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The Impact of the COVID-19 Recovery on California Transportation Revenue: A Scenario Analysis through 2040

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Abstract

The COVID-19 public health emergency has affected every aspect of life in California, reducing social and economic activity. Less activity translates to less travel, and less travel leads to less revenue generated from taxes on motor fuels. As California emerges from the COVID-19 crisis and returns to more normal levels of activity, the state must plan transportation system operations and maintenance in the context of deep uncertainty regarding future revenue.

To help decision makers navigate that uncertainty, we used spreadsheet models to estimate the impacts of different economic recovery scenarios from the COVID-19 pandemic on state-generated transportation revenue. Because it is not possible to anticipate future economic conditions, travel volumes, and vehicle markets with certainty, we created six potential economic recovery scenarios and projected future transportation revenue in California through 2040 under each.

Scenarios cannot foretell which conditions will predominate in future decades, but scenario analysis helps state officials assess the impact of different economic futures and policy choices, including policies to change the rates of adoption of alternative-fueled vehicles.

Key findings include:

- The projections from the six scenarios demonstrate that California transportation revenue by 2040 could range widely, from as little as $6.5 billion to as much as $10.9 billion, if the assumptions and conditions used to create particular scenarios are realized over time.
- The cumulative revenue raised between 2020 and 2040 varies by more than $40 billion across the scenarios, from $153 billion to $195 billion.
- In 2020, taxes on fuels will generate roughly three-quarters of state-generated transportation revenue. By 2040, however, taxes on fuels will generate a much smaller percentage of overall revenue. For example, in four of the six scenarios they generate less than a quarter of revenues.

1. Introduction

The COVID-19 crisis has resulted in dramatic reductions in economic activity and, consequently, in travel. Government entities across California reported precipitous declines in vehicle miles traveled (VMT) and the associated fuel sales that generate fuel tax revenue during the first quarter of 2020.

Travel volumes and fuel sales returned to near pre-COVID levels by the end of the summer.[1] Further, the economic contraction triggered by the shelter-in-place order seems destined to produce at least short-term reductions in vehicle sales, as consumers suffer financial hardships and hesitate to make major purchases in the face of tremendous uncertainty. Car sales declined steeply at the start of the pandemic, and have rebounded, but not to pre-COVID levels.[2] The recent surge in COVID-19 cases leads to continuing uncertainty about longer-term trends.

There was widespread recognition in the transportation industry that changes to travel behavior decreased fuel tax revenue, but uncertainty as to the extent and timing of the potential recovery. For example, IHS Markit reported on April 21, 2020, that national gasoline sales in late March were 47% down from sales one year earlier,[3] and traffic data firm Inrix reported that personal travel had dropped almost by half between late February (before most social distancing measures were in place) and early April.[4] And on April 6, 2020, the American Association of State Highway and Transportation Officials (AASHTO) sent a memo to the U.S Congress predicting "what will average at least a 30 percent loss in state transportation revenue in the next 18 months."[5] In California, reductions in travel continued through the summer of 2020 but recovered in later months as economic and social activity resumed gradually. The California Legislative Analyst reported that vehicle miles of travel in March and April were as much as 40 percent below the corresponding month a year earlier but that travel in June of 2020 was 14 percent below travel in June of 2019.[6] While a recovery had seemed to be occurring, COVID cases started to rise again in November, and new restrictions on daily activity are being put in place even as this report is being written.

What remains unclear is *how much* transportation revenue will be lost to California in both the short and longer term. To explore that question, we applied established spreadsheet models to project California transportation revenue through 2040 under six scenarios that vary both by the length of the downturn in travel and by transportation trends that include annual state VMT, light-duty fleet size, and the mix of internal-combustion engine (ICE) vehicles vs. zero-emission vehicles (ZEVs).

We chose this scenario approach because the immense uncertainly of the moment suggests that California would be wise to prepare for a range of possible futures with respect to the level of transportation revenue. The scenarios illustrate the revenue consequences of plausible alternative future economic conditions, vehicle fleet mixes, and levels of travel. There is no certainty that the future will resemble any of the chosen scenarios, but they nevertheless help state leaders assess and design policies to achieve desired outcomes.

The projections made for this study only consider transportation revenue collected directly by the state through a set of taxes and fees governed by California Senate Bill 1: The Road Repair and Accountability Act of 2017 (SB1). Revenue raised directly by the state is a critical component of transportation program funding in California, though it is only a portion of total funding spent on transportation. As of 2017, just before SB1 started taking effect, state sources provided about a third of California's transportation revenue, and the federal government about a fifth. Local governments raised the largest share, amounting to nearly half of all revenue for transportation. At the local level, county transportation sales taxes provide some counties with as much as a third of their transportation funding, and many jurisdictions devote general fund revenue to transportation programs.[7]

The remaining sections of the report are as follows:

- Section 2 presents the methodology, describing the projection models and the six scenarios tested.
- Section 3 presents the results from applying the models to the scenarios.
- Section 4 summarizes key findings and suggests several policy implications.
- Technical appendices present the formulas used to project revenue and details about the data used as model inputs, as well as the projected revenue from each of the SB1 taxes and fees.

2. Methodology

We projected revenue produced by taxes and fees collected by the State of California that (1) are collected from vehicle owners and users, and (2) have their proceeds dedicated to transportation programs.

The relevant taxes and fees are the gasoline excise tax, diesel excise tax, diesel sales tax, the Transportation Improvement Fee (TIF) assessed annually on all vehicles, and the Road Improvement Fee (RIF) assessed annually on ZEVs.[8] Table 1 shows the rate for each tax or fee at the start of the calendar year 2020, as established by SB1.

Table 1. State of California Transportation Tax and Fee Rates Established by SB1

Tax/fee	Rate as of January 1, 2020[a]
Fuel taxes	
Gasoline excise tax	Base excise (30¢ per gallon) + swap[b] excise tax (currently 17.3¢ per gallon)
Diesel excise tax	36¢ per gallon
Diesel swap[b] sales tax	5.75% on purchase price
Vehicle fees (annual)	
Transportation Improvement Fee (TIF)	$25 to $175 per vehicle annually, with rate depending on the vehicle's value
Road Improvement Fee (RIF)	$100 per ZEV with model year 2020 or later, annually (effective 7/1/2020)

Source: Adapted from California Legislative Analyst's Office, *Overview of 2017 Transportation Funding Package* (2017), http://www.lao.ca.gov/Publications/Report/3688.

[a] The rates are to be adjusted for inflation starting July 1, 2020, for the gasoline and diesel excise taxes, January 1, 2020, for the Transportation Improvement Fee, and January 1, 2021, for the Road Improvement Fee on ZEVs. The diesel sales tax rate remains fixed.

[b] For details about the "gas tax swap," including tax and fee rates prior to the swap, see Anne Brown, Mark Garrett, and Martin Wachs, "Assessing the California Fuel Tax Swap of 2010," *Transportation Research Record: The Journal of the Transportation Research Board*, no. 2670 (2017), pp. 16–23.

Given the enormous uncertainty inherent in projecting twenty years into the future, we explored a variety of different scenarios and projected revenue for each. We did not assess the likelihood that any particular scenario may occur.

2.a. The Projection Models

We constructed the projections by modifying existing spreadsheet models that estimate annual transportation revenue collected by the State of California. This set of models is adapted from ones the authors developed for three earlier research studies. The first of these projected revenue under different tax and fee rates,[9] the second compared revenue under different ZEV adoption scenarios,[10] and the third projected revenue through 2030 under different COVID-19 economic recovery scenarios.[11]

The spreadsheet model for this project was adapted from the study prepared this spring to consider a longer projection timeline (out to 2040) and updated model inputs related to diesel and gasoline consumption in light of the COVID crisis. In addition, this report considers different hypothetical scenarios, including price convergence for new ICE and ZEV light-duty vehicles and a drop in per-capita light-duty vehicle ownership rates.

The models calculate revenue by applying the tax and fee rates set under SB1[12] to projected sales of motor fuel for transportation purposes and the projected fleet size for both ICE and ZEV light-duty vehicles. Key inputs to the models include projected vehicle miles traveled, fuel efficiency rates for ICE vehicles, diesel fuel prices, the number of registered vehicles, ZEV adoption rates, and the sales price and depreciated value of light-duty vehicles. Technical Appendix A presents the formulas used to project revenue.

The projections used data from authoritative sources, such as revenue data from the State of California and widely used projections prepared by the Energy Information Administration (EIA) of the U.S. Department of Energy.[13] Complete details about the data sources and assumptions employed to operationalize the projections are available in Technical Appendix B.

2.b. The Recovery Scenarios

We constructed six recovery scenarios by positing a set of three possible trajectories for each of several transportation-specific model inputs that met two criteria: they have a major impact on revenue, and they are likely to be affected over time by the social and economic impacts of the COVID-19 pandemic. Other model inputs were kept constant across all scenarios, as explained Section 2C.

The model inputs for which we constructed the high, medium, and low trajectories are:

- ***Annual state VMT***: VMT directly affects fuel consumption and thus revenue from gasoline and diesel taxes. VMT rises and falls with the strength of the economy, and COVID-related lockdowns reduce VMT by reducing the number and variety of possible destinations available to travelers, thereby reducing people’s incentive to travel.

- ***Light-duty vehicle fleet size***: Light-duty vehicles pay the TIF, so TIF revenue will therefore be higher with larger light-duty vehicle fleets and lower with smaller fleets. The scenarios all assume that ZEV vehicle values and light-duty ZEV fleet size are related: high ZEV values will be associated with low numbers of light-duty ZEV vehicles, whereas low values will be associated with high numbers of ZEV light-duty vehicles.

- ***Light-duty ZEV fleet size***: The RIF is assessed on light-duty ZEVs (in addition to the TIF). RIF revenue will therefore be higher with larger ZEV fleets and lower with smaller ZEV fleets.

- ***Light-duty ZEV vehicle values***: TIF revenue is directly related to light-duty vehicle values because the fee rate is assessed as a function of vehicle value.

- ***Heavy-duty diesel fleet size***: Revenue from the diesel excise and sales taxes are larger when the number of diesel-powered vehicles—and thus diesel fuel consumption—is higher. Conversely, revenue from diesel taxes is lower when the diesel-powered percent of the heavy-duty fleet is lower. The scenarios all assume that heavy-duty diesel fleet size is inversely related to the size of the heavy-duty ZEV fleet. (All scenarios assume that 20% of the total heavy-duty vehicle fleet remains gasoline-powered through 2040.)

We estimated specific values for the high, medium, and low trajectory of these model inputs following three principles:

- ***Consider evidence of how COVID-19 has affected travel volumes and fuel sales.*** There is clear evidence that VMT fell dramatically as soon as states imposed shelter-in-place rules in March. Some communities saw VMT fall by 40%, 50%, and even 60%, although the dramatic declines of the early months have mostly eased with the passage of time.[14]

- ***Consider rates of year-to-year change since 2008[15] in vehicle ownership choices.*** We chose 2008 as the starting point for this analysis because that was the beginning of the Great Recession, and the recovery trajectory from that economic shock is a reasonable basis for predicting recovery from the COVID-19 public health emergency. In both cases, a major economic shock led to decreased employment and travel demand.

