost responsibility shares* obtained with the 2019-2021 HCAS model, which were unusual compared to those obtained with the 2017-2019 and 2021-2023 HCAS models. It is important to note that the 2019-2021 biennium covered the peak of the COVID-19 pandemic. Therefore, some of the pronounced differences observed in the *scaled equity ratios* and the *cost responsibility shares* results produced by the 2019-2021 HCAS model could be attributed to changes in revenue and cost patterns that took place during that time. Section 3.4 provides additional context about potential reasons why the results obtained with the 2019-2021 HCAS model are unusual.

3.2.1 Differences in Scaled Equity Ratios and Cost Responsibility Shares

Table 13 shows the values for the scaled equity ratios obtained by running the 2019-2021 HCAS model with projected data (i.e., All-Fee and Full-Fee) and actual data (i.e., All-Fee and Full-Fee). The last four columns of Table 13 indicate the percentage by which a vehicle category overpaid (e.g., 0.5% Over) or underpaid (e.g., 1.54% Under). Any cell in Table 13 in which the observed overpayment/underpayment percentage was larger/smaller than ±5% is highlighted in light gray. Table 14 shows the values for the *scaled equity ratios* with the heavy vehicle class encompassing all weight classes greater than 10,000 lbs.

Table 15 shows the values obtained for the cost responsibility shares by running the 2019-2021 HCAS model with projected data (i.e., All-Fee and Full-Fee) and actual data (i.e., All-Fee and Full-Fee). The last two columns of Table 15 show the percent difference between the values obtained with projected data and actual data for both the All-Fee and Full-Fee categories. Any cell in Table 15 in which the percent difference was larger/smaller than ±5% is highlighted in light gray. Table 16 shows the values of the cost responsibility shares for the heavy vehicle class encompassing all weight classes greater than 10,000 lbs.

Table 13. Differences in Scaled Equity Ratios for the 2019-2021 Biennium.

	Projected		Actual		Projected		Actual	
	All-Fee	**Full-Fee**	**All-Fee**	**Full-Fee**	**All-Fee**	**Full-Fee**	**All-Fee**	**Full-Fee**
Light (1 to 10,000 lbs)	1.0050	0.9846	0.6899	0.6825	0.50% Over	1.54% Under	***31.01% Under***	***31.75% Under***
Medium (10,001 to 26,000 lbs)	0.9939	1.0819	0.9934	1.1085	0.61% Under	***8.19% Over***	0.66% Under	***10.85% Over***
Heavy (26,001 lbs and Up)	0.9899	1.0247	17.0180	29.5820	1.01% Under	2.47% Over	***1601.80% Over***	***2858.20% Over***

Table 14. Differences in Scaled Equity Ratios with Adjusted Light and Heavy Vehicle Classes for the 2019-2021 Biennium.

	Projected		Actual		Projected		Actual	
	All-Fee	**Full-Fee**	**All-Fee**	**Full-Fee**	**All-Fee**	**Full-Fee**	**All-Fee**	**Full-Fee**
Light (1 to 10,000 lbs)	1.0050	0.9846	0.6899	0.6825	0.50% Over	1.54% Under	***31.01% Under***	***31.75% Under***
Heavy (10,001 lbs and Up)	0.9905	1.0314	8.6096	12.6005	0.85% Under	3.14% Over	***760.96% Over***	***1160.05% Over***

Table 15. Differences in Cost Responsibility Shares for the 2019-2021 Biennium.

	Projected		Actual		Difference (Actual - Projected)	
	All-Fee	**Full-Fee**	**All-Fee**	**Full-Fee**	**All-Fee**	**Full-Fee**
Light (1 to 10,000 lbs)	65.27%	67.16%	96.08%	97.34%	***30.81%***	***30.18%***
Medium (10,001 to 26,000 lbs)	5.05%	3.86%	2.05%	1.59%	-3.00%	-2.27%
Heavy (26,001 lbs and Up)	29.68%	28.98%	1.86%	1.08%	***-27.82%***	***-27.91%***

Table 16. Differences in Cost Responsibility Shares with Adjusted Light and Heavy Vehicle Classes for the 2019-2021 Biennium.

	Projected		Actual		Difference (Actual - Projected)	
	All-Fee	**Full-Fee**	**All-Fee**	**Full-Fee**	**All-Fee**	**Full-Fee**
Light (1 to 10,000 lbs)	65.27%	67.16%	96.08%	97.34%	***30.81%***	***30.18%***
Heavy (10,001 lbs and Up)	34.73%	32.84%	3.92%	2.66%	***-30.81%***	***-30.18%***

Figure 13 and Figure 14 depict graphically the differences observed in *scaled equity ratios* by running the 2019-2021 HCAS model with projected data (i.e., All-Fee and Full-Fee) and actual data (i.e., All-Fee and Full-Fee). As Figure 13 and Figure 14 show, no trends were observed in the *scaled equity ratios* in the 2019-2021 biennium. However, the differences in *scaled equity ratios* for the All-Fee and Full-Fee for the "Heavy" vehicle category are very pronounced. More specifically, the *scaled equity ratios* calculated with actual data are several orders of magnitude larger than those obtained with projected data.

Figure 15 and Figure 16 depict graphically the differences observed in *cost responsibility shares* by running the 2019-2021 HCAS model with projected data (i.e., All-Fee and Full-Fee) and actual data (i.e., All-Fee and Full-Fee). As Figure 11 and Figure 12 show, no trends or pronounced differences were observed in the *cost responsibility shares* values in the 2017-2019 biennium. However, the differences in *cost responsibility share* percentages for the All-Fee and Full-Fee for the "Light" and "Heavy" vehicle categories are very pronounced. More specifically, the *cost responsibility share* percentages calculated with actual data are approximately 30% larger than those obtained with projected data.

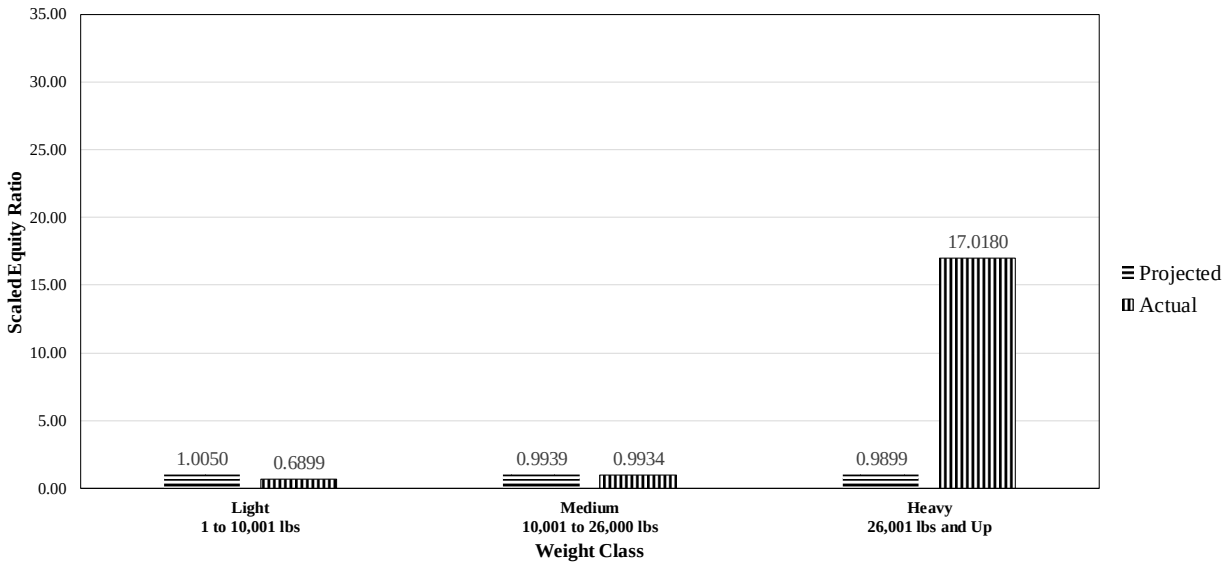

Figure 13. Graphical Comparison of the All-Fee Scaled Equity Ratios for the 2019-2021 Biennium.

