Examining the Economic Impacts of the Increased Fuel Efficiency Standards on State Gas-Tax Revenues

Jason Anderson
Air Force Institute of Technology

William Cunningham
Air Force Institute of Technology

Seong-Jong Joo
Air Force Institute of Technology

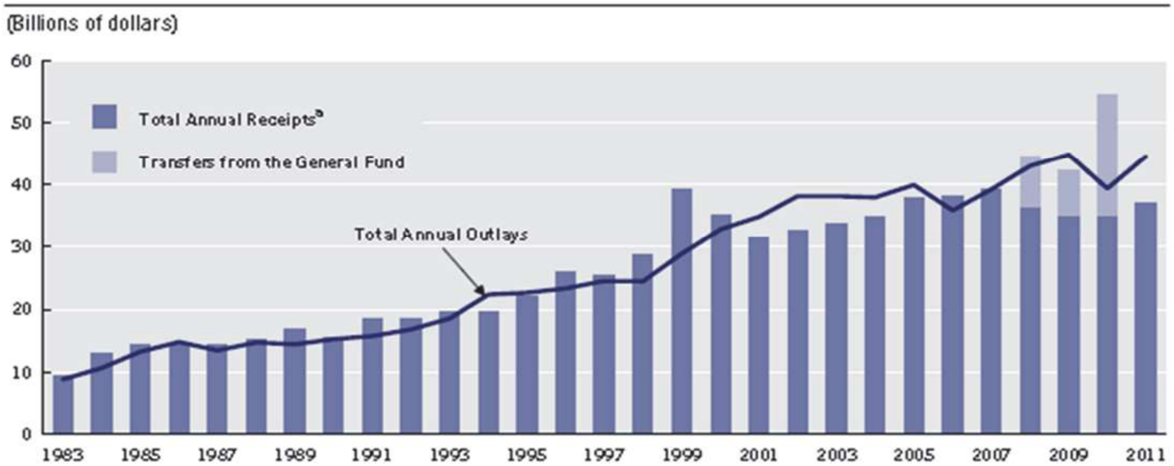
The US Department of Transportation announced an increase in the Corporate Average Fuel Economy standards for cars and light trucks on January 27, 2009, which affect vehicles in production until the year of 2025. The new standards will make the cars and light trucks more fuel efficient than before and lead to reduced gas-tax revenues at federal and state levels. Although some studies have investigated the impacts of the new standards at the federal level, no study specifies the state gas tax revenue impact. To fill this void, this research estimates the shortfall of state gas-tax revenues and its consequences.

INTRODUCTION

On January 27, 2009, the US Department of Transportation (DOT) was directed to increase the Corporate Average Fuel Economy (CAFE) standards on cars and light trucks (trucks, vans, and sport utility vehicles) out to 2025. This was done to reduce carbon dioxide and other greenhouse gas emissions. As this standard for miles per gallon (MPG) increases, there will be less fuel purchased and an associated shortfall in gas tax revenue. Research has been accomplished on shortfall revenue based on the federal gas tax (Congressional Budget Office, 2012; Grundler et al., 2015; Dutta and Patel, 2012; D Austin and Dinan, 2005), but a comprehensive analysis of state gas tax revenue has not been accomplished. In the first half of 2017, ten states (some states have not raised taxes for decades) have raised their gas tax substantially to make up for existing shortfalls (Davis, 2017). To understand the consequences of the increased CAFE standard, this research provides an analysis of the revenue losses out to 2050 incurred by the states, based on the individual state gas tax, in the event gas taxes per gallon do not change, and possible remedies for attaining this shortfall are not implemented.

This research builds upon the work done at the federal level by the Congressional Budget Office (CBO), the Environmental Protection Agency (EPA), other federal agencies, and scholars. Figure 1 depicts how shortfalls at the federal level between outlays and receipts began in 2001, and are generally widening since 2001 (Congressional Budget Office, 2012). This approach uses CBO estimates of the reduction in gallons used to calculate the effect on state's gas tax revenue. Based on these projections and the percentage of total U.S. gallons consumed in each state, an estimate is derived from each state's reduction in fuel consumed. Using 2016 state gasoline tax rates, and recognizing that each state establishes their unique rates and assuming these rates do not change over time, the effect of CAFE standards on each state's fuel tax revenue is estimated. For example, the federal gas tax is 18.4 cents per gallon, whereas Pennsylvania levies additional 58.2 cents per gallon. On the other hand, Alaska's fuel tax is only 8.95 cents per gallon, which translates into a 650 per cent difference. This range illustrates the necessity of analyzing each state individually.

FIGURE 1
THE HIGHWAY TRUST FUND'S OUTLAYS, RECEIPTS, AND TRANSFERS (CONGRESSIONAL BUDGET OFFICE OR CBO, 2012)



Source: Congressional Budget Office based on data from the Department of Transportation.

Note: Beginning in 2006, total annual outlays reflect a change in accounting treatment for certain outlays from the mass transit account. That change slowed the rate of spending from that account and thus reduced the amount recorded for outlays from the Highway Trust Fund relative to amounts in earlier years; certain outlays that had been treated as outlays in a single year are now spread across several years.

a. Includes excise tax revenues, interest earned on balances, and receipts from other sources.

LITERATURE REVIEW

The Corporate Average Fuel Economy (CAFE) program is designed to improve the efficiency of the light-duty vehicles by reducing fuel usage (Council National Research, 2002). The CAFE standards must be met by manufacturers or they are fined based on the number of vehicles sold and the amount the vehicle is under the standard (Council National Research, 2002). The CAFE standards projected to 2025 are in Table 1 below.