- ***Explore the impact of extreme changes in VMT, the light-duty fleet size, and/or the ZEV fleet size.*** It is conceivable that a very slow recovery from the COVID-19 crisis, increasing commitment to reducing greenhouse gas emissions, or other major disruptions in the state could produce trends in travel and vehicle ownership over the coming two decades that are radically different from the trends since 2008. For example, while this study was underway, California Governor Gavin Newsom issued Executive Order N-79-20, which directs state departments and agencies to adopt regulations and programs that would lead to no sales of new light-duty ICE vehicles as of 2035.[16]

Table 2 presents the high, medium, and low trajectories for each of the five key variable inputs used to build the recovery scenarios. The rationale behind those choices is as follows:

- ***Annual state VMT***: We defined the annual state VMT trajectories in relation to what we term the “pre-pandemic trend line.” To estimate what VMT would have been in the absence of COVID-19, we fit a trendline to data on total monthly VMT for every month from January 2015 to April 2020 and then extended that trendline to 2040.

  Using VMT data from February to July 2020 as a starting point to build the trajectories, we assumed for all three that annual VMT reached its lowest point in April 2020 — a 37% drop below the pre-pandemic trendline for that month — and then increased to 11% below the pre-pandemic trendline in August 2020.

The annual state VMT trajectories differ from that date on according to both the rate of VMT recovery and how a full VMT recovery is defined in comparison to the pre-pandemic trendline. The high and medium trajectories assume that the economy recovers enough to bring VMT up to or even above pre-pandemic trendline values within a few years. In contrast, the low VMT trajectory assumes a very slow economic recovery over the next decade that never fully returns to the pre-pandemic VMT trendline.[17]

- ***Light-duty vehicle fleet size*****:** The high and medium fleet-size trajectories were set in relation to year-to-year trends since 2012, the earliest year for which we had data. The high fleet-size trajectory assumes that consumer preferences and ability to pay for vehicle ownership continue to stay strong, with fleet size growing at the highest annual growth rate (1.9%) seen in recent years. The medium trajectory assumes consumer preferences and ability to pay for automobiles will remain roughly as they have been over the last several years, and so the fleet will grow at about the same average annual rate (0.8%) seen from 2012 to 2019. The low trajectory assumes that consumer demand for vehicles will decline such that per-capita vehicle ownership will fall from the current California rate of 0.78 vehicles per person[18] to 0.66 vehicles per person by 2040. To put that rate of 0.66 vehicles per person into context, it is the per-capita rate of vehicle ownership in Canada in 2015.[19]

- ***Light-duty ZEV fleet size*****:** The high trajectory assumes that, due to a combination of increasing consumer preferences for alternative-fuel vehicles and state legislation incentivizing their purchase, ZEVs will constitute a majority (75%) of light-duty registered vehicles by 2040. The medium trajectory assumes the number of ZEVs in California meet the state's targets of 1.5 million registered ZEVs by 2025 and 5 million by 2030. This trajectory reflects an underlying assumption that economic, social, and policy conditions will allow California to reach its goals, and that the ZEV fleet will grow exponentially through 2040. The low trajectory assumes that consumer demand for ZEVs will increase at the same rate as in the most recent year for which data is available (2018-2019), which is the highest growth rate in recent years.

- ***Light-duty ZEV vehicle value*****:** We assumed that light-duty vehicle values will follow EIA projections, but our research and conversations with subject-matter experts indicate that there is emerging consensus that ZEV light-duty vehicle values will decline over time more dramatically than EIA projections. Therefore, the scenarios vary the trajectory of declines in light-duty ZEV values to investigate the impact of different price convergence timelines on TIF revenue. The three ZEV vehicle value trajectories all assume that ZEV purchase prices and vehicle values decline linearly to converge at some point with those of ICE vehicles. The high trajectory assumes that ZEV values will remain high for the longest period, while the low trajectory assumes that values will decline fastest. The high-value trajectory assumes that ZEV values will converge to ICE values in 2040, the medium-value trajectory assumes that price convergence will occur more quickly (by 2035), and the low-value trajectory assumes that price convergence will occur even more quickly (by 2030).

- ***Diesel share of the heavy-duty fleet***: The high trajectory assumes the most aggressive replacement of the diesel fleet by ZEVs, with the number of diesel-powered heavy-duty vehicles declining to 40% of the heavy-duty fleet in 2030 and to 0% in 2034 and staying at 0% until 2040. The medium trajectory assumes more modest changes in the heavy-duty fleet, with diesel vehicles declining to 55% of all heavy-duty vehicles by 2030 and to 50% by 2040. The low trajectory follows EIA projections in assuming only small declines in the percent of diesel vehicles in the heavy-duty fleet, with the fleet falling only to 73% diesel by 2040.

Table 2. High, Medium, and Low Trajectories for the Variable Inputs Used to Construct the Scenarios

Variable Inputs	High	Medium	Low
Annual state VMT	VMT increases linearly to reach 90% of pre-COVID-10 levels by January 2021, increases linearly to predicted pre-COVID-19 levels by January 2022, and increases linearly to 120% of predicted levels based on pre-COVID-19 conditions by the end of 2040.	VMT remains at August 2020 levels until April 2021, then increases linearly to the predicted pre-COVID-19 level by April 2023, and remains at predicted pre-COVID-19 VMT through 2040.	VMT remains at August 2020 levels until March 2025, increases linearly to reach 90% of pre-COVID-19 levels December 31, 2030, and remains at 90% of predicted pre-COVID-19 VMT through 2040.
Light-duty vehicle fleet size	Light-duty fleet increases by 1.9% annually (highest year-to-year growth rate during 2008-2017).	Light-duty fleet increases by 0.8% annually (mean year-to-year growth rate from 2018-2019).	Light-duty fleet size declines linearly to 0.66 vehicles per person by 2040.
Light-duty ZEV fleet size	The number of light-duty ZEVs increases at an exponential rate so that they constitute 75% of light-duty registered vehicles by 2040.	Light-duty ZEV fleet size increases exponentially such that the state of California reaches its goals of 1.5 million ZEVs by 2025 and 5 million ZEVs by 2030. After 2030, the ZEV fleet grows by 1 million every year.	Light-duty ZEV fleet size increases by 94,112 vehicles per year (the annual rate of growth from 2018-2019).
Light-duty ZEV vehicle values	ZEV values start at EIA projections in 2020 and converge linearly to EIA projections for light-duty ICE vehicles by 2040.	ZEV values start at EIA projections in 2020 and converge linearly to EIA projections for light-duty ICE vehicles by 2035. After 2035, ZEV values follow EIA projections for light duty-vehicles.	ZEV values start at the EIA projections in 2020, converge linearly to EIA projections for light-duty ICE vehicles by 2030, and follow EIA projections to 2040.
Diesel share of the heavy-duty fleet	The diesel share of the heavy-duty fleet follows EIA projections, falling to 73% in 2040.	The diesel share of the heavy-duty fleet declines logarithmically to 55% by 2030 and 50% by 2040.	The diesel share of the heavy-duty fleet declines logarithmically to 40% by 2030 and 0% by 2034. After 2034, the heavy-duty fleet remains 0% diesel.

Table 3 shows how the six recovery scenarios draw on the high, medium, and low trajectories for the variable inputs described in Table 2. The scenarios are:

1. High carbon: high VMT + large fleet + low ZEV

2. High VMT + large fleet + high ZEV

3. All medium

4. High VMT + medium fleet + high ZEV

5. Medium VMT + medium fleet + high ZEV

6. Low carbon: low VMT + small fleet + high ZEV

The six scenarios differ along two major dimensions: travel behavior and changes in the fleet by motive power (ICE vs ZEV). We varied travel behavior by varying the amount of travel (VMT) and vehicle ownership levels (light-duty fleet size). We varied changes in the fleet by power source by examining changes in the number of ZEVs in the fleet (both light-duty and heavy-duty vehicles) and by examining changes in the values of light-duty ZEVs relative to the value of light-duty ICE vehicles. Our six scenarios thus represent different combinations of future patterns in travel behavior and fleet composition.

Although none of the three trajectories was designed to match Governor Newsom's executive order that the sale of light-duty ZEVs in California end in 2035, scenarios 2 through 5 are all compatible with the executive order in that the number of ICE vehicles in the fleet falls from 2035 onwards.

Table 3. Trajectories Chosen for Each Variable Model Input in the Scenarios

Scenarios	Annual state VMT	Light-duty fleet size	Light-duty ZEV fleet size	Light-duty ZEV vehicle values	Diesel share of heavy-duty fleet
1. High carbon: high VMT + large fleet + low ZEV	High	High	Low	High	High
2.High VMT + large fleet + high ZEV	High	High	High	Low	Low
3. All medium	Medium	Medium	Medium	Medium	Medium
4. High VMT + medium fleet + high ZEV	High	Medium	High	Low	Low
5. Medium VMT + medium fleet + high ZEV	Medium	Medium	High	Low	Low
6. Low carbon: low VMT + small + high ZEV	Low	Low	High	Low	Low

Note: Although scenarios one and six are labelled "High carbon" and "Low carbon," respectively, the intervening scenarios are not intended to rank carbon consumption outcomes.

2.c. Model Inputs Kept Constant Across All Scenarios

The models keep the majority of inputs constant across the six scenarios. We chose to keep factors constant across all the scenarios if they met either of two criteria:

- COVID-19 is unlikely to have a major impact on the trajectory otherwise predicted by observed data from 2008 to 2017. For example, it does not seem particularly likely that COVID-19 will have a substantial impact on long-term trends in diesel fuel prices.

- The variable has minimal impact on the total state revenue collected in any year. For example, gasoline-powered heavy-duty vehicles generate a tiny percentage of gasoline excise tax revenue, so we did not create different trajectories related to the numbers of these vehicles in the fleet.

For example, we assumed that inflation rates will stay low under all six scenarios (1.76% annually, which was the mean annual change from 2008 to 2019) and that vehicle values will depreciate over 15 years, in a straight line, to a zero-dollar salvage value. We also assumed for all scenarios that light-duty vehicles will account for a constant 89% of total state VMT, and that heavy-duty vehicles will account for a constant 10% of total state VMT.

3. Findings

This section presents the results of the projections, looking first at projected revenue under each scenario and then at the proportion of annual revenue raised from each tax and fee. (Technical Appendix D shows the value of the projected revenue for each individual tax and fee.)

3.a. Total Projected Transportation Revenue

Figure 1 presents the total revenue that California would collect from 2020 to 2040 under the six COVID-19 recovery scenarios. All projections are presented in inflation-adjusted 2020 dollars.

The annual revenue raised diverges among the scenarios steadily over time. By 2040, annual revenue ranges from a high of $10.9 billion for the high-carbon scenario (#1) to a low of $6.5 billion for the low-carbon scenario (#6).

The *cumulative* revenue raised from 2020 to 2040 varies by more than $40 billion across the scenarios. At one extreme, the high-carbon scenario (#1) generates a total of $195 billion by 2040. At the other extreme, the low-carbon scenario (#6) generates $153 billion by 2040.