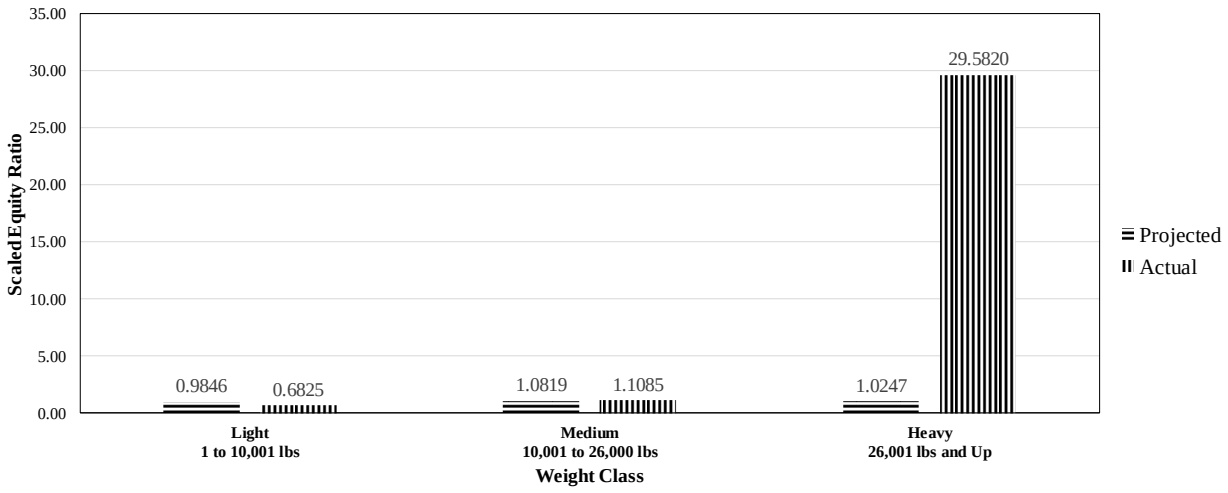

Figure 14. Graphical Comparison of the Full-Fee Scaled Equity Ratios for the 2019-2021 Biennium.

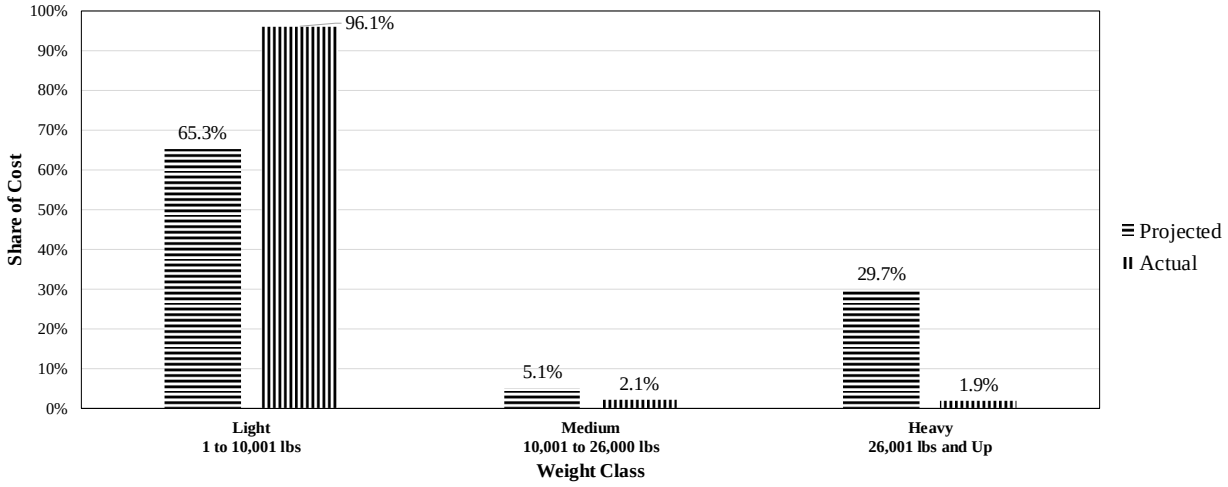

Figure 15. Graphical Comparison of All-Fee Cost Responsibility Shares for the 2019-2021 Biennium.

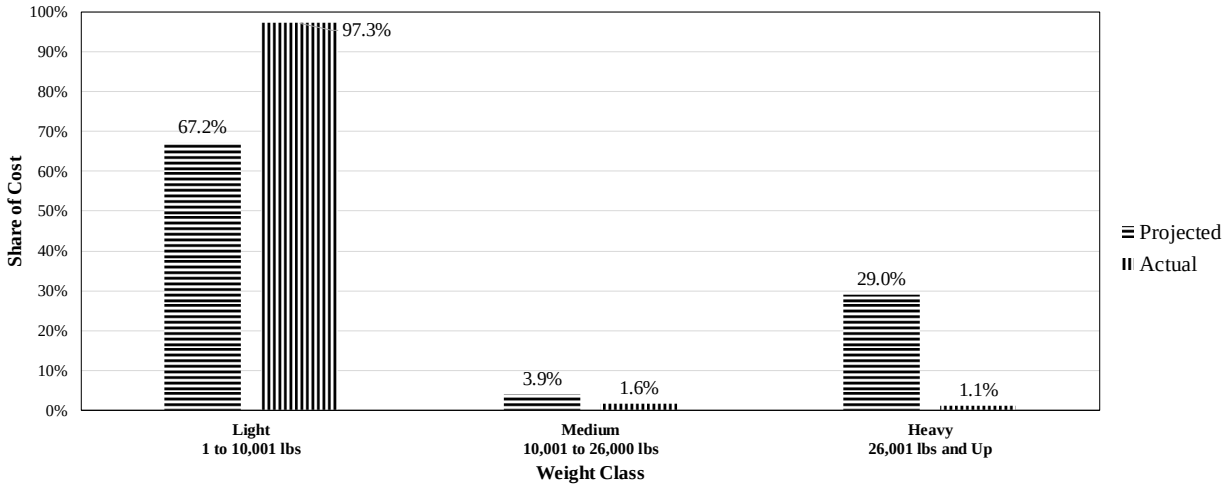

Figure 16. Graphical Comparison of the Full-Fee Cost Responsibility Shares for the 2019-2021 Biennium.

3.3 MODEL OUTPUT FOR THE 2021-2023 BIENNIUM

Following the data preparation procedure described in Section 0, the OSU research team used the 2021-2023 HCAS model to produce separate HCAS Output Workbooks using projected data (provided by EcoNW) and actual data (provided by ODOT). These HCAS Output Workbooks contain values for the *scaled equity ratios* and *cost responsibility shares* for different vehicle categories.

The results presented in Section 3.3.1 highlight the differences between the *scaled equity ratios* and the *cost responsibility shares* obtained with the 2021-2023 HCAS model.

3.3.1 Differences in Scaled Equity Ratios and Cost Responsibility Shares

Table 17 shows the values for the scaled equity ratios obtained by running the 2021-2023 HCAS model with projected data (i.e., All-Fee and Full-Fee) and actual data (i.e., All-Fee and Full-Fee). The last four columns of Table 17 indicate the percentage by which a vehicle category overpaid (e.g., 6.4% Over) or underpaid (e.g., 5.12% Under). Any cell in Table 17 in which the observed overpayment/underpayment percentage was larger/smaller than ±5% is highlighted in light gray. Table 18 shows the values for the *scaled equity ratios* with the heavy vehicle class encompassing all weight classes greater than 10,000 lbs.

Table 19 shows the values obtained for the *cost responsibility shares* by running the 2021-2023 HCAS model with projected data (i.e., All-Fee and Full-Fee) and actual data (i.e., All-Fee and Full-Fee). The last two columns of Table 19 show the percent difference between the values obtained with projected data and actual data for both the All-Fee and Full-Fee categories. Any cell in Table 19 in which the percent difference was larger/smaller than ±5% is highlighted in light gray. Table 20 shows the values of the *cost responsibility shares* for the heavy vehicle class encompassing all weight classes greater than 10,000 lbs.

Table 17. Differences in Scaled Equity Ratios for the 2021-2023 Biennium.

	Projected		Actual		Projected		Actual	
	All-Fee	**Full-Fee**	**All-Fee**	**Full-Fee**	**All-Fee**	**Full-Fee**	**All-Fee**	**Full-Fee**
Light (1 to 10,000 lbs)	0.9488	0.9284	0.9287	0.9092	***5.12% Under***	7.16% Under	***7.13% Under***	***9.08% Under***
Medium (10,001 to 26,000 lbs)	0.9934	1.0654	0.9933	1.0567	0.66% Under	***6.54% Over***	0.67% Under	***5.67% Over***
Heavy (26,001 lbs and Up)	1.1258	1.1763	1.1894	1.2476	***12.58% Over***	***17.63% Over***	***18.94% Over***	***24.76% Over***

Table 18. Differences in Scaled Equity Ratios with Adjusted Light and Heavy Vehicle Classes for the 2021-2023 Biennium.