TABLE 1
CAFE STANDARDS TO 2025 IN MILES PER GALLON (NHTSA, 2011)

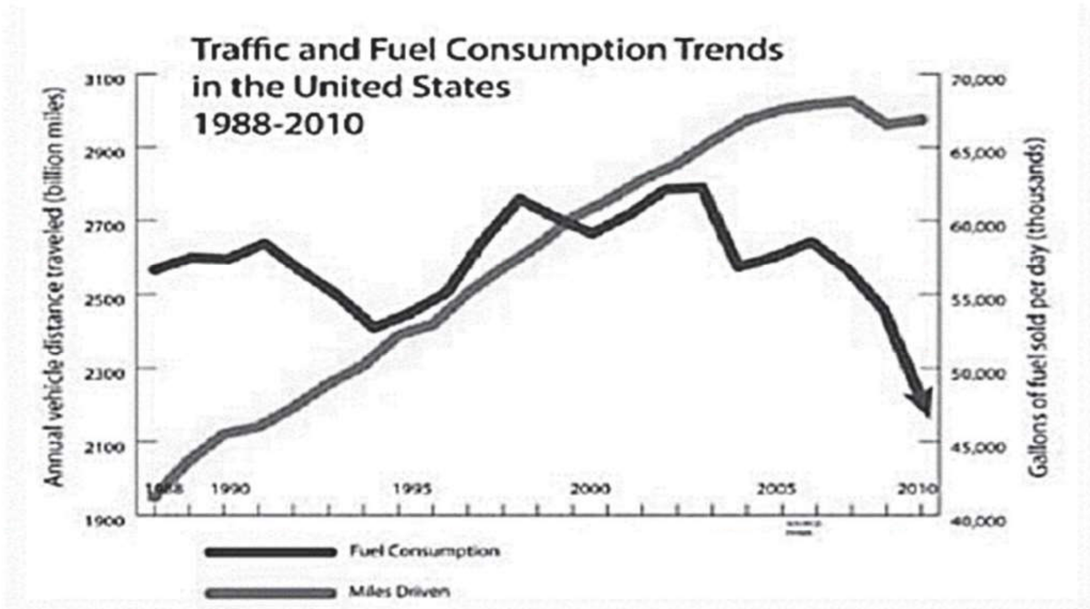
Model Year	Passenger Cars				Light Trucks			
	"footprint": 41 ft^2		"footprint": 55 ft^2		"footprint": 41 ft^2		"footprint": 75 ft^2	
	CAFE	EPA Window Sticker	CAFE	EPA Window Sticker	CAFE	EPA Window Sticker	CAFE	EPA Window Sticker
2012	36	27	28	21	30	23	22	17
2013	37	28	28.5	22	31	24	22.5	17
2014	38	28	29	22	32	24	23	18
2015	39	29	30	23	33	25	23.5	18
2016	41	31	31	24	34	26	24.5	19
2017	44	33	33	25	36	27	25	19
2018	45	34	34	26	37	28	25	19
2019	47	35	35	26	38	28	25	19
2020	49	36	36	27	39	29	25	19
2021	51	37	38	28	42	31	25	19
2022	53	38	40	30	44	33	26	20
2023	56	40	42	31	46	34	27	21
2024	58	41	44	33	48	36	28.5	22
2025	60	43	46	34	50	37	30	23

Passenger cars and light truck companies must meet unprecedented higher fuel efficiency in order not to be fined (MacKenzie and Heywood, 2015). Table 1 reveals that cars must become approximately 66 per cent more efficient in 2025 than 2012 standards, while trucks must become about 36 per cent more efficient.

Studies have focused on the impacts on federal gas tax revenues (Dutta and Patel, 2012), environmental impacts (Kargul et al., 2016; NHTSA, 2016), fleet fuel economy (Greene, 2010), consumer choice model based on fuel economy (Austin and Dinan, 2005; Greene and Liu, 2012), cost-benefit analysis (Helfand et al., 2015), and rebound effect due to increased fuel economy (Small and Hymel, 2014). Two major studies examining the federal revenue shortfall were accomplished by Duttta and Patel (2012) and the Congressional Budget Office (2012). Dutta and Patel looked at federal gas tax revenues and the revenue for the state of Michigan, while the CBO study concerned itself with the effects on federal gas tax revenues.

Historically, funds for highway construction and maintenance (federal or state), come primarily from gas tax revenue. More recently, there have not been sufficient funds to cover the expenses. This is primarily due to the stagnation in revenue due to less fuel purchased because of more efficient vehicles and additional miles being driven increasing maintenance and construction as shown in Figure 2.