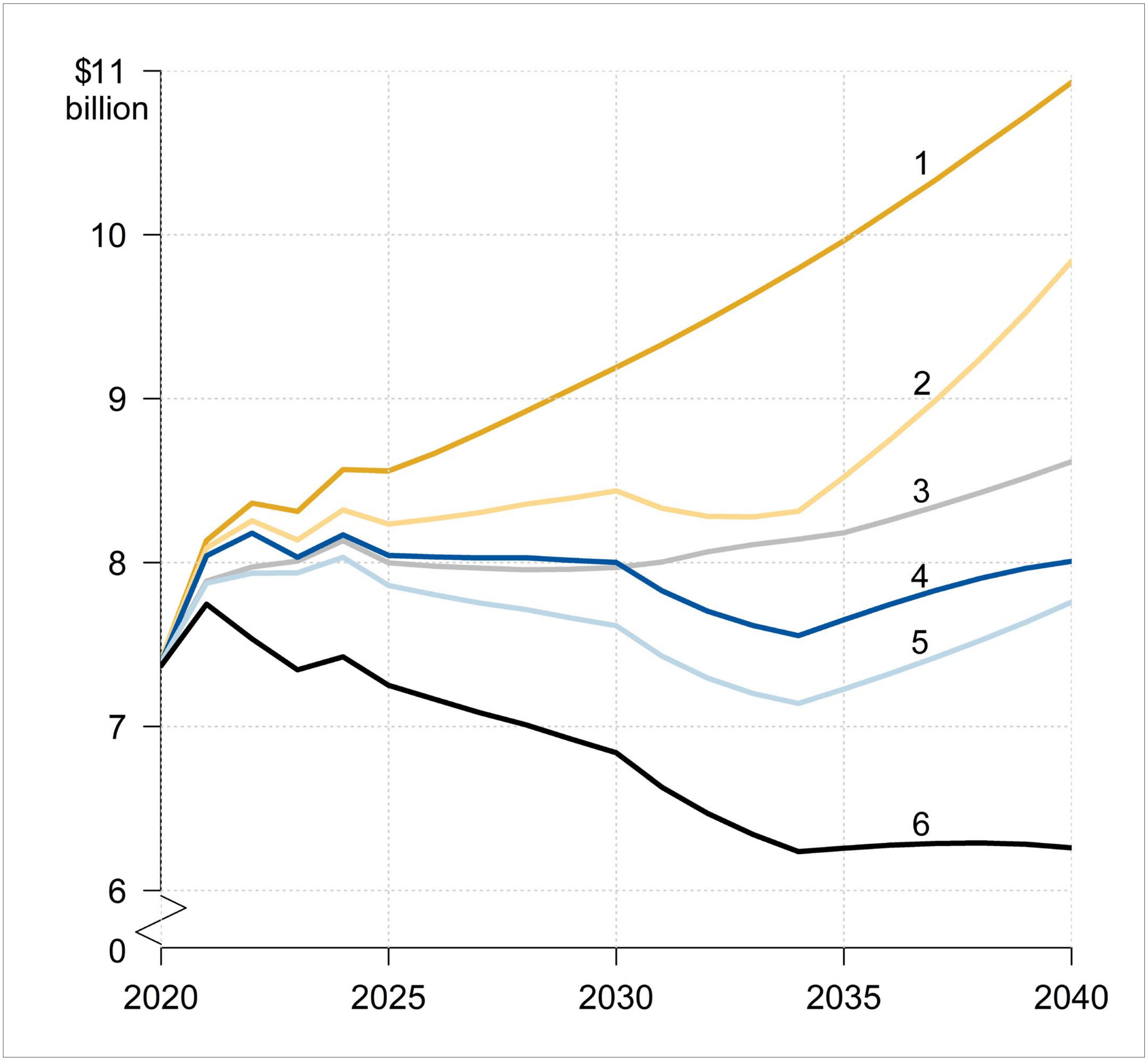

Figure 1. Total State Revenue by Scenario, 2020 – 2040 (2020 Dollars)

3.b. The Proportion of Annual Revenue Raised from Each Tax and Fee

Figure 2 shows for each scenario how the proportion of total California state revenue raised from each tax and fee changes over time.

In 2020, taxes on fuels generate roughly three-quarters of all revenue. By the year 2040, however, taxes on fuels will generate a smaller percentage of total revenue under every scenario. In the low-carbon scenario (#6), revenue from fuel taxes drops to just 23% of total revenue by 2040. At the other extreme, under the high-carbon scenario (#1) revenue from taxes on fuel drops only to 57% of total revenue by 2040.

The gasoline excise tax raises far more revenue than the combined diesel taxes. Even in Scenario 1, where diesel fuel taxes are proportionately larger in 2040 than for any other scenario, the combined diesel fuel excise and sales taxes raise 15% of total revenue compared to the 40% of total revenue raised from the gasoline excise taxes. For four of the other scenarios (#2, #4, #5, and #6), by 2040 the combined diesel taxes raise only 1% of total revenue.

Over time, revenue from fuel taxes will decline as a proportion of state transportation tax revenue even as the tax rates are increased annually to reflect inflation. This will occur because the scenarios assume some combination of (1) declining revenue from fuel taxes as more and more vehicles are ZEVs or extremely efficient ICE vehicles, and (2) higher revenue from the two annual fees assessed on light-duty vehicles (TIF and RIF) because ZEVs will be more expensive than their ICE counterparts for at least some of the coming years. Even in the high-carbon scenario (#1), which assumes that Californians continue to drive many miles in light-duty ICE vehicles and pay the associated fuel taxes, RIF and TIF revenue grows from 25% of total revenue in 2020 to 45% of total revenue in 2040. For every other scenario, the vehicle fees eventually become dominant, starting to generate more than half of all revenue between 2033 and 2035. By 2040, the vehicle fees will generate at least three-quarters of total revenue for four of the scenarios (#2, #4, #5, and #6).

The TIF, the annual fee assessed on all light-duty vehicles, will generate a steadily growing proportion of total revenue across all scenarios. In 2020 the TIF will generate 26% of revenue, but by 2040 the TIF will generate between 43% and 48% of total revenue for every scenario.

The trajectory of the RIF, the flat annual fee assessed on light-duty ZEVs, varies far more than the TIF among the scenarios. In the high-carbon scenario (#1), by 2040 the RIF will generate only 2% of total revenue. However, in the four scenarios with large light-duty ZEV fleets (#2, #4, #5, and #6), by 2040 the RIF will generate from 33% to 36% of total revenue.

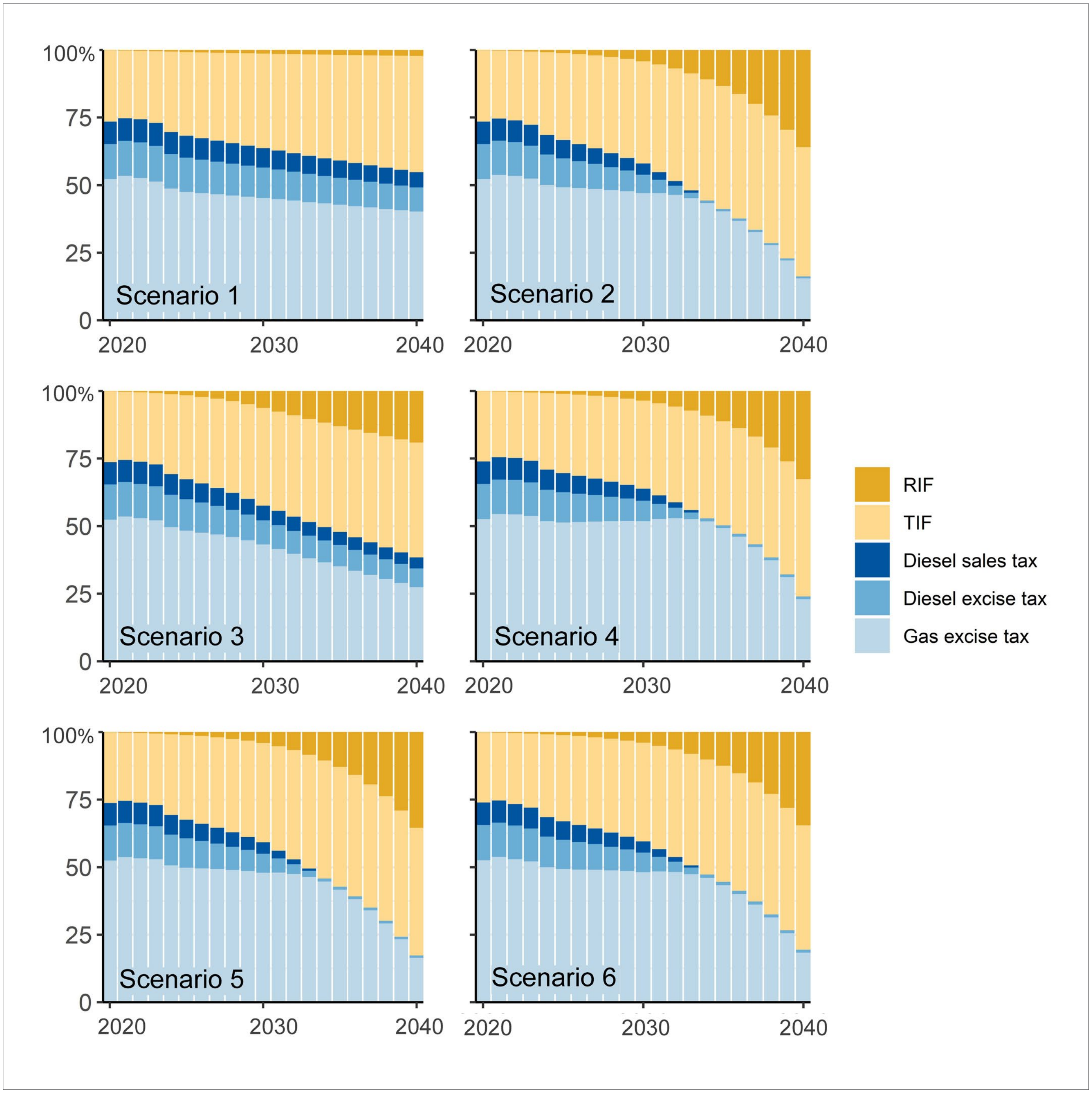

Figure 2. The Proportion of Total Revenue Raised from Each Tax and Fee 2020 – 2040, by Scenario

4. Conclusion

This research projected state-generated transportation revenue through 2040 using tested spreadsheet models and well-known data sources. Recognizing that COVID-19 has created unprecedented uncertainly as to future economic conditions and travel volumes, we created six economic recovery scenarios and projected transportation revenue through 2040 under each. The differences among the scenarios illuminate a range of possible futures for which the State of California may wish to prepare. Further, the scenarios show how specific policies could influence future revenue.

The annual revenue raised under different scenarios will diverge steadily over time. By 2040, annual revenue ranges from a high of $10.9 billion for the high-carbon scenario (#1) to a low of $6.5 billion for the low-carbon scenario (#6). Further, the projected *cumulative* revenue raised from 2020 to 2040 varies from $195 billion (Scenario #1) to $153 billion (Scenario #6).

The relative contribution of the fuel taxes and vehicle fees reverses over time under all but the high-carbon scenario. In every other scenario, the growth of ZEVs and increasing fuel efficiency of ICE vehicles reduce revenue from fuel taxes in proportion to revenue from the annual vehicle fees. In 2020, the fuel taxes contribute three-quarters of revenue, but by 2040 fuel taxes contribute no more than a quarter of revenues in four of the scenarios.

Should the state achieve its policy goals of reducing carbon emissions from the transportation sector—including Governor Newsom's recent Executive Order—policymakers may choose to change the structure of taxes to "replace" the revenue lost from fuel taxes.

One potential alternative to motor fuel taxes that is receiving increasing consideration is the concept of replacing motor fuel taxes with "road use charges." These charges, sometimes called "mileage fees" or "mileage-based user fees," assess drivers a fee for every mile traveled. California has completed a field trial of road-user charges,[20] and currently federal funding is providing for further development and testing of a road-user charge approach that could employ in-vehicle telemetry.

The use of long-term scenario analysis can be an extremely valuable part of the state's process of assessing potential future tax and fee options such as road-use charges.[21] For example, our spreadsheet models show that the gap in revenue between the scenarios that generate the most and the least fuel tax revenue in 2040 could be raised by supplementing the existing tax structure with a new road-user charge of one cent per mile. Should the state experience the lower VMT growth projected in the low-carbon scenario (#6), but wish to raise as much revenue as is generated by the high-carbon scenario (#1), it could make up the difference with a charge of 3.3 cents per mile on travel by light-duty vehicles. That mileage fee would generate as much revenue in 2040 as the high-carbon scenario would raise through both the fuel taxes and annual fees paid by light-duty vehicles.