	Projected		Actual		Projected		Actual	
	All-Fee	**Full-Fee**	**All-Fee**	**Full-Fee**	**All-Fee**	**Full-Fee**	**All-Fee**	**Full-Fee**
Light (1 to 10,000 lbs)	0.9488	0.9284	0.9287	0.9092	***5.12% Under***	7.16% Under	***7.13% Under***	***9.08% Under***
Heavy (10,001 lbs and Up)	1.1070	1.1635	1.1604	1.2245	***10.7% Over***	***16.35% Over***	***16.04% Over***	***22.45% Over***

Table 19. Differences in Cost Responsibility Shares for the 2021-2023 Biennium.

	Projected		Actual		Difference (Actual - Projected)	
	All-Fee	Full-Fee	All-Fee	Full-Fee	All-Fee	Full-Fee
Light (1 to 10,000 lbs)	67.63%	69.55%	69.24%	71.20%	1.61%	1.65%
Medium (10,001 to 26,000 lbs)	5.27%	3.72%	4.55%	3.49%	-0.72%	-0.23%
Heavy (26,001 lbs and Up)	27.10%	26.72%	26.21%	25.30%	-0.89%	-1.42%

Table 20. Differences in Cost Responsibility Shares with Adjusted Light and Heavy Vehicle Classes for the 2021-2023 Biennium.

	Projected		Actual		Difference (Actual - Projected)	
	All-Fee	Full-Fee	All-Fee	Full-Fee	All-Fee	Full-Fee
Light (1 to 10,000 lbs)	67.63%	69.55%	69.24%	71.20%	1.61%	1.65%
Heavy (26,001 lbs and Up)	32.37%	30.45%	30.76%	28.80%	-1.61%	-1.65%

Figure 17 and Figure 18 depict graphically the differences observed in *scaled equity ratios* by running the 2021-2023 HCAS model with projected data (i.e., All-Fee and Full-Fee) and actual data (i.e., All-Fee and Full-Fee). As Figure 17 and Figure 18 show, no trends or pronounced differences were observed in the *scaled equity ratios* in the 2021-2023 biennium.

Figure 19 and Figure 20 depict graphically the differences observed in *cost responsibility shares* by running the 2021-2023 HCAS model with projected data (i.e., All-Fee and Full-Fee) and actual data (i.e., All-Fee and Full-Fee). As Figure 19 and Figure 20 show, no trends or pronounced differences were observed in the *cost responsibility shares* values in the 2021-2023 biennium.

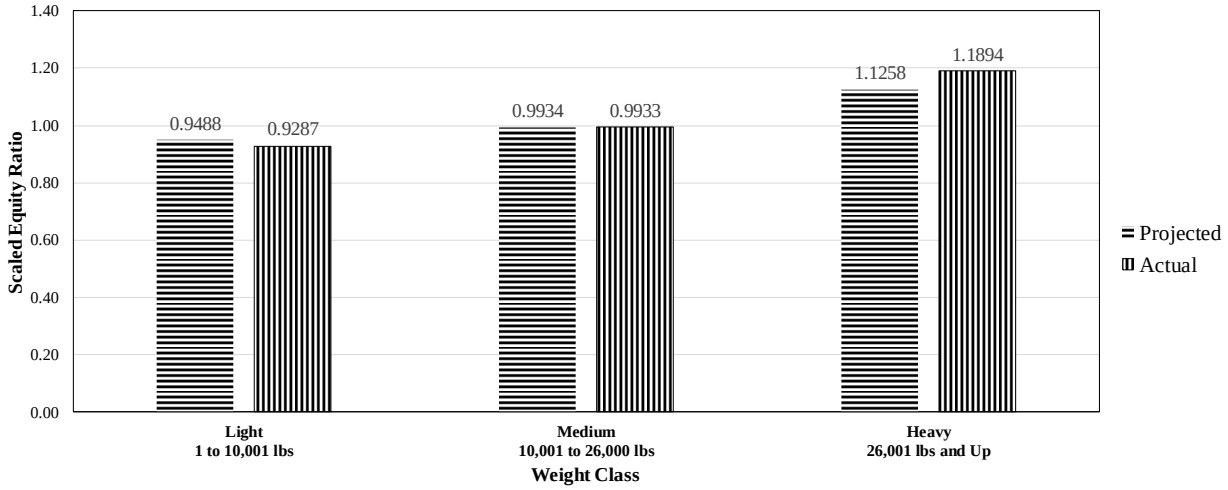

Figure 17. Graphical Comparison of the All-Fee Scaled Equity Ratios for the 2021-2023 Biennium.

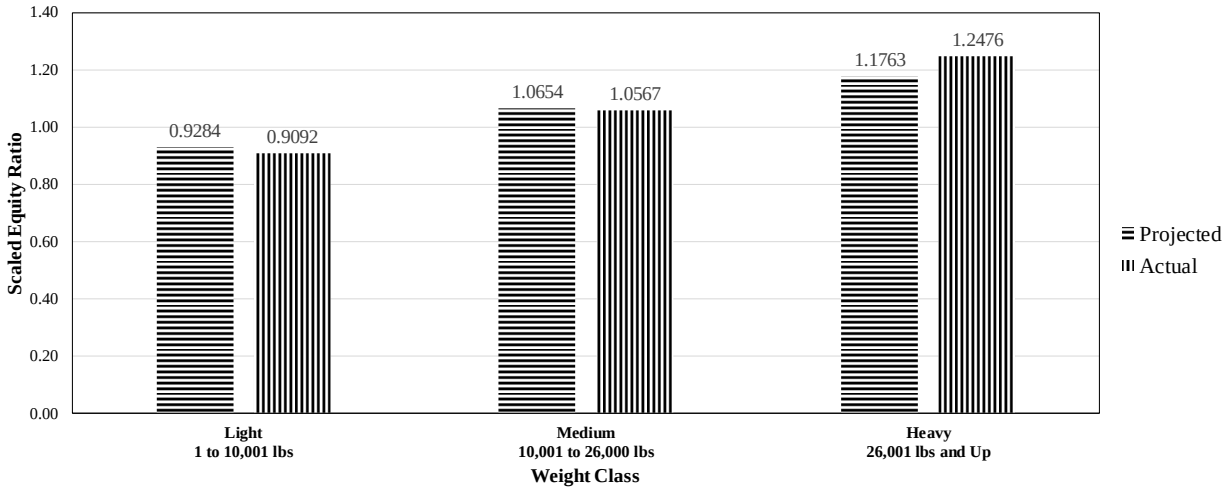

Figure 18. Graphical Comparison of the Full-Fee Scaled Equity Ratios for the 2021-2023 Biennium.

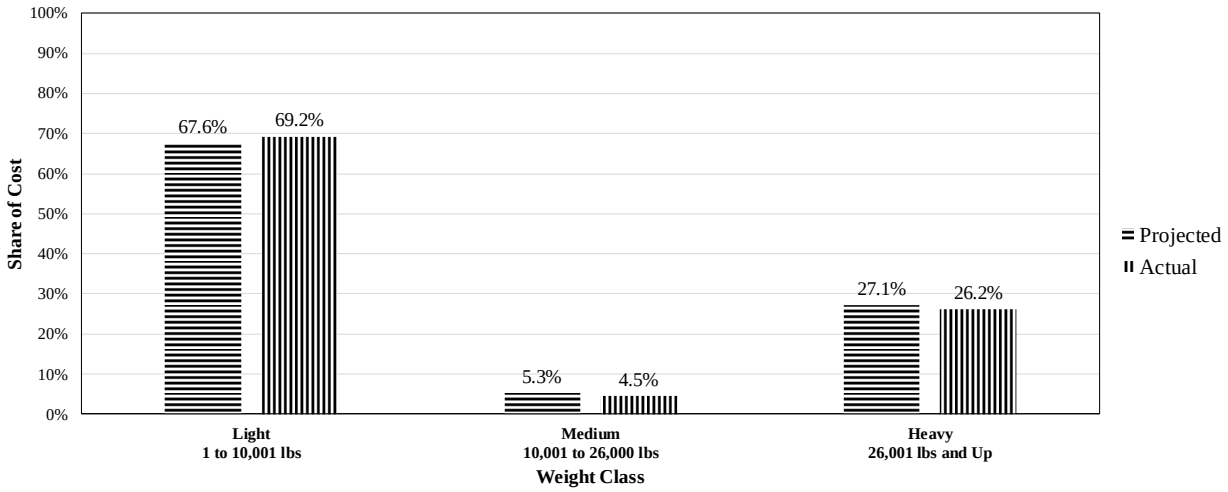

Figure 19. Graphical Comparison of All-Fee Cost Responsibility Shares for the 2021-2023 Biennium.