FIGURE 2
BARRELS CONSUMED AND MILES DRIVEN

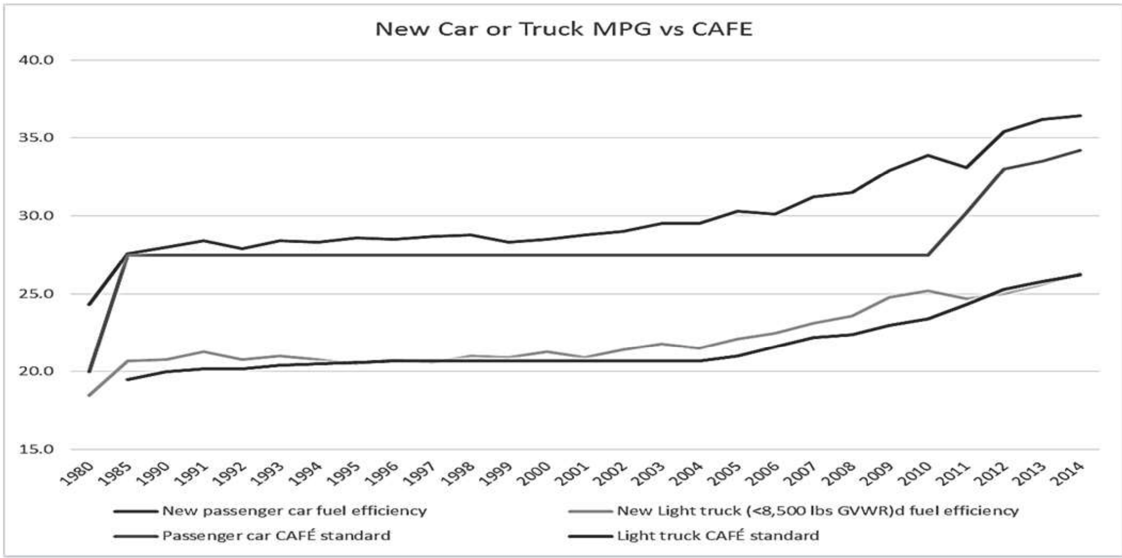


(Dutta and Patel, 2012)

This reduction in gas tax revenue widens the gap between the revenue and outlays. The gas tax revenue diminishes based on a step function imposed at the beginning of each annual increase in CAFE standards and then follows an inverse logistic function due to the retirement of less fuel-efficient older cars. As of 2017, a new car is not decommissioned for approximately 11 years (Consumer reports.org, 2016), that is, a new car sold in 2017 will be on the road until 2028. This implies that the full effect of the CAFE standards will not be seen in 2025 but rather around 2036.

New cars are often exceeding the CAFE standards, further exacerbating shortfalls in gas tax revenue. Data from DOT and NHTSA (FHWA, 2015) shows that on average the new passenger cars exceed the CAFE standards by 7.6 per cent and light trucks by 2.9 per cent (see Figure 3).

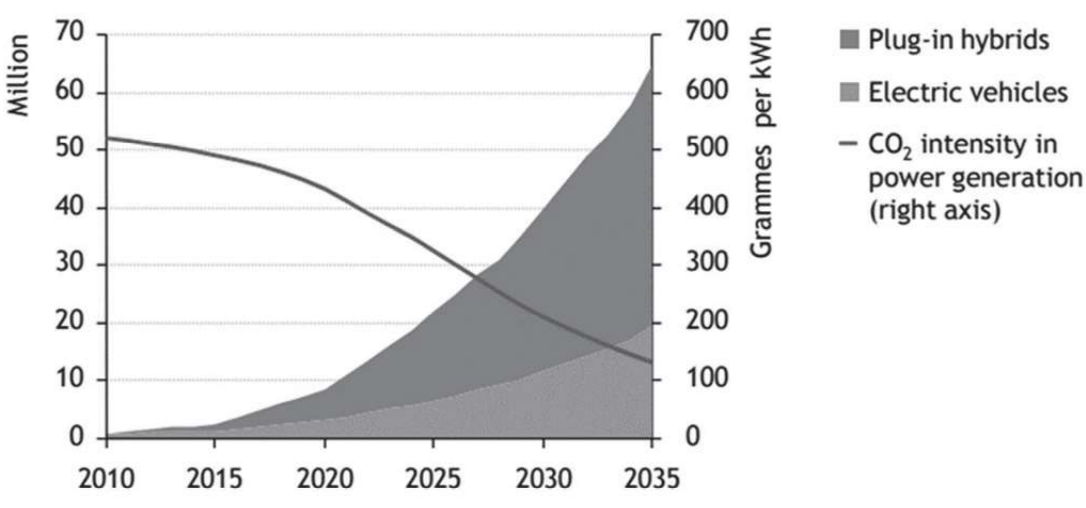
FIGURE 3
NEW CAR SALES MPG VS. CAFE



The CBO report, regarding federal fund losses, assumes that the shortfall is based solely on CAFE standards, which, historically, have been exceeded with higher average MPG for passenger cars and light trucks. If this continues, then the shortfall at both a state and federal level would be more pronounced than the estimates provided later in this research as well as government estimates.

Additional state funding shortfalls may also result due to the move towards electric and other hybrid vehicles. Hybrid cars are gaining traction due to the increased capacity of the battery and alternative fuels. Research has shown that hybrid vehicles are growing at a fast pace and estimated that plug-in hybrids and electric vehicles would reach 39 per cent of net sales by 2035 as shown in Figure 4 (Annual Energy Review, 2011).