The study findings highlight the possibility that California's policy leaders will need to prepare for a future with considerably less revenue from fuel taxes and vehicle registration revenue than had been expected prior to the pandemic. At the same time, the different outcomes projected across the scenarios underscore the potential for policy choices to change the revenue trajectory substantially from what would otherwise occur.

Endnotes

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6. California Legislative Analyst's Office, *Impact of COVID 19 on State Transportation Revenues,* September 17, 2020, https://lao.ca.gov/Publications/Report/4268.

7. For an overview of transportation revenue at all levels of government in California, see *Transportation Funding in California 2020* (2020), prepared by Caltrans, Division of Transportation Planning, Office of Transportation Economics, https://dot.ca.gov/-/media/dot-media/programs/transportation-planning/documents/transportation-funding-booklet/2020-final-transportation-funding-a11y.pdf.

8. Revenue from the state's base vehicle registration fee and vehicle license fee was not projected because the proceeds are not dedicated for transportation programs.

9. Martin Wachs, Hannah King, and Asha Weinstein Agrawal, *The Future of California Transportation Revenue* (San Jose: Mineta Transportation Institute, October 2018).

10. Martin Wachs, Hannah King, and Asha Weinstein Agrawal, *The Impact of ZEV Adoption on California Transportation Revenue* (San Jose: Mineta Transportation Institute, July 2019).

11. Asha Weinstein Agrawal, Hannah King, and Martin Wachs, *The Impact of COVID-19 on California Transportation Revenue* (Mineta Transportation Institute, May 2020).

12. The models adjust the tax and fee rates over time, following the schedule set in SB1.

13. US Energy Information Administration, *Alternative Fuel Infrastructure Expansion: Costs, Resources, Production Capacity, and Retail Availability for Low-Carbon Scenarios*, April 2013, https://www.nrel.gov/docs/fy13osti/55640.pdf.

14. Mark Burfiend, “INRIX U.S. National Traffic Volume Synopsis: Issue #5 (April 11 – 17, 2020)” (INRIX, April 20,2020), https://inrix.com/blog/2020/04/covid19-us-traffic-volume-synopsis-5/.

15. Or since the first year in which data was available.

16. Office of Governor Gavin Newsom, “Governor Newsom Announces California Will Phase Out Gasoline-Powered Cars & Drastically Reduce Demand for Fossil Fuel in California’s Fight Against Climate Change,” September 23, 2020, https://www.gov.ca.gov/2020/09/23/governor-newsom-announces-california-will-phase-out-gasoline-powered-cars-drastically-reduce-demand-for-fossil-fuel-in-californias-fight-against-climate-change/.

17. For example, it is possible that even after the economy returns to “normal,” the public will embrace trends like teleworking and telemedicine that reduce travel. It is also possible that the economy suffers so much that the closure of some businesses becomes permanent, and falling average household income leads people to reduce travel.

18. State of California, Department of Finance, “Projections,” http://www.dof.ca.gov/forecasting/demographics/projections/.

19. Statistics Canada, “Table 23-10-0067-01: Vehicle Registrations, by Type of Vehicle” (2020), DOI: https://doi.org/10.25318/2310006701-eng.

20. California State Transportation Agency, *California Road Charge Pilot Program Final Report* (2017), https://caroadcharge.com/projects/california-s-road-charge-pilot/.

21. Caltrans, “Road Charge Program,” https://dot.ca.gov/programs/road-charge.

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TECHNICAL APPENDIX A: FORMULAS USED TO PREDICT REVENUE

This appendix presents the formulas used to project the revenue generated by each tax and fee.

Gasoline Excise Tax Revenue

1a.

$$\text{Gasoline excise tax revenue in Year X} = \text{Gallons of gasoline consumed in Year } X * \text{CPI-adjusted gasoline excise tax rate in Year } X$$

1b.

$$\text{Gallons of gasoline consumed in Year } X = \frac{\text{VMT from light-duty gas-powered vehicles in Year } X}{\text{MPG of light-duty gasoline vehicles in Year } X} + \frac{\text{VMT from heavy-duty gas-powered vehicles in Year } X}{\text{MPG of heavy-duty gasoline vehicles in Year } X}$$

1c.

$$\text{Projected VMT from light-duty gas-powered vehicles in Year } X = \text{Share of state VMT driven by gasoline-powered light-duty vehicles (assumed to be 0.89)} * \text{Total state VMT in Year } X * \text{ICE share of the overall light-duty fleet in Year } X$$

1d.

$$\text{Projected VMT from heavy-duty gas-powered vehicles in Year } X = \text{Share of total state VMT driven by heavy-duty vehicles (assumed to be 0.1)} * \text{Total state VMT in Year } X * \text{Share of the heavy-duty fleet that is gasoline-powered (assumed to be 0.2)}$$

Diesel Excise Tax Revenue

2a.

$$\text{Diesel excise tax revenue in Year } X = \left(\text{Gallons of diesel consumed in Year } X * \text{CPI-adjusted diesel excise tax rate in Year } X\right) + \left(\text{IFTA gallons of diesel consumed in Year } X * \$0.27 \text{ (IFTA rate)}\right)$$

2b.

$$\text{Projected gallons of diesel consumed in Year } X = \frac{\text{VMT from heavy-duty diesel-powered vehicles in Year } X}{\text{MPG of heavy-duty diesel vehicles in Year } X}$$

2c.

$$\text{Projected IFTA gallons of diesel consumed in Year } X = \text{IFTA gallons of diesel in Year } X\text{-}1 + \left(\text{The average annual rate of decrease } (-0.01)^{*} * \text{IFTA gallons of diesel in Year } X\text{-}1\right)$$

* We assume an annual decrease of -0.01 for every year. This is the average rate of decrease from 200 to 2019.

2d.

$$\text{Projected VMT from heavy-duty diesel-powered vehicles in Year } X = \text{Share of state annual VMT driven by heavy-duty vehicles } (0.1) * \text{Total state VMT in Year } X * \text{Diesel-powered share of the overall heavy-duty fleet in Year } X$$

Diesel Sales Tax Revenue

3a.
$$\text{Diesel sales tax revenue in Year } X = \text{Gallons of diesel consumed in Year } X * \text{Inflation-adjusted diesel price in Year } X * \text{Diesel sales tax rate (5.75\%)}$$

3b.
$$\text{Projected gallons of diesel consumed in Year } X = \frac{\text{VMT from heavy-duty diesel-powered vehicles in Year } X}{\text{MPG of heavy-duty diesel vehicles in Year } X}$$

3c.
$$\text{Projected VMT from heavy-duty diesel-powered vehicles in Year } X = \text{Share of annual state VMT driven by heavy-duty vehicles (0.1)} * \text{Total state VMT in Year } X * \text{Diesel-powered share of the overall heavy-duty fleet in Year } X$$

Transportation Improvement Fee (TIF) Revenue

4a.
$$\text{TIF revenue in Year } X = \text{ICE TIF revenue in Year } X + \text{ZEV TIF revenue in Year } X$$

4b.
$$\text{ICE TIF revenue in Year } X = \sum \text{Number of ICE vehicles in each TIF Value Bin* (for Year } X\text{) including 15-year straight-line depreciation} * \text{Each CPI-Adjusted TIF Value Bin rate in Year } X$$

* A "value bin" covers all of the vehicle values in a given year that will pay the same amount of TIF. Vehicles may have different values but be in the same value bin.

4c.
$$\text{ZEV TIF revenue in Year } X = \sum \text{Number of ZEV vehicles in each TIF Value Bin (for Year } X\text{) including 15-year straight-line depreciation} * \text{Each CPI-Adjusted TIF Value Bin rate in Year } X$$

Road Improvement Fee (RIF) Revenue

5a.

$$\text{RIF revenue in Year } X = \text{Net ZEV registrations in Year } X * \text{CPI-adjusted RIF rate for Year } X$$

5b.

$$\text{Net ZEV registrations in Year } X = \text{ZEV registrations in Year } X \text{ given by a f(x) fitted using trajectories in Table 2} - \text{Exempted ZEVs*}$$

Note: The RIF fee is assessed annually on model year 2020 or later ZEVs. The models assume 15-year straight-line depreciation for vehicles, meaning a model year 2020 vehicle is off the road by 2035. Similarly, we calculate the number of exempt light-duty ZEVs in the fleet—all vehicles model year 2019 or older—the same way.

* We assume that the number of exempt ZEVs declines linearly from 302,550 in 2019 to zero in 2035.

TECHNICAL APPENDIX B: DATA SOURCES AND ASSUMPTIONS USED AS MODEL INPUTS

The table below presents the model inputs, noting for each the data source and assumptions.

The six inputs for which we constructed the three trajectories used to build scenarios are highlighted in blue.

Input	Data source & years of data used	Assumptions
Tax and fee rates		
Rates under SB1 for the gasoline excise tax, diesel excise tax, diesel sales tax, Road Improvement Fee, and Transportation Improvement Fee	California Legislative Information SB1 Transportation Funding Bill Text	We assumed that the gasoline excise tax rate, diesel excise tax rate, and Road Improvement Fee rate will be adjusted for inflation using the California Consumer Price Index (CPI), following the methodology specified in SB1.
Economic Indicators		
California Consumer Price Index	State of California Department of Industrial Relations California Consumer Price Index (2008-2019)	We assumed the California Consumer Price Index (CPI) will continue to increase by 2.04% annually. This rate is the mean annual change in the California CPI from 2008 to 2019.
Inflation rate	Bureau of Labor Statistics Consumer Price Index (2008-2019)	We assumed inflation continues at 1.76% per year. This rate is the mean annual change from 2008 to 2019.

Input	Data source & years of data used	Assumptions
VMT		
Annual state VMT	US Department of Transportation, Federal Highway Administration, “Traffic Volume Trends” (2015-2020)	We defined the annual state VMT trajectories in relation to what we term the “pre-pandemic trendline.” To estimate what VMT would have been had COVID-19 not struck, we fit a trendline to data on total monthly VMT for every month from January 2015 to April 2020 and then extended that trendline to 2040. Then, using VMT data from February to July 2020 as a starting point to build the trajectories, we assumed for all three that annual VMT reached its lowest point in April 2020 — a 37% drop below the pre-pandemic trendline for that month — and then increased to 11% below the pre-pandemic trendline in August 2020. From that point, the trajectories vary as follows: • High trajectory: VMT increases linearly to reach 90% of pre-COVID-10 levels by January 2021, increases linearly to predicted pre-COVID-19 levels by January 2022, and increases linearly to 120% of predicted levels based on pre-COVID-19 conditions by the end of 2040. • Medium trajectory: VMT remains at August 2020 levels until April 2021, then increases linearly so to the predicted pre-COVID-19 level by April 2023, and remains at predicted pre-COVID-19 VMT through 2040. • Low trajectory: VMT remains at August 2020 levels until March 2025, increases linearly to reach 90% of pre-COVID-19 levels December 31, 2030, and remains at 90% of predicted pre-COVID-19 VMT through 2040
Share of annual state VMT driven by light-duty vehicles	US Department of Transportation, Office of Freight Management and Operations, “Figure 3-8: Share of Highway Vehicle Miles Traveled by Vehicle Type: 2010,” in *Facts and Figures 2012*	We assumed that the share of VMT by vehicle remains the same as in 2010, when light duty-vehicles constituted 89% of VMT, heavy-duty vehicle constituted 10%, and the remainder was constituted by transit vehicles and other vehicles not considered in this analysis.
Share of annual state VMT driven by heavy-duty vehicles	US Department of Transportation, Office of Freight Management and Operations, “Figure 3-8: Share of Highway Vehicle Miles Traveled by Vehicle Type: 2010,” *Facts and Figures 2012*	We assumed that the share of VMT by vehicle remains the same as in 2010, when light duty-vehicles constituted 89% of VMT, heavy-duty vehicle constituted 10%, and the remainder was constituted by transit vehicles and other vehicles not considered in this analysis.