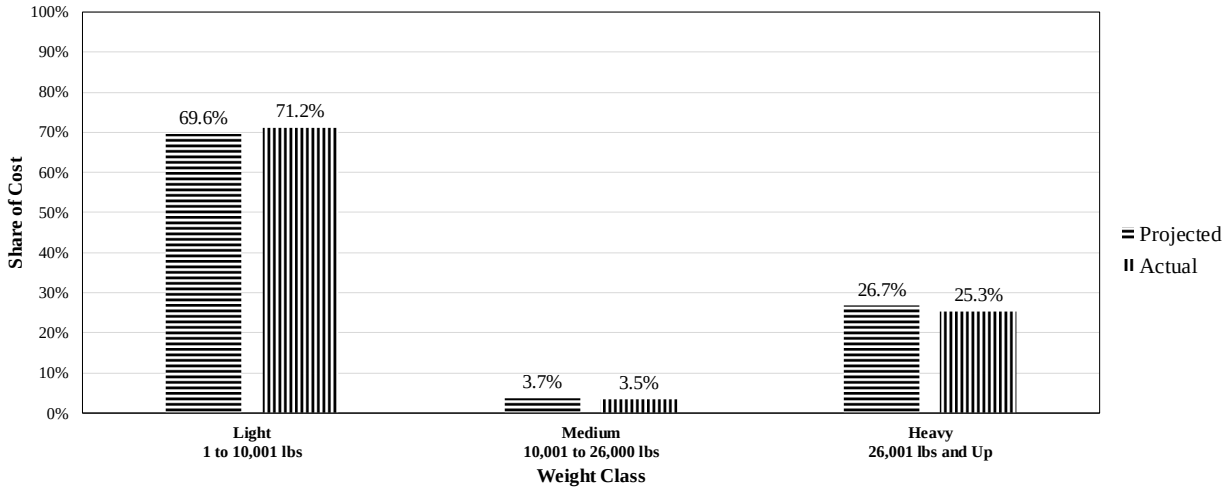

Figure 20. Graphical Comparison of the Full-Fee Cost Responsibility Shares for the 2021-2023 Biennium.

3.4 ADDITIONAL CONTEXT ABOUT THE RESULTS FOR THE 2019-2021 BIENNIUM

As illustrated in Section 3.2, the values obtained for the *scaled equity ratios* and *cost responsibility shares* when the 2019-2021 HCAS model was run using actual data varied significantly (for some vehicle categories) when compared to the results obtained with the 2017-2019 and 2021-2023 HCAS models.

A preliminary analysis into the potential causes for the unusual results produced by the 2019-2021 HCAS model seems to indicate that there may be two potential explanations:

1. The magnitude difference between the projected and actual values for revenues and costs that correspond to the 2019-2021 biennia were larger when compared to those observed for the 2017-2019 and 2021-2023 biennia.
2. This large difference in magnitude in revenues and costs may have exceeded the thresholds that the 2019-2021 HCAS model was designed to accommodate – a potential logic flaw that manifests when unexpected and improbable values are used. The causes of this behavior in the HCAS model should be further investigated.

The 2019-2021 HCAS model was developed in 2018 and utilized forecasted (i.e., projected) data produced in 2018. The COVID-19 pandemic was an unexpected event that happened during the 2019-2021 biennium. It is very likely that the revenue and cost projections prepared in 2018 did not account for the effects that this disruptive event would have on actual data.

Since HCAS models were originally designed to work with projected revenues and costs, the differences in magnitude between projected and actual revenues and cost values may provide additional insight that explains the unusual results obtained when running the 2019-2021 HCAS model with actual data. Sections 3.4.1 through 3.4.4 present data that contrast the differences in magnitude observed in the revenues and the different costs categories (i.e., project, non-project, and local) used to run the three HCAS models evaluated in this study. In Section 3.4.5, a synthesis of the differences in the revenue and cost data is presented to elucidate any significant tends. Finally, Section 3.4.6 discusses additional potential limitations of the HCAS model.

3.4.1 Revenue

It is important to note, however, that the projected revenue values do not include increases to HB 2017 funding, which may contribute to the magnitude of the differences. Appendix A includes a table that compares the projected versus actual revenue for each biennium.

Table 21 shows the differences between actual and projected revenue for the 2017-2019, 2019-2021, and 2021-2023 biennia. The dollar amount difference is calculated as shown in Equation 1, whereas the percent difference is calculated as shown in Equation 2.

$$Dollar\ (\$) Difference = Actual\ Revenue - Projected\ Revenue \quad (1)$$

$$Percentage\ (\%)\ Difference = \frac{(Actual\ Revenue - Projected\ Revenue)}{Projected\ Revenue} \quad (2)$$

As Table 21 shows, the actual revenue for 2019-2021 was 6.70% lower than projected for that biennium. In contrast, the actual revenue for 2017-2019 and 2021-2023 exceeded the projected revenue by 13.17% and 0.64%, respectively. It is important to note, however, that the projected revenue values do not include increases to HB 2017 funding, which may contribute to the magnitude of the differences. Appendix A includes a table that compares the projected versus actual revenue for each biennium.

Table 21. Differences in Actual versus Projected Revenues Across Biennia.

Revenue Source	Differences (Actual Revenue - Projected Revenue)					
	2017-2019		2019-2021		2021-2023	
	$	%	$	%	$	%
Basic/Motorcycle/Moped Light Reg	$93,804,201	28.33%	($54,621,299)	-10.93%	($3,812,007)	-0.74%
Truck Normal Reg	$10,020,900	32.05%	($300,094)	-0.68%	$2,201,914	4.53%
Bus Normal Reg	$55,798	7.30%	($467,430)	-41.08%	($183,077)	-18.90%
Farm Reg	$1,673,938	26.19%	($1,191,253)	-13.43%	($1,073,896)	-11.27%
Charitable/Non-Profit & Tow Reg	$33,066	11.80%	($121,596)	-30.31%	($135,430)	-32.12%
Tow Reg	$179,657	29.66%	($55,707)	-6.89%	($5,479)	-0.58%
Heavy Fixed Load Vehicle Reg	$47,408	24.53%	($79,465)	-32.70%	($60,573)	-25.70%
E-Plate Reg	$162,358	490.02%	$13,662	28.65%	$4,364	7.07%
School Bus Reg	$8,471	216.93%	($568)	-18.57%	$957	43.75%
Light Trailer Reg	$3,203,465	22.36%	($2,200,440)	-11.81%	($1,263,148)	-6.20%
Heavy/Special/Rental Trailer Reg	$367,247	136.06%	$38,186	12.09%	$128,427	34.65%
Light Titles - New/First OR/Transfer	$24,123,080	15.26%	($53,704,115)	-24.85%	($791,239)	-0.39%
Heavy Titles - New/First OR/Transfer	$768,207	17.37%	($672,695)	-15.37%	$306,661	7.77%
Motor Carrier Interstate Reg	$5,486,148	8.78%	$3,134,931	4.94%	($8,774,461)	-12.43%
Motor Carrier Intrastate Reg	$1,607,361	6.77%	$2,626,910	11.05%	$3,229,993	13.90%
Motor Carrier Trip Permits	($2,992,907)	-39.56%	($1,503,051)	-24.41%	($2,026,804)	-29.64%
Weight-Mile Tax (includes late fees)	$87,588,914	14.12%	$16,800,880	2.08%	$33,279,497	3.80%
Road Use Assessment Fee	$866,677	22.68%	$788,638	15.23%	$1,807,229	29.89%
Gas Tax - both gas and use (diesel) tax revenue	$87,055,847	7.78%	($111,341,020)	-8.39%	($2,926,421)	-0.22%
Totals	**$314,059,836**	**13.17%**	**($202,855,526)**	**-6.70%**	**$19,906,510**	**0.64%**

3.4.2 Project Expenditures

For all three biennia, the actual project expenditures were lower than projected. However, the actual minus projected difference observed for the 2019-2021 biennium is significantly larger (i.e., 46.9%). In contrast, these differences were 29.84% and 6.03% for the 2017-2019 and 2021-2023 biennia, as shown in Table 22.

3.4.3 Non-Project Costs

In the 2019-2021 biennium, the actual non-project costs were 39.05% larger than projected. In contrast, the actual non-project costs were smaller than projected (7.39% and 10.05%, respectively) for the 2017-2019 and 2021-2023 biennia as shown in Table 23.

3.4.4 Local Costs

In the 2019-2021 biennium, actual local cost were 47% lower than projected. In contrast, local costs were 93.28% and 224.23% higher than projected for the 2017-2019 and 2021-2023 biennia, as shown in Table 24.

3.4.5 Overall Trend

Table 25 synthesizes the data presented in Table 21 through Table 24 to illustrate the overall trends in the differences between actual versus projected values for revenues and cost categories (i.e., project, non-project, and local). For the 2019-2021 biennium, the projected values in three out of four input data categories (i.e., revenue, non-project costs, and local costs) were larger than the actual values, whereas the other two biennia were lower than the actual value. The OSU research team believes that the 46.90% difference in project costs may have also have a pronounced effect on the unusual results observed when running the 2019-2021 HCAS model with actual data because the HCAS models proved to be very sensitive to changes in project costs during the evaluation process.