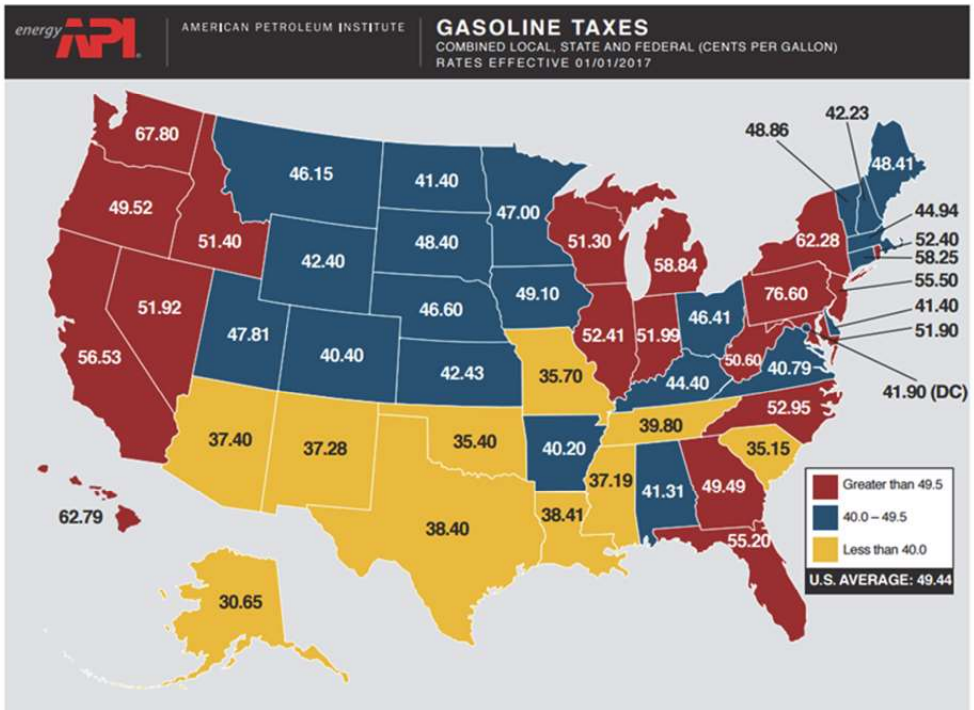
FIGURE 4
GROWTH OF ALTERNATIVE VEHICLES



(Annual Energy Review, 2011)

More money is also procured through state than federal state tax revenue. In fact, the state tax revenue brings in approximately 57.4 per cent of funding for the United States, and in some states, the tax revenue is as high as 72.0 per cent and as low as 32.7 per cent as shown in **Error! Reference source not found.**.

FIGURE 5
GASOLINE TAXES



(American Petroleum Institute, 2017)

As shown, the state gas tax brings in more revenue than the federal gasoline tax and needs to be examined based upon the new CAFE standards. The next section will detail how this research will analyze the state shortfall that can be expected based on the decrease in fuel consumption.

METHOLOLOGY

Data on US gallons not consumed based on CAFE standards were derived from the studies conducted by EPA and NHTSA (See Table 2) of the effects of the proposed CAFE standards, and both predicted similar reductions in gasoline consumption (U.S. Federal Register, 2011).

TABLE 2
GALLONS NOT CONSUMED DUE TO CAFE STANDARDS

Year	Million gallons loss
2017	194
2018	641
2019	1326
2020	2277
2021	3673
2022	5424
2023	7520
2024	9919
2025	12658
2030	25581
2040	40391
2050	47883

The CBO report (2012) provides estimates on the highway trust fund to 2050 based on the 18.4 cents federal gas tax per gallon. Although estimates for the years of 2025, 2030, and 2050 are available, there are missing values for the periods between these years such as between 2026 and 2029; 2031 and 2039; 2041 and 2049. Estimates were found through extrapolation to find the missing values (Armstrong, Green, and Graefe, 2015).

To estimate the missing values of the combined state tax shortfalls for these years, linear and non-linear regression models were developed from available data. Out of the models tested, a quadratic model of the following form was found to be the best fit for data:

$$\hat{y} = c + \beta_1 x_1 + \beta_2 x_2^2. \quad (1)$$

The integral of the above regression function was used to get the sum of the shortfall, where t is the starting point or year and $(t+n)$ is the ending year. Thus, the following mathematical expression yielded the sum of the shortfalls between two points:

$$\int_{x=t}^{x=(t+n)} \hat{y}dx = \int_{x=t}^{x=(t+n)} (c + \beta_1 x_1 + \beta_2 x_2^2)dx. \quad (2)$$

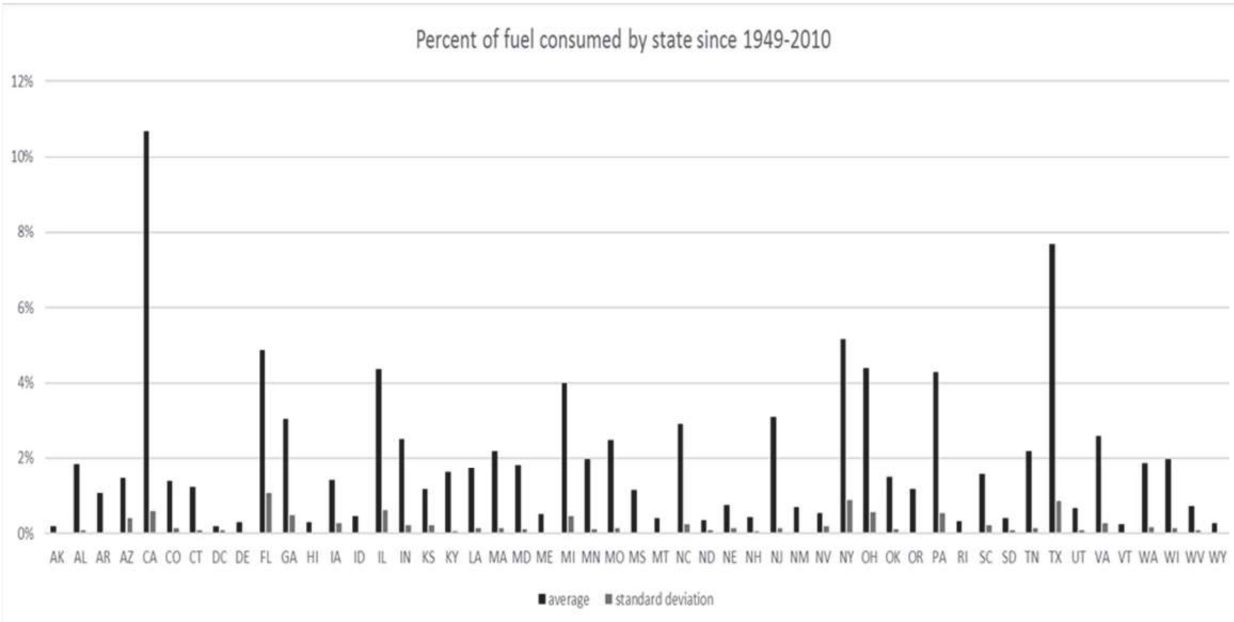
For example, for the years between 2025 and 2030 inclusively, the following equation derived:

$$y = 774{,}200{,}000.00 + 24{,}467{,}570.58x^2. \quad (3)$$

To get the cumulative revenue shortfalls, t = 9 was assigned to the year of 2025, and t = 14 was assigned to the year of 2030, based on the starting year of 2017 for estimating tax-revenue shortfalls was t = 1. The integral of the quadratic function, Equation (3), from t = 9 to t = 14 inclusively yielded $20,305,051,573 for the six years from 2025 to 2030 for the “low” estimate. This process was repeated for the three-time segments (2025-2030, 2030-2040, and 2040-2050). Three estimates for these time segments were computed (high, low, and average) based on a 95 per cent confidence interval.

To find the state gas tax revenue, the projected CBO numbers are used in conjunction with percentage apportionments by state and the associated state tax to estimate the projected tax revenue by state. The number of state gallons of gas consumed has been collected for the years between 1949 and 2010 inclusively and used for computing mean and standard deviation for each state (See Figure 6) enabling the computation shortfall per state up to the year 2050 (U.S. EIA, 2012).

FIGURE 6
PER CENT OF US FUEL CONSUMED BY STATE



ANALYSIS

The result from the extrapolation using the quadratic function is depicted in Figure 7. This figure shows the annual state tax shortfall for the given year out to 2050 in millions of dollars (note the x-axis represents years 2017 = 1 to 2050 =34). The three curves represent the high, average, and low estimates based on a 95 per cent confidence interval. The solid dots represent the extrapolated state data estimates from the EPA and NHTSA federal data (as reference above). For example, the year 2050 or 34, the annual state tax shortfall is estimated to be between 10.4 billion dollars and approximately 16.0 billion dollars with the average estimated at 13.2 billion dollars.

FIGURE 7
ANNUAL STATE TAX SHOERTFALL

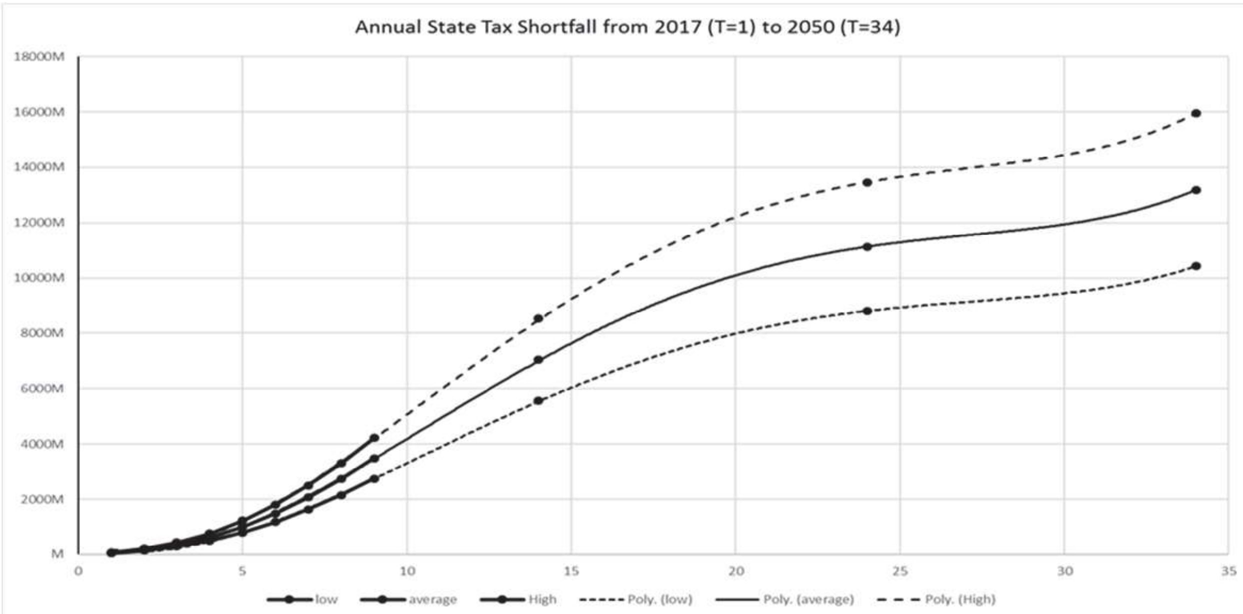


Table 3 provides information regarding the state reduction in gas tax revenue based on current state tax rates and projected changes in fuel consumption due to the CAFE standards. Each state (column 1) is listed in Table 3 with their associated per cent of total US gas consumption (column 2), standard deviation (column 3), years of state tax revenue shortfalls (columns 4-10), and the last column is the cumulative shortfall over the years 2017 to 2050 per state.