Input	Data source & years of data used	Assumptions
Motor fuel-related inputs		
Gallons of diesel covered under the International Fuel Tax Agreement (IFTA)	California Board of Equalization Taxes and Fees - Annual Summaries (2006-2019)	We were unable to obtain data on the number of gallons of diesel covered under IFTA historically in California. Therefore, we estimated gallons of diesel covered under IFTA by dividing California's annual IFTA tax revenue receipts by the IFTA tax rates. We assumed the IFTA rate adjusts according to historical trends (-0.01 per year). We assumed that California's share of the total number of gallons of diesel sold nationally each year increases by 4% annually. That rate is the mean year-to-year change in California's share of the national total of gasoline sold from 2008 to 2017.
IFTA Component B tax rate	California Board of Equalization IFTA Tax Rates (2007-2017)	We assumed the IFTA Component B rate remains at $0.27 per gallon, which is the mean rate from 2007 to 2017. The IFTA Component B rate rose and fell slightly from year to year during the period from 2007 to 2017, but there was no obvious growth, so we assumed there would be no change in the IFTA Component B tax rate moving forward. We were unable to obtain data on the number of gallons of diesel covered under IFTA historically in California. Therefore, we estimated gallons of diesel covered under IFTA by dividing California's annual IFTA tax revenue receipts by the IFTA tax rates.
Diesel prices	United States Energy Information Commission Gasoline and Diesel Fuel Prices; Region: United States (2012-2018)	We predicted a range of values for each year. The high trajectory is based on the highest price in the observed 2012 - 2018 data, the medium trajectory is based on the 5-year average, and the low trajectory is based on the lowest price in the observed data. Starting from these prices, we constructed three price trajectories by assuming that prices increased with inflation into the future.

Input	Data source & years of data used	Assumptions
Vehicle-related inputs		
Light-duty fleet size	California Department of Motor Vehicles Forecasting Unit Vehicle Registrations provided by personal communication to the authors (2012-2020)	This input includes both registered and non-operational light-duty vehicles in California. We used historical vehicle registration rates to estimate future vehicle registration rates. We modeled three trajectories for the rate of increase in the number of vehicle registrations: • 1.9% (median year-to-year growth rate from 2012-2019) • 0.7% (year-to-year growth rate from 2018-2019) • Vehicle registrations declines linearly to 0.66 vehicles per person by 2040. To put that number in context, it is the 2015 vehicle ownership rate from Canada, as reported by Statistics Canada. We assumed the number of registered non-operational vehicles (which do not pay registration fees) stays constant at 2.5% of the light-duty fleet.
Light-duty ZEV fleet size	California Department of Motor Vehicles Vehicle Registrations by Type, provided by personal communication to the authors (2012-2019)	The three trajectories used as inputs to the scenarios for the rate of increase are: • The number increases so that ZEVs constitute 75% of light-duty registered vehicles by 2040 • The number increases exponentially such that the state of California reaches its goals of 1.5 million ZEVs by 2025 and 5 million ZEVs by 2030. After 2030, this exponential rate of increase continues. • The number increases at the rate seen from 2018-2019 (94,112 vehicles per year), which was the highest year-to-year rate of increase We assumed that the number of exempt ZEVs declines linearly from 302,550 in 2019 to zero in 2035.

Input	Data source & years of data used	Assumptions
Diesel share of the heavy-duty fleet	United States Energy Information Commission Annual Energy Outlook 2020: Freight Transportation Energy Use	• High trajectory: following EIA projections, the diesel share drops to 73% of the heavy-duty fleet in 2040 • Medium trajectory: the diesel share declines logarithmically to 55% by 2030 and 50% by 2040 • Low trajectory: the diesel share declines logarithmically to 40%
Age of the vehicle fleet	Oak Ridge National Laboratory Transportation Energy Data Book Light Duty Vehicles in Operation by Age (2013)	We assumed that, through 2040, the age composition of the vehicle fleet mirrors the age composition in 2013. Vehicle age is used to determine the size of the overall light-duty fleet: we use a 15-year straight-line vehicle depreciation assumption, in which light-duty vehicles "age out" of the fleet after 15 years.
Light-duty ICE vehicle values	United States Energy Information Administration Annual Outlook 2020 (Region: United States)	We assumed that new light-duty ICE vehicles have values equal to EIA projections through 2040.
Light-duty ZEV vehicle values	United States Energy Information Administration Annual Outlook 2020 (Region: United States)	We project the purchase price of new ZEV vehicles in relation to the price of ICE vehicles. The three trajectories for ZEV values are: • High trajectory: ZEV values start at EIA projections in 2020 and converge to EIA projections for light-duty ICE vehicles by 2040. • Medium trajectory: ZEV values start at EIA projections in 2020 and converge to EIA projections for light-duty ICE vehicles by 2035. • Low trajectory: ZEV values start at EIA projections in 2020 and converge to EIA projections for light-duty ICE vehicles by 2030.
Light-duty gasoline vehicle MPG	United States Energy Information Administration Annual Outlook 2020 (Region: United States)	We assumed "average" light-duty gasoline MPG is proportional to EIA-projections for the percent of light-duty vehicles with gasoline engines, plug-in 10 gasoline hybrid engines, and plug-in 10 gasoline hybrid engines. In other words, as the percentage of the light-duty fleet comprised by hybrid engine vehicles increases, average light-duty gasoline MPG also increases.

Input	Data source & years of data used	Assumptions
Heavy-duty gasoline vehicle MPG	United States Energy Information Administration Annual Outlook 2020 (Region: United States)	We assumed heavy-duty gasoline MPG equals EIA projections through 2040. We assumed “average” heavy-duty gasoline MPG is proportional to the percent of heavy-duty gasoline vehicles with gasoline engines and plug-in gasoline hybrid engines.
Heavy-duty diesel vehicle MPG	United States Energy Information Administration Annual Outlook 2020 (Region: United States)	We assumed heavy-duty diesel MPG equals EIA projections through 2040. We assumed “average” heavy-duty diesel MPG is proportional to the percent of heavy-duty diesel vehicles with diesel engines and plug-in diesel hybrid engines.

TECHNICAL APPENDIX C: TRAJECTORIES OF THE KEY VARIABLES USED TO CONSTRUCT THE RECOVERY SCENARIOS

This appendix shows the high, medium, and low trajectories for the five variables used to construct the scenarios: annual state VMT, light-duty vehicle fleet size, light-duty ZEV fleet size, light-duty ZEV vehicle values, and heavy-duty diesel fleet size.