3.4.6 Additional Potential Limitation of the HCAS Model

In modeling, it is common to calibrate models by trading off accuracy and sensitivity to changes in data inputs. In other words, narrower thresholds for data variation tend to increase accuracy of the model. This is because the model will have to account for less variability and therefore reduce the need to account for large levels of uncertainty. This approach works well in scenarios where input data is expected to remain within the thresholds for which the model is designed.

As shown in It is important to note, however, that the projected revenue values do not include increases to HB 2017 funding, which may contribute to the magnitude of the differences. Appendix A includes a table that compares the projected versus actual revenue for each biennium.

Table 21 through Table 25, the large differences observed between actual and projected revenue and cost data in the 2019-2021 biennium may indicate that, for this period, the thresholds that the

HCAS model is calibrated to handle were exceeded. Therefore, the validity of the calculated *scaled equity ratios* and *cost responsibility shares* using actual revenue and cost data for the 2019-2021 biennium cannot be substantiated nor refuted by the OSU research team as a result of this study.

Table 22. Differences in Actual versus Projected Project Expenditures Across Biennia.

Funding Source	Differences (Actual Project Expenditures - Projected Project Expenditures)					
	2017-2019		2019-2021		2021-2023	
	$	%	$	%	$	%
Federal	($127,165,255)	-17.33%	($634,854,195)	-55.85%	($457,082,196)	-43.10%
State	($28,866,117)	-18.52%	$34,704,755	17.91%	$512,327,557	275.02%
Other	($141,555,213)	-72.16%	($86,719,582)	-75.93%	($113,362,436)	-72.66%
Bond (OTIA + JTA)	$17,534,396	16.11%	$10,552,174	56.35%	($18,638,595)	-207.84%
Totals	**($280,052,190)**	**-29.84%**	**($676,316,848)**	**-46.90%**	**($76,755,670)**	**-6.03%**

Table 23. Differences in Actual versus Projected Non-Project Costs Across Biennia.

Allocation Brackets for Non-Project Costs	Differences (Actual Non-Project Costs - Projected Non-Project Costs)					
	2017-2019		2019-2021		2021-2023	
	$	%	$	%	$	%
State	($75,394,785)	-4.20%	$205,796,653	10.06%	$494,514,026	21.63%
Federal	($182,869,361)	-18.29%	$544,781,890	69.63%	($1,241,610,370)	-57.59%
Bond	$143,610,355	100.00%	($21,127,464)	-72.16%	($7,735,600)	-100.00%
OITA	$50,935,829	66.59%	$49,111,488	58.35%	($178,730,650)	-60.32%
JTA	($199,534,263)	-42.40%	$23,158,415	8.16%	($29,311,941)	-9.82%
Other	$1,280,273	0.63%	$474,795,920	1105.55%	$448,269,240	532.58%
Total	**($261,971,953)**	**-7.39%**	**$1,276,516,902**	**39.05%**	**($514,605,295)**	**-10.05%**

Table 24. Differences in Actual versus Projected Local Costs Across Biennia.

Local Costs	Differences (Actual Local Costs – Projected Local Costs)					
	2017-2019		2019-2021		2021-2023	
	$	%	$	%	$	%
Receipts	$248,842,405	24.41%	$253,487,796	22.05%	$272,183,473	-16.32%
Disbursements	$190,601,788	19.92%	$300,187,524	28.58%	$135,442,543	10.15%
Receipts - Disbursements	**$58,240,616**	**93.28%**	**($46,699,728)**	**-47.00%**	**$136,740,931**	**224.23%**

Table 25. Differences in Actual versus Projected Across Biennia.

Category	Differences (Actual - Projected)					
	2017-2019		2019-2021		2021-2023	
	$	%	$	%	$	%
Revenue	$314,059,836.00	13.17%	($202,855,526.00)	-6.70%	$19,906,510.00	0.64%
Project Costs	($280,052,190.00)	-29.84%	($676,316,848.00)	-46.90%	($76,755,670.00)	-6.03%
Non-Project Costs	($261,971,952.76)	-7.39%	$1,276,516,902.22	39.05%	($514,605,295.49)	-10.05%
Local Costs	$58,240,616.46	93.28%	($46,699,728.00)	-47.00%	$136,740,930.74	224.23%

3.5 REVENUE ATTRIBUTION

In addition to scaled equity ratios and cost responsibility shares, the HCAS Output Workbooks contain revenue attribution data based on vehicle weight class. The results presented in this section highlight the differences between the *attributed revenues* obtained by aggregating the data collected from each biennium's HCAS Output Workbook.

Table 26 shows the percentage of revenue attributed to the Light Vehicle weight class (between 1 and 10,000 lbs.), whereas Table 27 shows the percentage of revenue attributed to the Heavy Vehicle weight class (greater than 10,000 lbs.). The revenue percentages shown in Table 26 and Table 27 are divided across 11 different revenue sources, representing each revenue source or tax instrument used by ODOT's forecasting model.

It is worth noting that revenue, as allocated to weight classes by the HCAS model, is calculated using an internally adjusted mile per gallon (MPG) per weight class. The MPG adjustment appears to be the section in the Python code where the thresholds are being exceeded by the 2019-2021 actual revenue data (as explained in Section 3.4.1), thus generating the unusual results observed in Table 26 and Table 27 (see cell with blue and red numbers), and in Figure 21 and Figure 22.

Table 26. Light Vehicle Revenue Attribution.

Revenue Source	2017-2019		2019-2021		2021-2023	
	Projected	Actual	Projected	Actual	Projected	Actual
Gas Tax	98.20%	98.56%	98.16%	**100.88%**	99.02%	99.08%
Diesel Tax	65.35%	70.44%	61.62%	**120.52%**	70.73%	71.82%
VMT Tax	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
M97 Tax	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
WMT	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Flat Fee	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
RUAF	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Registration	71.87%	72.80%	76.94%	74.68%	75.44%	75.44%
Other MC	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Subsidy	17.01%	23.96%	16.11%	18.53%	16.90%	16.95%
Full Fee VMT	92.63%	92.63%	92.51%	92.51%	92.13%	92.13%

Table 27. Heavy Vehicle Revenue Attribution.

Revenue Source	2017-2019		2019-2021		2021-2023	
	Projected	Actual	Projected	Actual	Project	Actual
Gas Tax	1.80%	1.44%	1.84%	**-0.88%**	0.98%	0.92%
Diesel Tax	34.65%	29.56%	38.38%	**-20.52%**	29.27%	28.18%
VMT Tax	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
M97 Tax	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
WMT	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Flat Fee	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
RUAF	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Registration	28.13%	27.20%	23.06%	25.32%	24.56%	24.56%
Other MC	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Subsidy	82.99%	76.04%	83.89%	81.47%	83.10%	83.05%
Full Fee VMT	7.37%	7.37%	7.49%	7.49%	7.87%	7.87%

Figure 21and Figure 22 depict graphically the differences observed in *attributed revenues* by running each biennium's HCAS model. Figure 21 depicts the attributed revenues for the Light Vehicle class, whereas Figure 22 depicts the attributed revenues for the Heavy Vehicle class.

Only the revenue sources or tax instruments with observable differences between projected data and actual data are shown in Figures 21 and 22 (e.g., M97 Tax and Flat Fee, while demonstrating different allocation percentages, do not differ across projected or actual data over any biennium). No trends are present in the data, but pronounced differences were observed in the Diesel Tax section of the 2019-2021 biennium generated with actual data for both the Light and Heavy Vehicle weight classes. Additionally, the Gas Tax and Diesel Tax sections of the actual data for the 2019-2021 biennium exceeded 100% in the Light Vehicle weight class, while the Gas Tax and Diesel Tax sections of the actual data for the same biennium were negative in the Heavy Vehicle weight class.