TABLE 3
REDUCTION IN STATE GAS TAX REVENUE (MILLION DOLLARS)

	% US Gas	σ	2017	2018	2019	2020	2030	2040	2050	Cumulative
AK	0.18%	0.04%	0.1	0.3	0.7	1.1	13	20	24	475
AL	1.83%	0.07%	1.0	3.2	6.7	11.5	129	204	242	4754
AR	1.08%	0.04%	0.6	1.9	3.9	6.8	76	120	142	2796
AZ	1.45%	0.39%	0.8	2.6	5.3	9.1	102	162	192	3771
CA	10.68%	0.59%	5.7	18.8	39.0	66.9	752	1188	1408	27676
CO	1.39%	0.14%	0.7	2.4	5.1	8.7	98	154	183	3591
CT	1.23%	0.10%	0.7	2.2	4.5	7.7	86	136	162	3180
DC	0.18%	0.08%	0.1	0.3	0.7	1.1	13	20	24	468
DE	0.30%	0.01%	0.2	0.5	1.1	1.9	21	34	40	781
FL	4.85%	1.07%	2.6	8.6	17.7	30.4	342	540	640	12585
GA	3.03%	0.48%	1.6	5.3	11.1	19.0	213	337	399	7845
HI	0.30%	0.03%	0.2	0.5	1.1	1.9	21	33	39	774
IA	1.42%	0.28%	0.8	2.5	5.2	8.9	100	158	188	3691
ID	0.46%	0.03%	0.2	0.8	1.7	2.9	33	52	61	1204
IL	4.35%	0.63%	2.3	7.7	15.9	27.3	306	483	573	11267
IN	2.50%	0.23%	1.3	4.4	9.1	15.7	176	278	330	6489
KS	1.18%	0.21%	0.6	2.1	4.3	7.4	83	131	155	3055
KY	1.61%	0.06%	0.9	2.8	5.9	10.1	114	180	213	4184
LA	1.73%	0.14%	0.9	3.1	6.3	10.9	122	193	229	4496
MA	2.17%	0.13%	1.2	3.8	7.9	13.6	153	242	287	5633
MD	1.82%	0.12%	1.0	3.2	6.6	11.4	128	202	240	4716
ME	0.52%	0.03%	0.3	0.9	1.9	3.3	37	58	69	1350
MI	3.99%	0.45%	2.1	7.0	14.6	25.0	281	444	526	10337
MN	1.96%	0.11%	1.0	3.5	7.1	12.3	138	218	258	5073
MO	2.47%	0.15%	1.3	4.4	9.0	15.5	174	275	326	6401
MS	1.15%	0.04%	0.6	2.0	4.2	7.2	81	128	152	2994
MT	0.41%	0.04%	0.2	0.7	1.5	2.6	29	46	54	1065
NC	2.91%	0.24%	1.6	5.1	10.6	18.2	205	323	383	7534
ND	0.36%	0.08%	0.2	0.6	1.3	2.2	25	40	47	928
NE	0.75%	0.13%	0.4	1.3	2.8	4.7	53	84	99	1954
NH	0.44%	0.07%	0.2	0.8	1.6	2.7	31	49	58	1134
NJ	3.08%	0.13%	1.6	5.4	11.2	19.3	217	342	406	7976
NM	0.69%	0.03%	0.4	1.2	2.5	4.3	49	77	91	1785
NV	0.55%	0.19%	0.3	1.0	2.0	3.4	38	61	72	1416
NY	5.15%	0.88%	2.8	9.1	18.8	32.3	363	573	679	13352
OH	4.39%	0.55%	2.3	7.7	16.0	27.5	309	488	579	11378
OK	1.50%	0.12%	0.8	2.7	5.5	9.4	106	167	198	3896
OR	1.17%	0.04%	0.6	2.1	4.3	7.3	82	130	154	3034
PA	4.29%	0.54%	2.3	7.6	15.7	26.9	302	477	565	11113
RI	0.34%	0.04%	0.2	0.6	1.2	2.1	24	37	44	869
SC	1.57%	0.21%	0.8	2.8	5.7	9.9	111	175	208	4080
SD	0.40%	0.08%	0.2	0.7	1.4	2.5	28	44	52	1027
TN	2.18%	0.13%	1.2	3.9	8.0	13.7	154	243	288	5657
TX	7.68%	0.85%	4.1	13.6	28.0	48.1	541	854	1012	19905
UT	0.67%	0.08%	0.4	1.2	2.4	4.2	47	74	88	1734
VA	2.57%	0.26%	1.4	4.5	9.4	16.1	181	286	339	6661
VT	0.24%	0.01%	0.1	0.4	0.9	1.5	17	27	32	625
WA	1.86%	0.17%	1.0	3.3	6.8	11.7	131	207	245	4824
WI	1.98%	0.14%	1.1	3.5	7.2	12.4	140	220	261	5135
WV	0.71%	0.08%	0.4	1.3	2.6	4.5	50	79	94	1842
WY	0.28%	0.03%	0.2	0.5	1.0	1.8	20	31	37	732
US	100.00%	100.00%	53	177	365	627	7045	11123	13186	259239
Cumulative	0.00%	0.00%	53	230	595	1222	40275	137523	259239	

In this table, the last two rows represent the 50-state total shortfall for the selected year (row labeled *US*), the last row (*Cumulative*) shows cumulative totals for all 50 states from 2017 to the specified year (note not all years are depicted for size of table), and the last cell represents the cumulative state shortfall from 2017 to 2050. For example, in 2017, Alaska (AK) will have decreased gas tax revenue of approximately 0.1 million dollars and the cumulative shortfall out to 2050 is approximately 475.0 million dollars. Similarly, the aggregate decrease in revenue of all states is approximately 259.2 billion dollars. Additionally, for 2030 the *US* row shows 7.045 billion dollars that represents the shortfall for the year 2030 for all states; the *cumulative* value of 40.275 billion dollars represents the cumulative shortfall from 2017 to 2030 for all states.

DISCUSSION AND CONCLUSION

This research provides a conservative estimate of the impact of increased CAFE standards on gas tax revenue by state, assuming that state tax rates do not change. The likely effect is higher than might be expected. This research did not consider the impact on gas tax revenue due to increased use of electric vehicles, both hybrids, and pure electric, nor the effect of alternative fuels, such as natural gas and hydrogen. Additionaly, the actual fuel economy, thus fewer gallons consumed, may be higher than the CAFE standards, and less fuel-efficient vehicles may replace older ones at an increased rate, depending on future fuel prices and taxes.