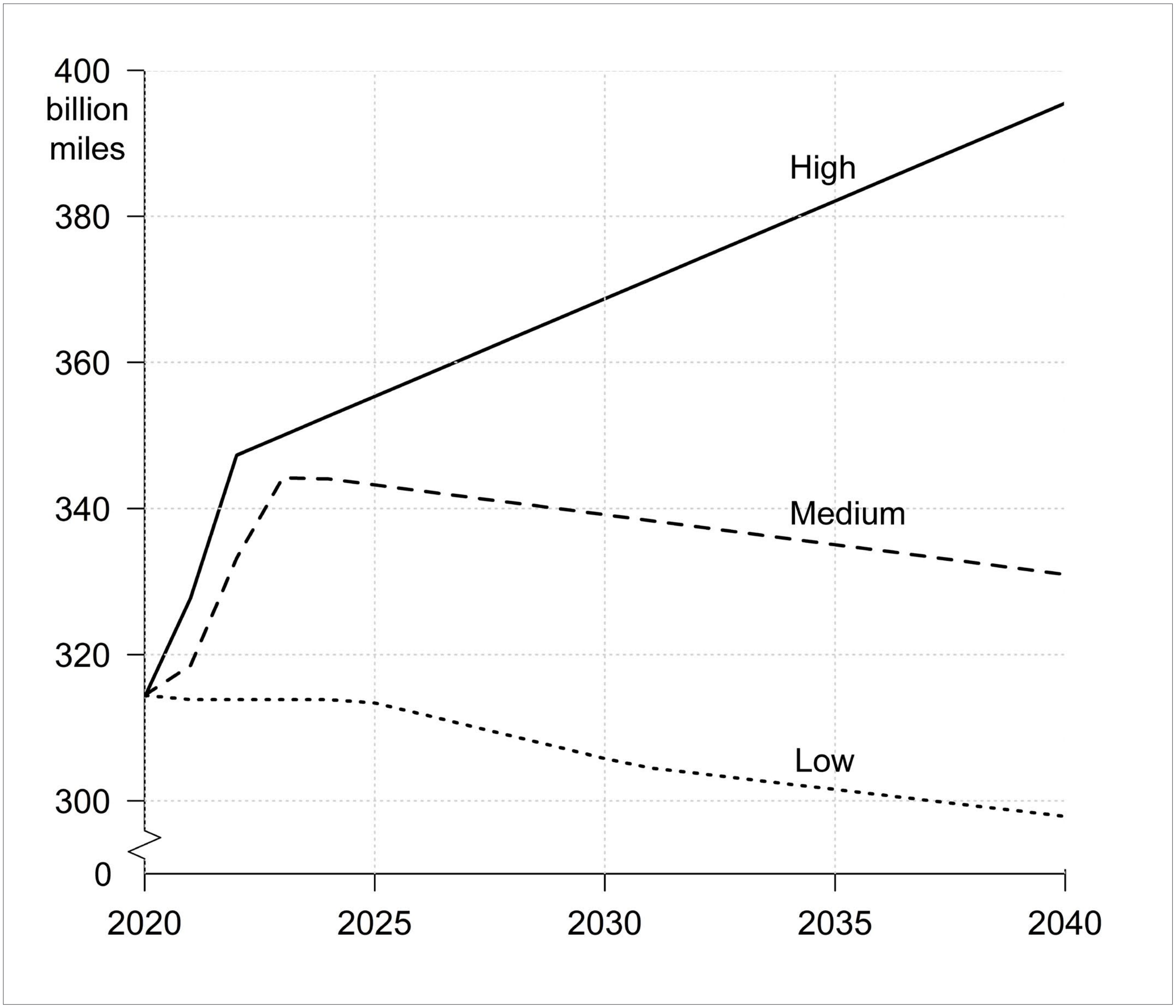

Figure C1. Total Annual State VMT Trajectories, 2020 – 2040

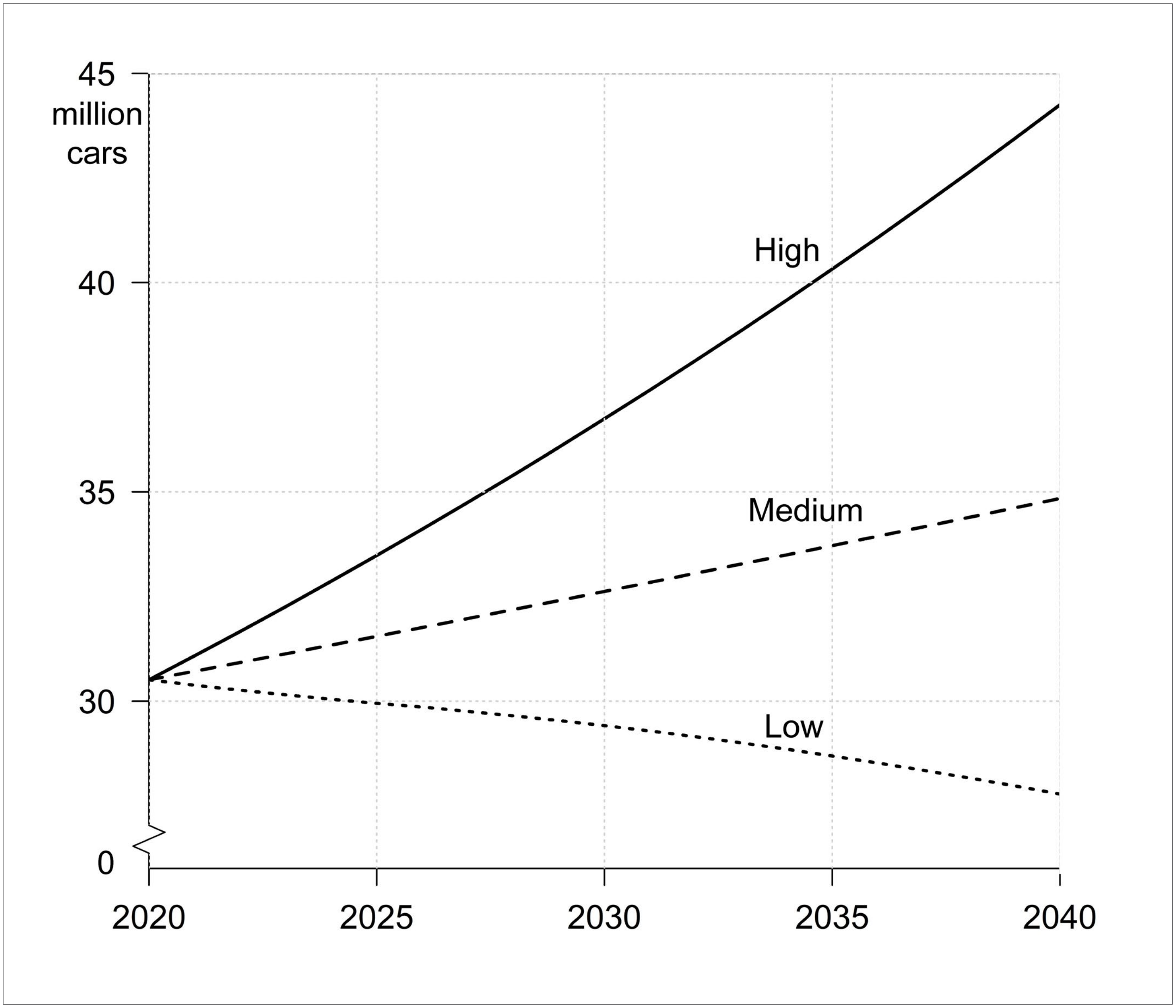

Figure C2. The Light-Duty Vehicle Fleet Size Trajectories, 2020 – 2040

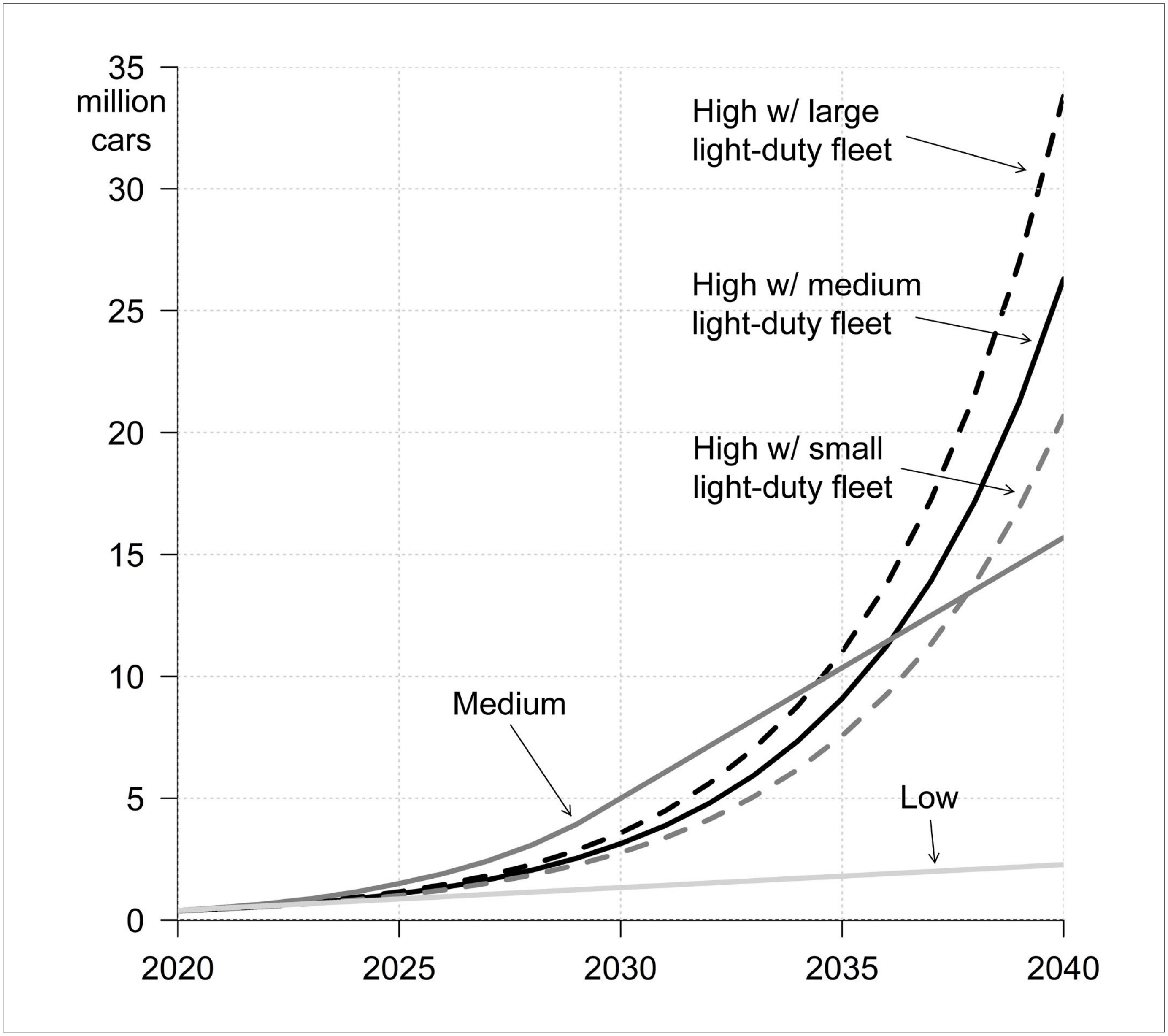

Figure C3. The Light-Duty ZEV Fleet Size Trajectories, 2020 – 2040

Note: For the high trajectory, the light-duty ZEV fleet size is a function of the light-duty ICE fleet size. Therefore, the figure shows values for the high ZEV fleet size trajectory given each of the three possible ICE fleet sizes.