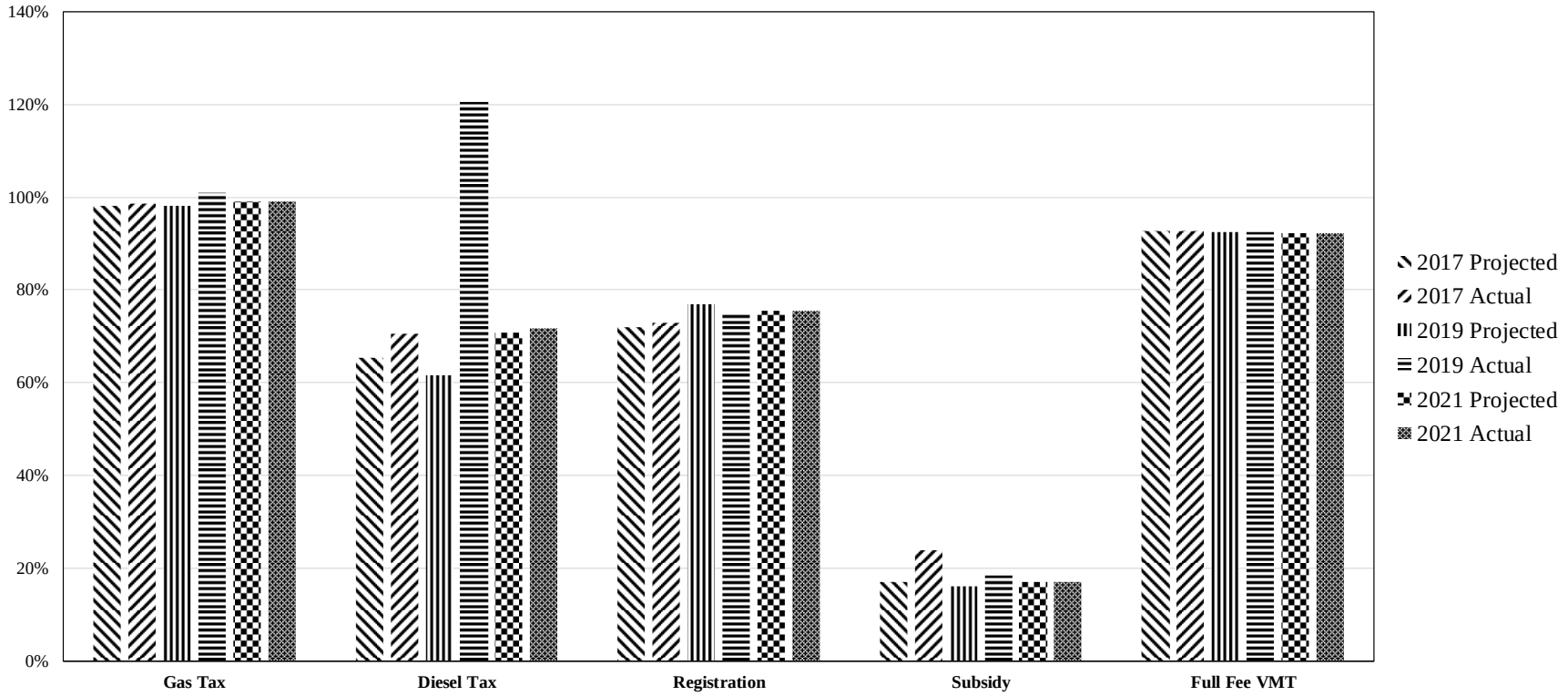

Figure 21. Observable Differences in Attributed Revenues for Light Vehicles

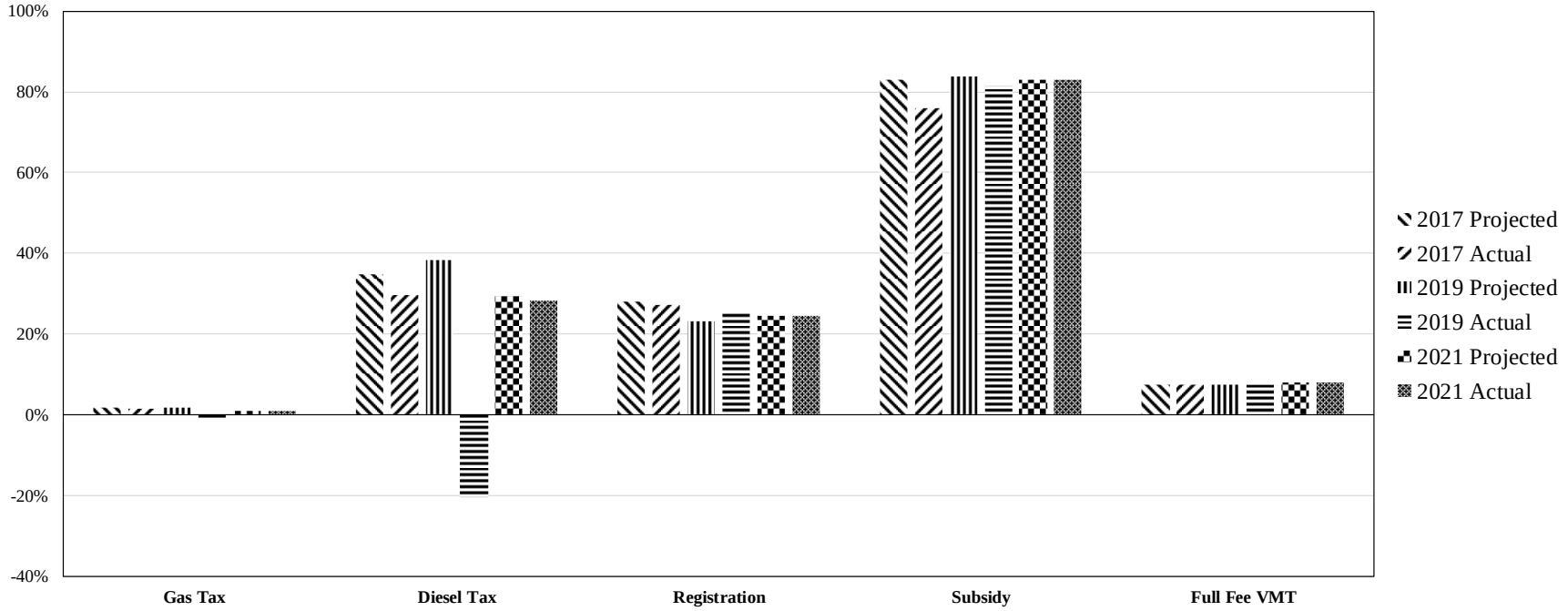

Figure 22. Observable Differences in Attributed Revenues for Heavy Vehicles

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 CONCLUSIONS

The Oregon Highway Cost Allocation Study (HCAS) plays a critical role in the State of Oregon's efforts to ensure that highway maintenance, operation, and improvement costs are fairly distributed among various road users (Merriss, n.d.). The Oregon's Office of Economic Analysis (OEA) tasked a team of researchers from Oregon State University (OSU) to (1) verify that the HCAS models for the 2017-2019, 2019-2021, and 2021-2023 biennia can be executed and produce the same output using projected data, and (2) to examine the differences on the *scaled equity ratios* and *cost responsibility shares* across vehicle classes when using actual revenue and costs data versus projected data. To fulfill these tasks, the Oregon Department of Transportation (ODOT) provided the OSU research team with three HCAS models developed by EcoNW for the biennia 2017-2019, 2019-2021, and 2021-2023.

Based on the evaluation conducted by the OSU research team, the following conclusions were reached:

1. The HCAS models for the 2017-2019, 2019-2021, and 2021-2023 biennia can be run using projected and actual data using the Anaconda environment to accommodate different Python versions.
2. For all three biennia, the projected data for Revenue, Project Expenditures, Non-Project Costs, and Local Costs that ODOT provided to EcoNW match the Input Workbook that EcoNW prepared for the Python model, with some exceptions. Specifically, some projected data were not included in the Input Workbook provided by EcoNW.
3. The HCAS models for the 2017-2019, 2019-2021, and 2021-2023 biennia produce the same outputs as the outputs generated by EcoNW when using the Input Workbook that EcoNW prepared for the Python model. The outputs generated by the OSU research team are the same as those provided to ODOT by EcoNW.
4. The *scaled equity ratios* and *cost responsibility shares* generated using projected versus actual data for each biennium differ as they are sensitive to project costs.
    a. In some cases, the differences in the *cost responsibility shares* for light-weight, medium-weight, or heavy-weight vehicles exceed ±5% when comparing actual versus projected data.
    b. In the 2019-2021 biennium, these differences are pronounced and are likely due to the effect of the COVID-19 pandemic and the actual data exceeding threshold limitations present in the HCAS's Python model.
        - Due to these special circumstances, the validity of the calculated scaled equity ratios and cost responsibility shares using actual revenue and cost data for the 2019-2021 biennium cannot be substantiated nor refuted by the OSU research team as a result of this study.