Table 4 shows the total motor fuel tax revenue by state, total tax collections by state, and the percentage of total tax revenue contributed by the gas tax revenue (Perez, 2008).

TABLE 4
STATE GAS TAX REVENUE AS PER CENT OF TOTAL REVENUE

State	Motor Fuel Tax Revenue*	Total State Tax Collections*	Motor Fuel %	State	Motor Fuel Tax Revenue*	Total State Tax Collections*	Motor Fuel %
AL	559.1	7,614.20	7.3%	MT	120.5	1,638.30	7.4%
AK	29.9	1,773.80	1.7%	NE	303.8	3,705.50	8.2%
AZ	496.3	11,173.80	4.4%	NV	255.5	4,310.30	5.9%
AR	445.5	6,317.60	7.1%	NH	132	1,942.80	6.8%
CA	3,365.00	90,908	3.7%	NJ	NA	NA	0.0%
CO	553.6	7,767.00	7.1%	NM	149.4	4,178.90	3.6%
CT	481.8	10,297.70	4.7%	NY	530	47,828.40	1.1%
DE	117.9	3,347.00	3.5%	NC	1,280.10	21,981.60	5.8%
FL	2,161.70	32,636.00	6.6%	ND	124.3	1,188.00	10.5%
GA	850	15,200.00	5.6%	OH	1,671.90	23,011.90	7.3%
HI	162.9	4,597.40	3.5%	OK	301.3	6,652.70	4.5%
ID	222.7	3,160.50	7.0%	OR	404.9	6,962.70	5.8%
IL	1363.8	26,160.00	5.2%	PA	780.9	26,596.20	2.9%
IN	579.7	12,281.90	4.7%	RI	142.2	3,005.10	4.7%
IA	430.1	6,351.20	6.8%	SC	504.9	7,422.00	6.8%
KS	425.6	4,718.50	9.0%	SD	140.6	1,010.80	13.9%
KY	469.6	9,165.90	5.1%	TN	607.5	9,578.90	6.3%
LA	576	9,219.50	6.2%	TX	2,259.60	29,838.30	7.6%
ME	224.2	3,235.90	6.9%	UT	335.3	5,543.50	6.0%
MD	752.8	12,462.50	6.0%	VT	91	1,472.80	6.2%
MA	685.5	17,087.90	4.0%	VA	880.9	15,638.00	5.6%
MI	1,070.00	22,242.50	4.8%	WA	952.5	13,988.20	6.8%
MN	647.3	15,818.00	4.1%	WV	311.6	3,904.20	8.0%
MS	435	5,096.20	8.5%	WI	957.1	11,396.70	8.4%
MO	749.2	9,862.80	7.6%	WY	82.5	1,506.10	5.5%
				Average state			6.1%

**: Millions of Dollars*
(Perez, 2008)

The data is for 2005, the most current year available to the authors. Also, some states list all motor fuel tax revenue, while some break it down by gasoline and diesel. Therefore, in some cases, the percentage of tax revenue accounted for by gasoline tax is slightly overstated. However, the majority of motor fuel revenue is made up of the gasoline tax, so the error is not significant. What this table illustrates is that gas tax revenues contribute an average of over six per cent to total state tax revenues. While the vast majority of states earmark this revenue for road and highway infrastructure, some states will divert this revenue for other uses. If the revenue from the gas tax is not sufficient to keep up with a state's necessary expenditures for surface infrastructure, then additional revenue must be diverted from other sources, much like the federal government has had to do in the recent past.

Each state will experience large deficits due to two main factors: escalating maintenance and infrastructure costs that are the result of more future miles driven and less revenue due to a decrease in gallons purchased. Miles driven in the U.S. continue to increase and recently surpassed 3 trillion miles (Federal Highway Administration, 2016). Normally, gas tax revenue would increase at a similar rate, which would offset the new infrastructure and higher maintenance costs but as noted in the literature review, cars must become approximately 66 per cent more efficient to meet the 2025 CAFE standards while trucks must become approximately 36 per cent more efficient. Moreover, vehicles have generally exceeded the standards by approximately 7.6 per cent (cars) and 2.9 per cent (trucks). This research estimates a cumulative shortfall of approximately 259.2 billion dollars by 2050 in tax revenue at the state level if tax rates remain the same. By 2050 the annual state tax shortfall is estimated to be between 10.4 billion dollars and approximately 16.0 billion dollars with the average estimated at 13.2 billion dollars, which is the largest amount for all years and will continue to grow as older cars are retired.

To summarize the importance of these numbers, they can be compared to the data from Table 5. First, the state gas tax shortfall in 2050 alone would represent 42 per cent of the total gas tax revenue for all states in 2005. Second, the total cumulative shortfall from 2017 to 2050 is approximately 43 per cent of the total state tax revenue from all sources in 2005. Third, the cumulative shortfall from 2017 to 2050 is approximately 831 per cent of the total state gas tax in 2005.

There has been much discussion of late as to the deteriorating transportation infrastructure in our nation, including roads, tunnels, and bridges. President Trump seemed to be a champion of increased funding but attempted to cut the budget for the Department of Transportation severely. However, the highway trust fund was not affected, and Congress has not agreed to the cuts. There has also been interest in increasing the federal highway tax to fund transportation improvements. While no one has a crystal ball to forecast the future of funding, it is a certainty that more money will be needed to maintain and improve our infrastructure.