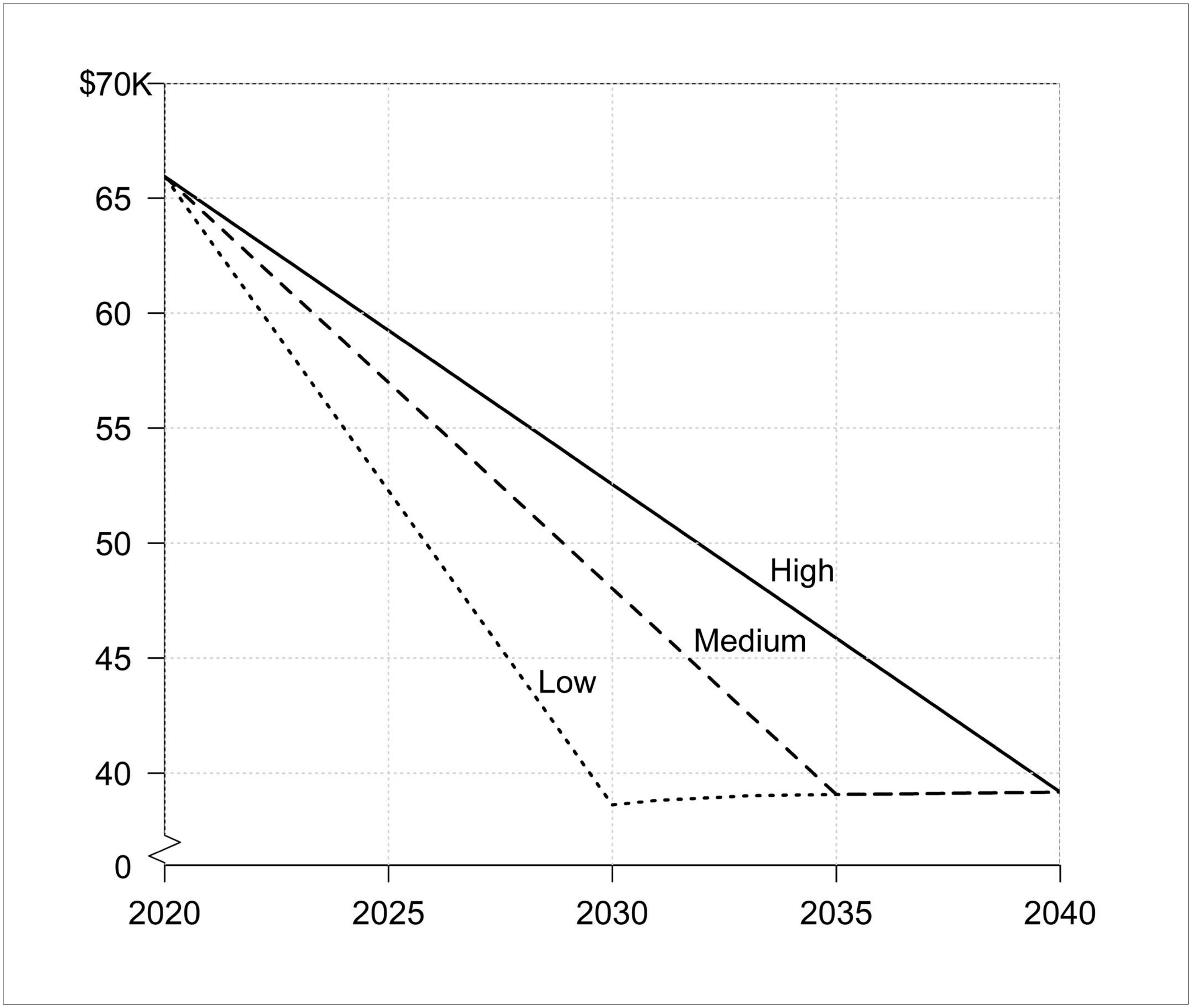

Figure C4. Light-Duty ZEV Vehicle Values, 2020 – 2040

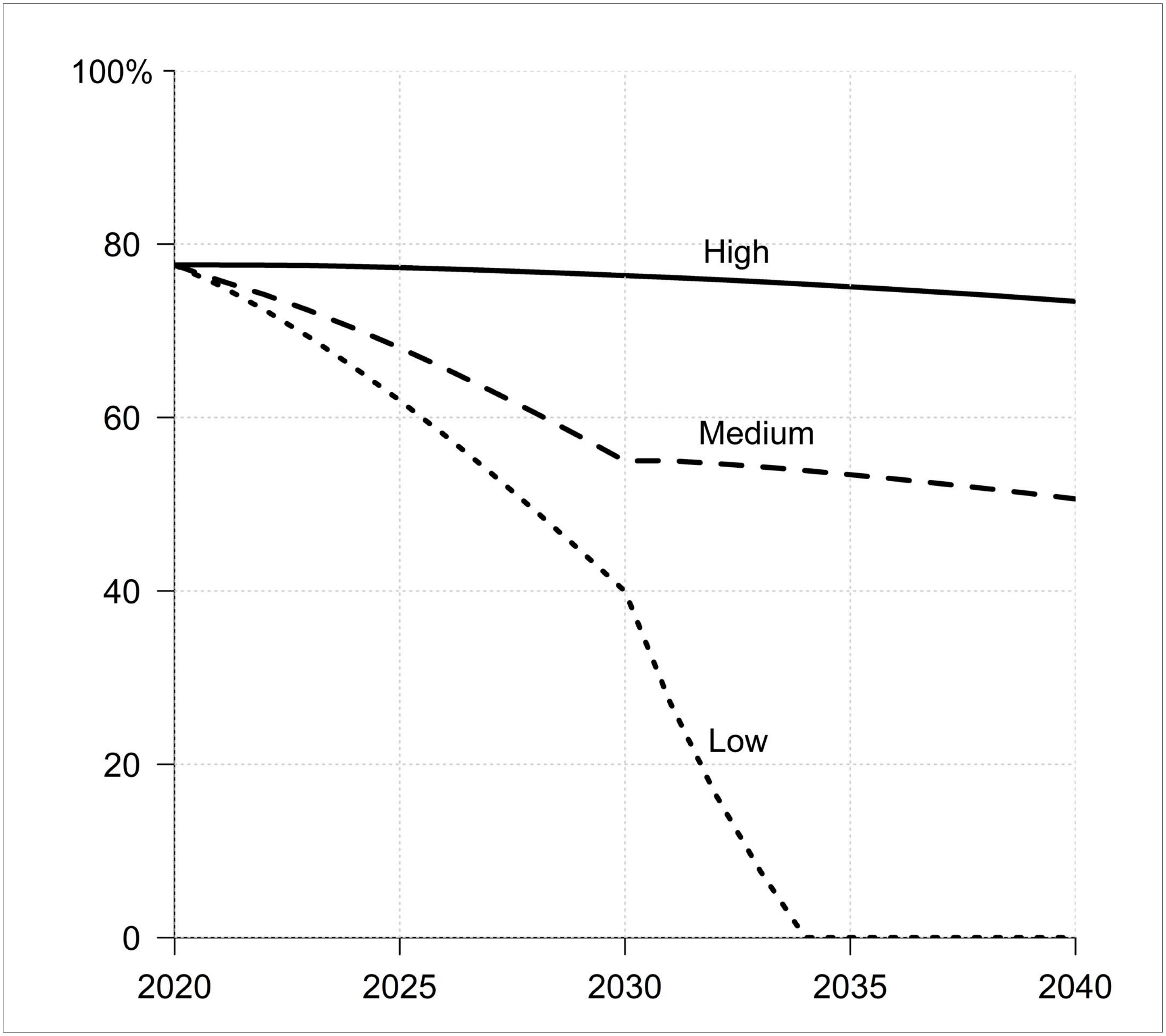

Figure C5. Heavy-Duty Diesel Fleet Composition Used to Construct the Scenarios, 2020 – 2040

TECHNICAL APPENDIX D: PROJECTED TRANSPORTATION REVENUE BY TAX/FEE

This appendix presents figures showing the projected revenue for each tax and fee under each scenario. For the combination of trajectories used to build each scenario, see Table 3.