4.2 RECOMMENDATIONS

After completing the evaluation of the HCAS models for the 2017-2019, 2019-2021, and 2021-2023 biennia, the OSU research team would like to recommend the following to OEA:

1. **Perform Further Research on the Limitations of the HCAS Model**. There is evidence to suggest that the 2017-2019, 2019-2021, and 2021-2023 HCAS models were designed to utilize projected and actual revenue and cost input data that does not exceed expected thresholds. Given the special circumstances that occurred during the 2019-2021 biennium, the results produced by the HCAS Python model are outliers and should be treated as such. One potential study can be conducted to improve upon this limitation by further exploring the mechanisms within the HCAS Python code and testing widening the thresholds so that future models can accommodate larger differences.

2. **Streamline the Coding of Project WorkTypes.** As documented in Section 2.6.1, the process to convert alphabetic codes (as used internally by ODOT) into numeric codes (as used by the HCAS Python model) is inconsistent and labor intensive. Further research is needed to streamline and standardize this process to achieve consistent and replicable WorkType coding.

3. **Improve the Documentation on Project WorkType and Bridge Type Coding.** The existing approach for coding the project WorkType and bridge type is not replicable due to lack of clear documentation. ODOT assigns alphabetic codes to each project according to the type of work. For the HCAS model, each project is classified using two groups of numeric codes:

    a. WorkType Code. In the HCAS model's Input Excel Workbook, the WorkType code ranges from 1-68 and then from 101-168 listed with a short description for each code. However, in the HCAS report, only the WorkType numeric codes (i.e., 1-68 in 2017-2019 and 1-66 in 2019-2021 and 2021-2023) are listed with description. While the WorkType numeric codes were included in the HCAS reports, no additional information is provided on the logic, rules, or processes to convert ODOT's alphabetic code to the HCAS numeric code. Further inquiries with EcoNW yielded a "Decoder Ring" for the WorkType. The "Decoder Ring" only converts approximately 50% of ODOT's alphabetic codes, with the remaining coded classified as "varies". Further assistance from ODOT engineers was needed to code the remaining projects using the HCAS WorkType input.
    b. Bridge Type Code. In the HCAS model's Input Excel Workbook, bridges were coded using a numeric code between 0 to 4 without any description. In the HCAS report and appendices, the Bridge Type was not mentioned or included. Further inquiries with EcoNW yielded a bridge classification for the code that is based on the bridge physical dimensions. However, this bridge classification cannot be used to code the projects as project descriptions do not include the bridge physical dimensions necessary for coding.

Without clear documentation on the processes, logic, and rules that EcoNW employed to convert the ODOT alphabetic codes to the HCAS numeric code, replicating the HCAS consistently was an issue. The study conducted by OSU received extensive assistance from ODOT engineers in coding the approximately 50% of the projects into the HCAS numeric code, and this process is unsustainable. Clear documentation on the process, logic, and rules employed to convert the ODOT alphabetic work type code to the HCAS numeric code is needed to ensure consistency and replicability of the HCAS in the future.

APPENDIX A

Projected and Actual Revenue for each Biennium

Table A1. 2017-2019 Biennium Revenue Difference Between Projected and Actual.

Revenue Source	Projected	Actual	Actual - Projected	%
Basic/Motorcycle/Moped Light Reg	$331,133,266	$424,937,467	$93,804,201	28.33%
Truck Normal Reg	$31,269,456	$41,290,357	$10,020,900	32.05%
Bus Normal Reg	$763,861	$819,659	$55,798	7.30%
Farm Reg	$6,392,199	$8,066,137	$1,673,938	26.19%
Charitable/Non-Profit & Tow Reg	$280,183	$313,249	$33,066	11.80%
Tow Reg	$605,682	$785,339	$179,657	29.66%
Heavy Fixed Load Vehicle Reg	$193,273	$240,681	$47,408	24.53%
E-Plate Reg	$33,133	$195,491	$162,358	490.02%
School Bus Reg	$3,905	$12,376	$8,471	216.93%
Light Trailer Reg	$14,324,260	$17,527,725	$3,203,465	22.36%
Heavy/Special/Rental Trailer Reg	$269,915	$637,163	$367,247	136.06%
Light Titles - New/First OR/Transfer	$158,058,433	$182,181,513	$24,123,080	15.26%
Heavy Titles - New/First OR/Transfer	$4,422,741	$5,190,948	$768,207	17.37%
Motor Carrier Interstate Reg	$62,497,903	$67,984,051	$5,486,148	8.78%
Motor Carrier Intrastate Reg	$23,738,208	$25,345,569	$1,607,361	6.77%
Motor Carrier Trip Permits	$7,564,593	$4,571,686	($2,992,907)	-39.56%
Weight-Mile Tax (includes late fees)	$620,453,792	$708,042,706	$87,588,914	14.12%
Road Use Assessment Fee	$3,821,332	$4,688,010	$866,677	22.68%
Gas Tax - both gas and use (diesel) tax revenue	$1,118,884,800	$1,205,940,647	$87,055,847	7.78%
Totals	**$2,384,710,935**	**$2,698,770,774**	**$314,059,836**	**13.17%**

Table A2. 2019-2021 Biennium Revenue Difference Between Projected and Actual.

Revenue Source	Projected	Actual	Actual - Projected	%
Basic/Motorcycle/Moped Light Reg	$499,661,129	$445,039,830	($54,621,299)	-10.93%
Truck Normal Reg	$43,902,538	$43,602,444	($300,094)	-0.68%
Bus Normal Reg	$1,137,838	$670,409	($467,430)	-41.08%
Farm Reg	$8,869,735	$7,678,483	($1,191,253)	-13.43%
Charitable/Non-Profit & Tow Reg	$401,154	$279,558	($121,596)	-30.31%
Tow Reg	$809,011	$753,304	($55,707)	-6.89%
Heavy Fixed Load Vehicle Reg	$243,038	$163,573	($79,465)	-32.70%
E-Plate Reg	$47,693	$61,355	$13,662	28.65%
School Bus Reg	$3,058	$2,490	($568)	-18.57%
Light Trailer Reg	$18,625,759	$16,425,319	($2,200,440)	-11.81%
Heavy/Special/Rental Trailer Reg	$315,799	$353,985	$38,186	12.09%
Light Titles - New/First OR/Transfer	$216,091,413	$162,387,298	($53,704,115)	-24.85%
Heavy Titles - New/First OR/Transfer	$4,376,465	$3,703,770	($672,695)	-15.37%
Motor Carrier Interstate Reg	$63,414,176	$66,549,107	$3,134,931	4.94%
Motor Carrier Intrastate Reg	$23,771,831	$26,398,741	$2,626,910	11.05%
Motor Carrier Trip Permits	$6,158,668	$4,655,617	($1,503,051)	-24.41%
Weight-Mile Tax (includes late fees)	$807,629,660	$824,430,540	$16,800,880	2.08%
Road Use Assessment Fee	$5,176,909	$5,965,547	$788,638	15.23%
Gas Tax - both gas and use (diesel) tax revenue	$1,326,340,310	$1,214,999,290	($111,341,020)	-8.39%
Totals	**$3,026,976,184**	**$2,824,120,660**	**($202,855,526)**	**-6.70%**

Table A3. 2021-2023 Biennium Revenue Difference Between Projected and Actual.

Revenue Source	Projected	Actual	Actual - Projected	%
Basic/Motorcycle/Moped Light Reg	$516,727,702	$512,915,695	($3,812,007)	-0.74%
Truck Normal Reg	$48,559,160	$50,761,074	$2,201,914	4.53%
Bus Normal Reg	$968,491	$785,414	($183,077)	-18.90%
Farm Reg	$9,530,309	$8,456,413	($1,073,896)	-11.27%
Charitable/Non-Profit & Tow Reg	$421,663	$286,233	($135,430)	-32.12%
Tow Reg	$939,823	$934,344	($5,479)	-0.58%
Heavy Fixed Load Vehicle Reg	$235,656	$175,083	($60,573)	-25.70%
E-Plate Reg	$61,746	$66,110	$4,364	7.07%
School Bus Reg	$2,188	$3,145	$957	43.75%
Light Trailer Reg	$20,383,295	$19,120,147	($1,263,148)	-6.20%
Heavy/Special/Rental Trailer Reg	$370,641	$499,068	$128,427	34.65%
Light Titles - New/First OR/Transfer	$202,277,861	$201,486,622	($791,239)	-0.39%
Heavy Titles - New/First OR/Transfer	$3,944,489	$4,251,150	$306,661	7.77%
Motor Carrier Interstate Reg	$70,564,421	$61,789,960	($8,774,461)	-12.43%
Motor Carrier Intrastate Reg	$23,243,527	$26,473,520	$3,229,993	13.90%
Motor Carrier Trip Permits	$6,837,091	$4,810,287	($2,026,804)	-29.64%
Weight-Mile Tax (includes late fees)	$876,579,689	$909,859,186	$33,279,497	3.80%
Road Use Assessment Fee	$6,046,070	$7,853,299	$1,807,229	29.89%
Gas Tax - both gas and use (diesel) tax revenue	$1,323,920,790	$1,320,994,369	($2,926,421)	-0.22%
Totals	**$3,111,614,609**	**$3,131,521,119**	**$19,906,510**	**0.64%**