Even if there were a massive increase in federal funding, to take advantage of this money, the states would need their own source of matching funds. They are unable to tap the federal funds due to a lack of matching funds. Also, they still must construct and maintain their local streets and state highways. If their source of funding declines due to reductions in the number of gallons of gas purchased due to increased CAFE standards, then the states have very little options, none of which are good. They can divert money from other state uses by tapping their general fund. They may leave city streets and state highways in disrepair, or they can find other sources of revenue, such as increasing the state gas tax.

As cars continue to consume less fuel, it will be important to develop different methods of collecting funds to sustain and create new infrastructure. The current system has been shown to have limitations based on changing technologies and the move away from fossil fuels. Some studies already focused on taxes based on miles driven (McMullen, Zhang, and Nakahara, 2010; Parry, 2005), but more research needs to be accomplished at the state level for possible acceptance into both state and federal generation of revenue.

Although this research is novel in that it examines the shortfall for states it also has limitations. First, this research assumes that the current state taxes will remain the same. Recently, numerous states increased their state tax, and some of them for the first time in over two decades (Davis, 2017). As some of these states have doubled their state gas tax, it is likely this trend will continue to occur based on the numbers found in this research. Future research should perform an analysis on the most palatable approach to raising state gas taxes as the future shortfalls are not linear. For example, should a state raise its gas tax by one per cent each year, or should they increase it by 50 per cent every ten years?

Another limitation of this research is that it does not account for future technological changes that may decrease the cost of the maintenance of roads or new construction of roads. There have been major advancements in maintaining a road both regarding time as well as longevity, and equating these changes into this research could further refine the expected shortfall.

This research is not intended to be a doomsday predictor. Rather, it is a warning to states, and the federal government, that alternative sources of revenue must be investigated to mitigate the unintended consequences of the increasing CAFE standards. This will have serious impacts on all users of the US highway and road system.

REFERENCES

American Petroleum Institute. (2017). Motor Fuel Taxes.

Annual Energy Review. (2011). *U.S. Energy Information Administration*, Vol. EIA-0384.

Armstrong, J., Green, K., & Graefe, A. (2015). Golden rule of forecasting: Be conservative. *Journal of Business Research*, 68(8), 1717–1731.

Austin, D., & Dinan, T. (2005). Clearing the air: The costs and consequences of higher CAFE standards and increased gasoline taxes. *Journal of Environmental Economics and Management*, 50(3), 562–582.

Congressional Budget Office (CBO). (2012, May). How Would Proposed Fuel Economy Standards Affect the Highway Trust Fund ? 76, 1–10.

Consumerreports.org. (2017). How to Make Your Car Last 200,000 Miles - Consumer Reports. *Consumer Reports*.

Council National Research. (2002). Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards. *National Academies Press Science.*

Davis, C. (2017). Gas Taxes Will Rise in 7 States to Fund Transportation Improvements – ITEP. *Institute on Taxation and Economic Policy*.

Dutta, U., & Patel, N. (2012). *The Impact of Energy Efficient Vehicles on Gas Tax (Highway Trust Fund) and Alternative Funding For Infrastructure Construction, Upgrade, and Maintenance*.

Federal Highway Administration. (2016). *Alternative Fuels Data Center: Maps and Data*, available at: https://www.afdc.energy.gov/data/ (accessed 18 July 2017).

FHWA. (2015). *Highway Statistics*, Washingont, DC, available at: Federal Highway Administration.

Greene, D. (2010). *How Consumers Value Fuel Economy : A Literature Review How Consumers Value Fuel Economy*.

Greene, D., & Liu, C. (2012). *Peer Review for the Consumer Vehicle Choice Model and Documentation, Report*.

Grundler, C., Quality, A., & Agency, U.S.E.P. (2015). LIGHT-DUTY VEHICLE GREENHOUSE GAS STANDARDS : 2025 AND BEYOND.

Helfand, G., Revelt, J-M., Reichle, L., Bolon, K., McWilliams, M., Sha, M., Smith, A., et al. (2015). *Searching for Hidden Costs : A Technology - Based Approach to the Energy Efficiency Gap in Light - Duty Vehicles Draft Searching for Hidden Costs : A Technology - Based Approach to the Energy Efficiency Gap in Light - Duty Vehicles*.

Kargul, J., Moskalik, A., Barba, D., Newman, K., & Dekraker, P. (2016). Estimating GHG Reduction from Combinations of Current Best-Available and Future Powertrain and Vehicle Technologies for a Midsized Car Using EPA's ALPHA Model. *SAE Technical Papers*, Vol. April No. August 2012, p. 16.

MacKenzie, D., & Heywood, J.B. (2015). Quantifying efficiency technology improvements in U.S. cars from 1975–2009. *Applied Energy*, 157, 918–928.

McMullen, B., Zhang, L., & Nakahara, K. (2010). Distributional impacts of changing from a gasoline tax to a vehicle-mile tax for light vehicles: A case study of Oregon. *Transport Policy*, 17(6), 259–366.

NHTSA. (2016). *Midterm Evaluation of Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards for Model Years 2022-2025*.

Parry, I.W. (2005). Is Pay-as-You-Drive insurance a better way to reduce gasoline than gasoline taxes?" *American Economic Review*, Vol. 1 No. May, pp. 288–93.

Perez, A. (2008). *Earmarking State Taxes*.

Small, K., & Hymel, K. (2014). *Peer Review for the Report "The Rebound Effect from Fuel Efficiency Standards : Measurement and Projection to 2035", Peer Review for the Report "The Rebound Effect from Fuel Efficiency Standards: Measurement and Projection to 2035"*.

U.S. EIA. (2012). *Annual Energy Review 2011*, *U.S. Energy Information Administration*, available at:https://doi.org//EIA-1384(2011).

U.S. Federal Register. (2011). *Federal Register*, 76(231), 75123–75128.