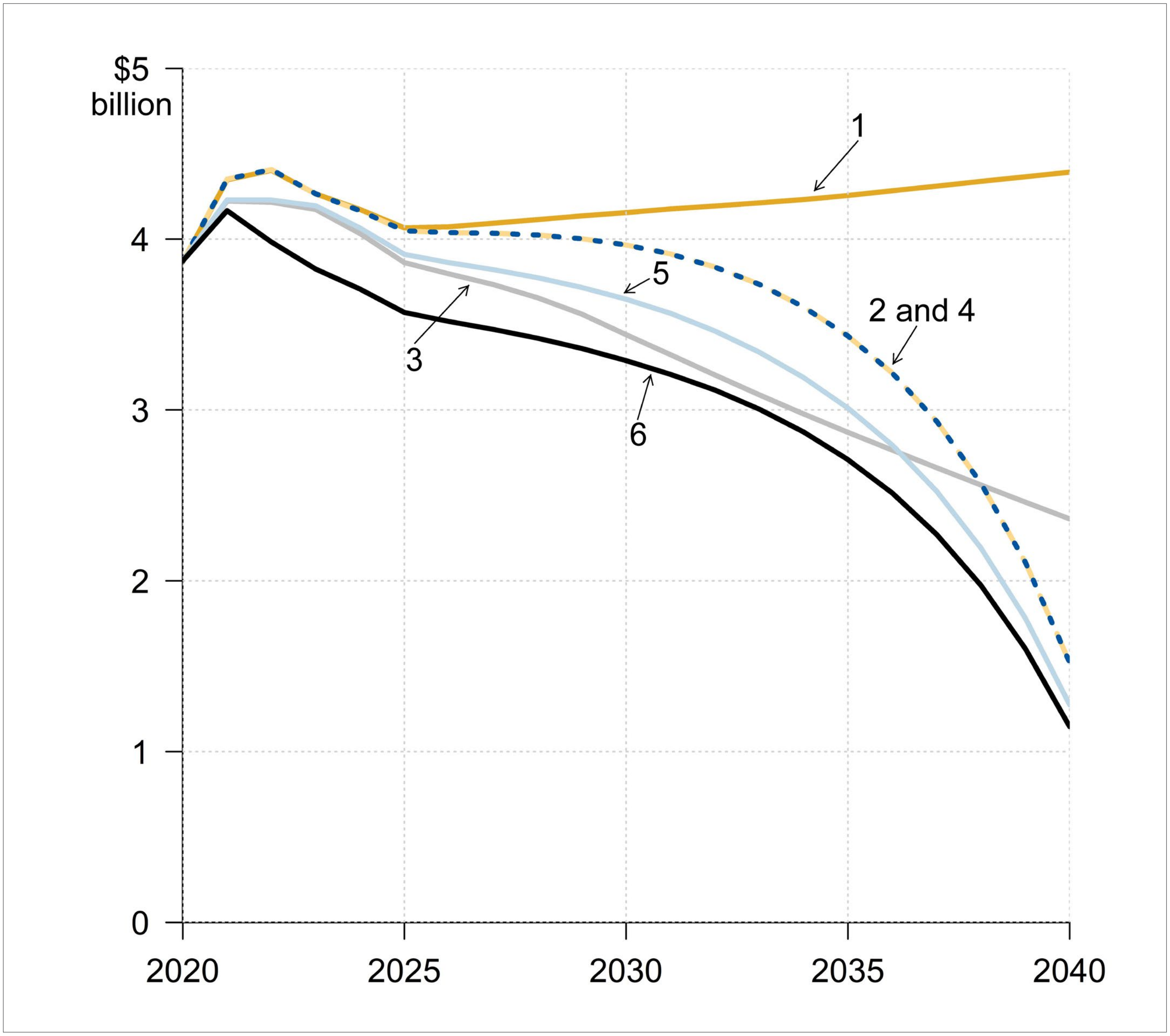

Figure D1. Gasoline Excise Tax Revenue Under All Scenarios, 2020 – 2040

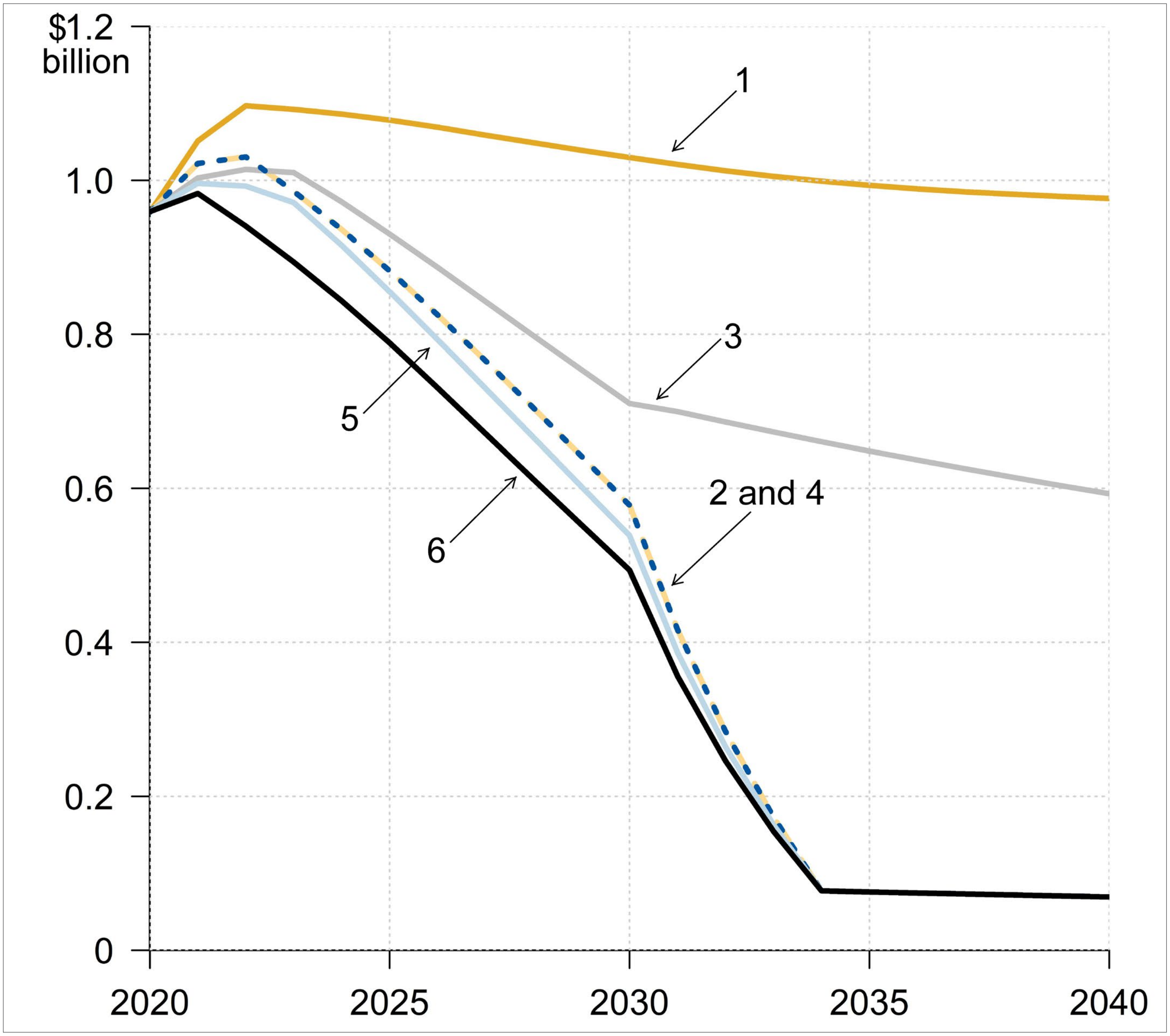

Figure D2. Diesel Excise Tax Revenue Under All Scenarios, 2020 – 2040

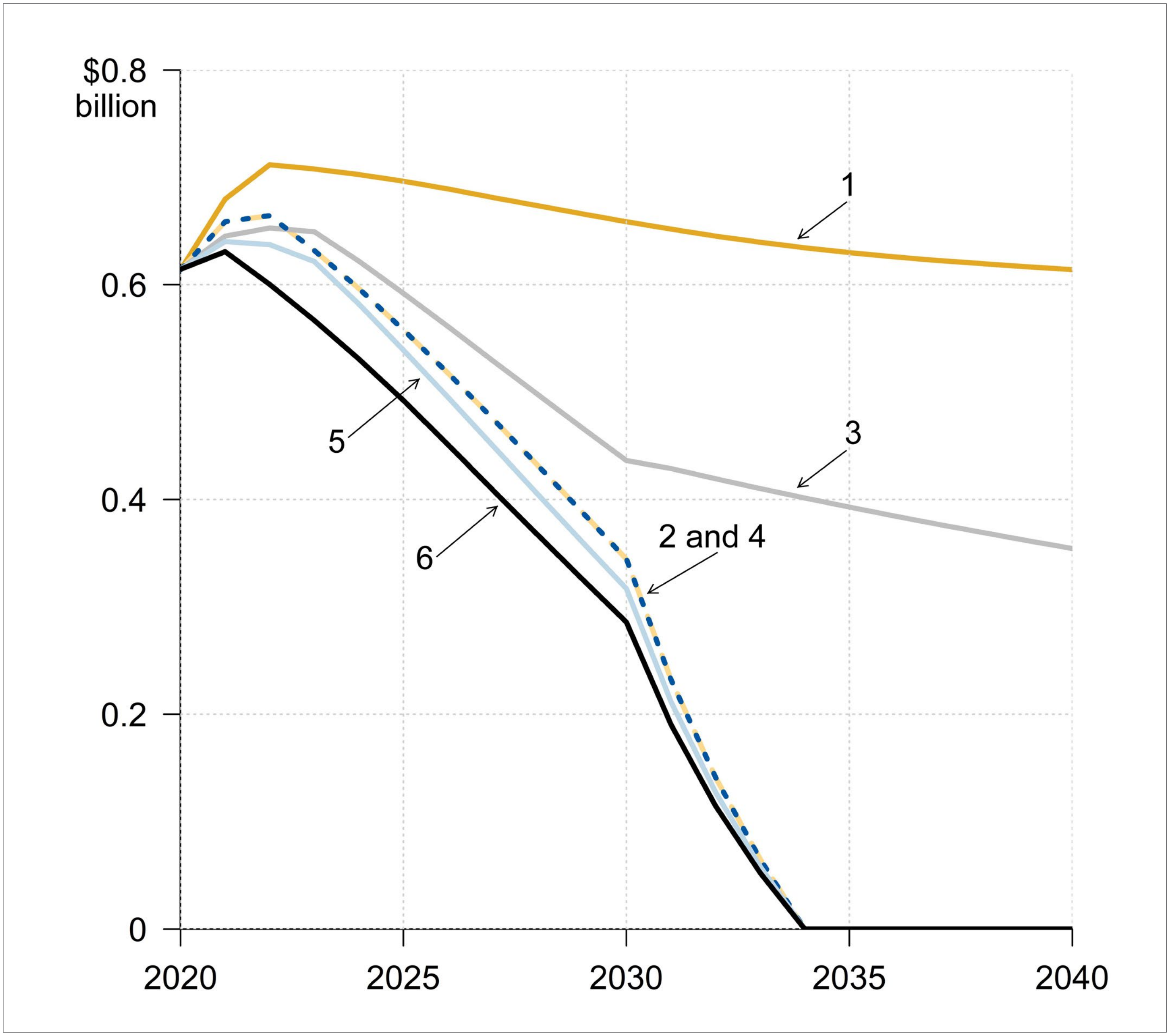

Figure D3. Diesel Sales Tax Revenue Under All Scenarios, 2020 – 2040

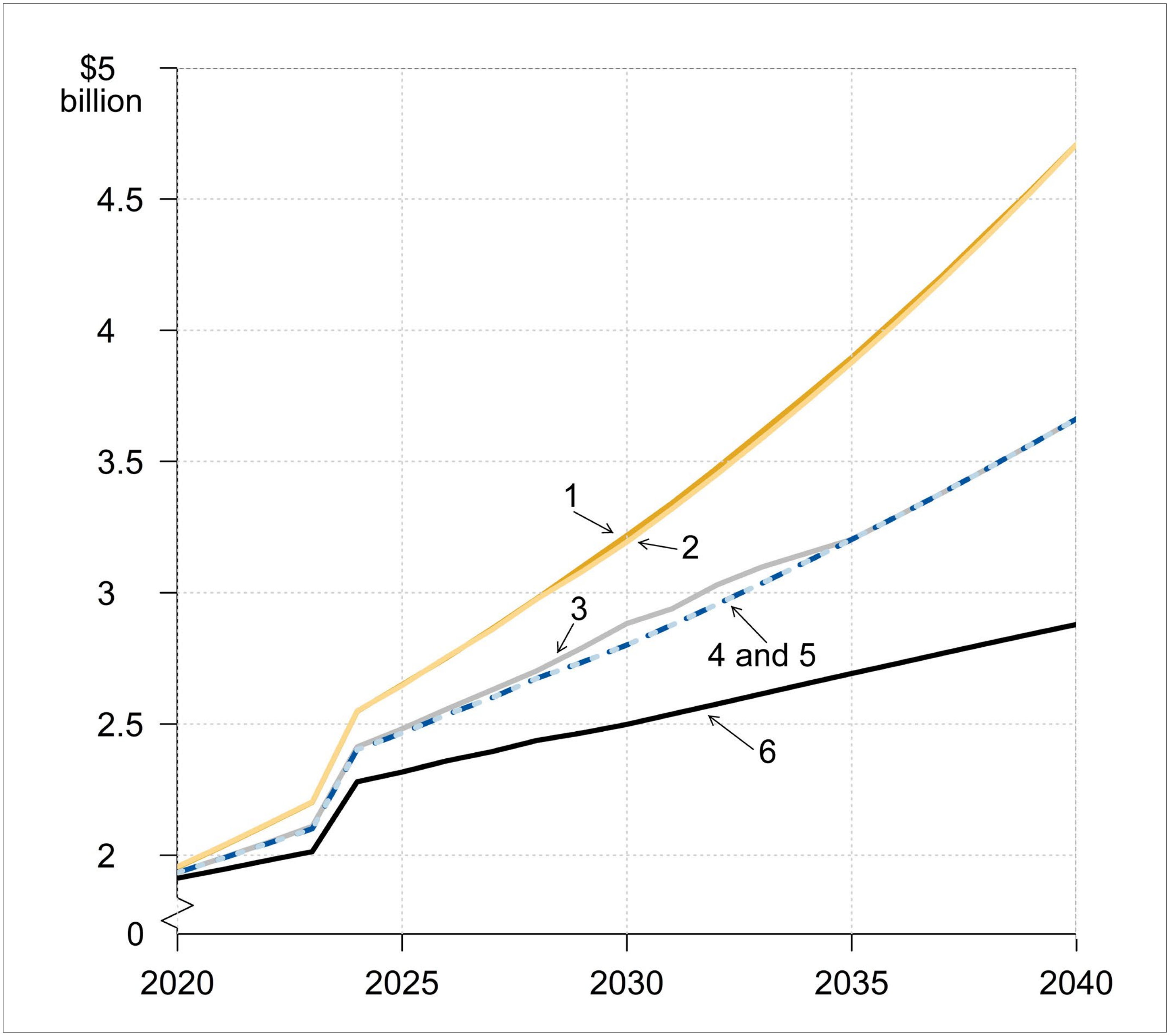

Figure D4. Transportation Improvement Fee (TIF) Under All Scenarios, 2020 – 2040

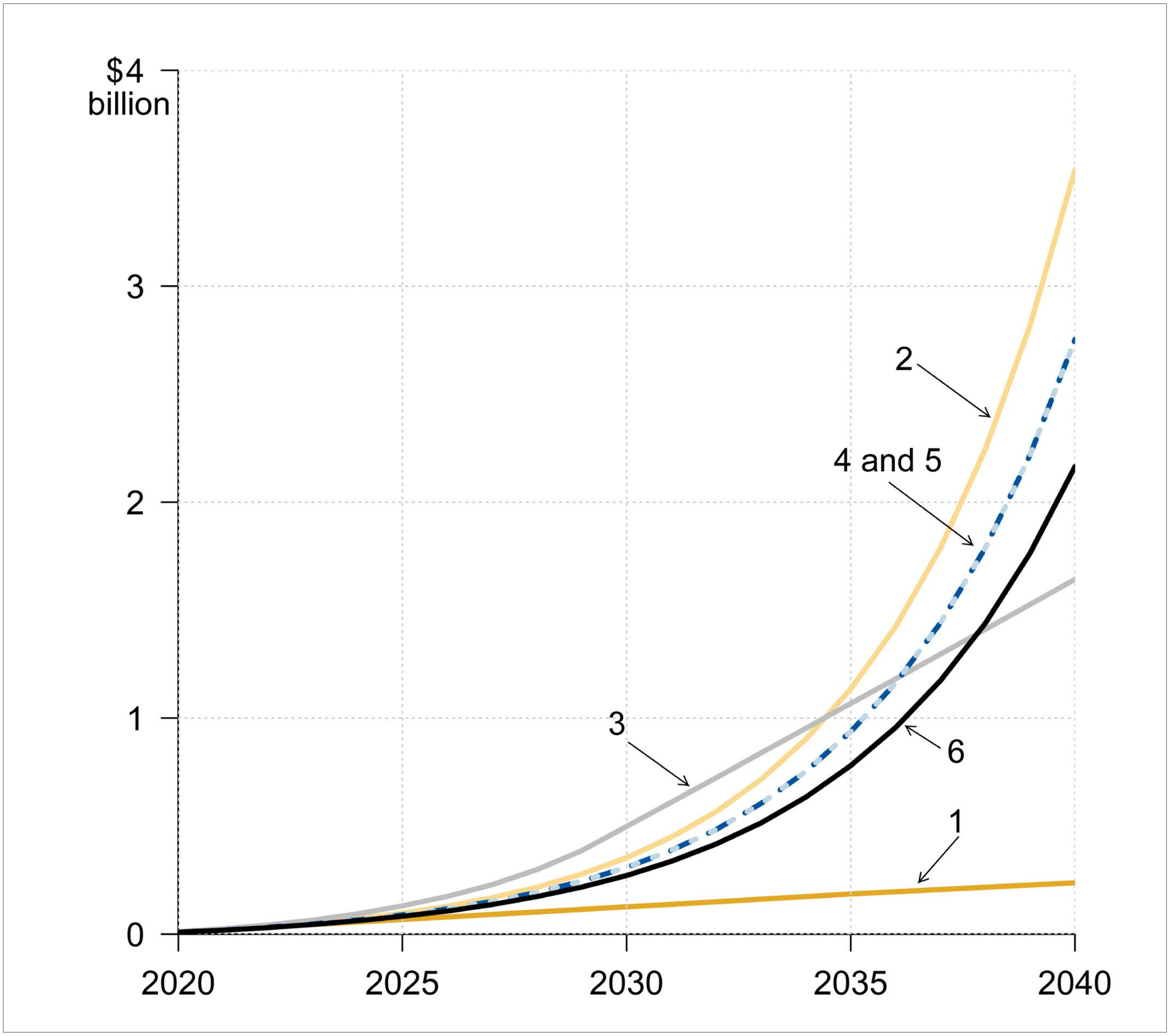

Figure D5. Roadway Improvement Fee (RIF) Revenue Under All Scenarios, 2020 – 2040