APPENDIX B

Data Files and Information Received and Utilized in this Study

1. HCAS Models Evaluated

File Name: HCAS Model 20161212.zip
Model biennium: 2017-2019
Excel file and folder (containing multiple .txt files):
Inputs:

- \HCAS Model 20161212.zip\HCAS Model 20161212\scenarios\2017 Fourth Draft\inputs\HCAS Inputs.xlsx
- \HCAS Model 20161212.zip\HCAS Model 20161212\scenarios\2017 Fourth Draft\inputs\txt\

Outputs:

- \HCAS_Model_20161212\HCAS Model 20161212/scenarios\2017 Fourth Draft/outputs\HCAS Outputs 2017 Fourth Draft.xlsx
- \HCAS_Model_20161212\HCAS Model 20161212\scenarios\2017 Fourth Draft\outputs\txt

File Name: HCAS 19-21 Model.zip
Model biennium: 2019-2021
Excel file and folder (containing multiple .txt files):
Inputs:

- \HCAS 19-21 Model.zip\2019 HCAS\scenarios\2019_final\inputs\HCAS Inputs.xlsx
- \HCAS 19-21 Model.zip\2019 HCAS\scenarios\2019_final\inputs\txt\

Outputs:

- \HCAS_19-21_Model\2019 HCAS\scenarios\2019_final\outputs\HCAS Outputs 2019_final.xlsx
- \HCAS_19-21_Model\2019 HCAS\scenarios\2019_final\outputs\txt

File Name: 2021_final_v2.zip
Model biennium: 2021-2023
Excel file and folder (containing multiple .txt files):
Inputs:

- \2021_final_v2.zip\2021_final_v2\inputs\hcas inputs 2021_final_v2.xlsx
- \2021_final_v2.zip\2021_final_v2\inputs\txt\

Outputs:

- \2021_final_v2.zip\2021_final_v2\outputs\HCAS Outputs 2021_final_v2_orig.xlsx
- \2021_final_v2.zip\2021_final_v2\outputs\ \txt\

2. HCAS Output Workbooks Provided to ODOT

File name: HCAS Outputs 2017 Fourth Draft.xlsx
Format: xlsx
Tab names:

- Intro
- Model VMT
- Costs to Allocate by SWT
- Allocated Costs by SWT
- Allocated Costs
- Attributed Revenues
- Alt. Attributed Revenues
- MPG
- Equity
- Summary
- Alt. Equity
- Alt. Summary

File name: HCAS Outputs 2018 test.xlsx
Format: xlsx
Tab names:

- Intro
- Model VMT
- Costs to Allocate by SWT
- Allocated Costs by SWT
- Allocated Costs
- Attributed Revenues
- Alt. Attributed Revenues
- MPG
- Equity
- Summary
- Alt. Equity
- Alt. Summary

File name: HCAS Outputs 2019_final.xlsx
Format: xlsx
Tab names:

- Intro
- Model VMT
- Sheet1
- Costs to Allocate by SWT
- Allocated Costs by SWT
- Allocated Costs
- Attributed Revenues
- Alt. Attributed Revenues
- MPG
- Equity VMT
- Equity
- Summary
- Alt. Equity
- Alt. Summary

File name: HCAS Outputs 2021_final.xlsx
Format: xlsx
Tab names:

- Intro
- Model VMT
- Costs to Allocate by SWT
- Allocated Costs by SWT
- Allocated Costs
- Attributed Revenues
- Alt. Attributed Revenues
- MPG
- Equity VMT
- Equity
- Summary
- Alt. Equity
- Alt. Summary

3. Projected Input Data Files

File name: 2015 Survey Form Combined City County.xls
Format: xls
Tab names:
- I Receipts
- II Disbursements
- III Debt Status

File name: 2017 Survey Form Combined City County.xls
Format: xls
Tab names:
- I Receipts
- II Disbursements
- III Debt Status

File name: 2020 LRSS Master Combined City County.xlsm
Format: xlsm
Tab names:
- I Receipts
- II Disbursements
- III Debt Status
- IV (EXPENDITURES)

File name: Cost to Allocate and Project Expenditures 17-19 w-Actuals.xlsx
Format: xlsx
Tab names:
- HCAS-Projects
- 17-19 Cost to Allocate
- 17-19 Actuals

File name: Costs to Allocate and Projects Expenditures 19-21 w-Actuals.xlsx
Format: xlsx
Tab names:
- HCAS-Projects
- 19-21 Cost to Allocate
- 19-21 Actuals

File name: Costs to Allocate and Projects Expenditures 2021-23 Final.xlsx
Format: xlsx
Tab names:
- HCAS-Projects 21-23
- 21-23 Cost to Allocate_BdgtUnit

File name: Costs to Allocate and Projects Expenditures 21-23 w-Actuals.xlsx
Format: xlsx
Tab names:
- HCAS-Projects
- 21-23 Cost to Allocate
- 21-23 Actuals

File name: Transactions Revenues 2017-19.xlsx
Format: xlsx
Tab names:
- Rev to Hwy Fund

File name: Transactions Revenues 2019-21_June 2018 Forecast.xlsx
Format: xlsx
Tab names:
- Rev to Hwy Fund

File name: Transactions Revenues 2021-23_April 2021 Forecast.xlsx
Format: xlsx
Tab names:
- Rev to Hwy Fund

4. Actual Data Files

File name: 2018 Survey Form Combined City County.xls
Format: xls
Tab names:
- I Receipts
- II Disbursements
- III Debt Status

File name: 2019 Survey Combined City County_working file.xlsm
Format: xlsm
Tab names:
- I Receipts 2018
- I Receipts
- II Disbursements
- II Disbursements 2018
- III Debt Status
- IV (EXPENDITURES)
- paste Receipts here
- paste Disbursements here
- Compare 2018-2019

File name: 2020 LRSS Master Combined City County.xlsm
Format: xlsm
Tab names:
- I Receipts
- II Disbursements
- III Debt Status
- IV (EXPENDITURES)

File name: 2021 LRSS Master Combined City County.xlsm
Format: xlsm
Tab names:
- I Receipts
- II Disbursements
- III Debt Status
- IV (EXPENDITURES)

File name: 2022 LRSS Master Combined City County11-28.xlsm
Format: xlsm
Tab names:
- I Receipts
- II Disbursements
- III Debt Status
- IV (EXPENDITURES)

File name: 2023 LRSS Master Combined City County 11-28.xlsm
Format: xlsm
Tab names:
- I Receipts
- II Disbursements
- III Debt Status
- IV (EXPENDITURES)

File name: Actual Project Expenditures 17-19.xlsx
Format: xlsx
Tab names:
- **Sheet1**

File name: Actual Project Expenditures 19-21.xlsx
Format: xlsx
Tab names:
- **Sheet1**

File name: Actual Project Expenditures 21-23.xlsx
Format: xlsx
Tab names:
- Sheet1

File name: CityCounty Email Transcription - MalikMolina 2024-8-6.xlsx
Format: xlsx
Tab names:
- **Sheet1**

File name: Costs to Allocate and Projects Expenditures 17-19 w-Actuals.xlsx
Format: xlsx
Tab names:
- HCAS-Projects
- 17-19 Cost to Allocate
- 17-19 Actuals

File name: Costs to Allocate and Projects Expenditures 19-21 w-Actuals.xlsx
Format: xlsx
Tab names:
- HCAS-Projects
- 19-21 Cost to Allocate
- 19-21 Actuals

File name: Costs to Allocate and Projects Expenditures 21-23 w-Actuals.xlsx
Format: xlsx
Tab names:
- HCAS-Projects
- 21-23 Cost to Allocate
- 21-23 Actuals

File name: RE_ _Clarification needed_ Cities_Counties Non-Project Expenditure.msg
Format: msg
Tab names: N/A

File name: Transactions Revenues Actuals.xlsx
Format: xlsx
Tab names:
- Rev to Hwy Fund

5. Files provided by EcoNW

File name: 4-30-2021 Highway Cost Allocation Study (Bridge Spans).xlsx
Format: xlsx
Tab names:
- Query1

File name: FW_ HCAS Question for Look-Back Study_ Work Types Mapping.msg
Format: msg
Tab names: N/A

File name: HCAS - ECOnorthwest follow-up.msg
Format: msg
Tab names: N/A

File name: hcas_worktype_decoder_ring.xlsx
Format: xlsx
Tab names:
- hcas_worktypes

File name: project_costs.R
Format: R
Tab names: N/A