HUMPHREY SCHOOL OF PUBLIC AFFAIRS
UNIVERSITY OF MINNESOTA

Distance-Based User Fee: Financial Analysis and Rate Setting

FINAL REPORT

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October 2021

Published by:

Minnesota Department of Transportation
Office of Research & Innovation
395 John Ireland Boulevard, MS 330
St. Paul, Minnesota 55155-1899

DEPARTMENT OF TRANSPORTATION

Acronyms

DBF	Distance-Based Fee
DOR	Department of Revenue
EV	Electric Vehicle
HEV	Hybrid Electric Vehicle
ICE	Internal Combustion Engine
MFT	Motor Fuel Tax
MnDOT	Minnesota Department of Transportation
MPG	Miles per Gallon
SM	Shared Mobility
TH	Trunk Highway
VMT	Vehicle Miles Traveled

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1. Introduction

The current funding system for surface transportation may no longer be sustainable due to its reliance on motor fuel taxes. The continued growth of vehicle fuel efficiency, alternative energy sources, and inflation will reduce the ability of the motor fuel tax to reliably generate future revenues to fund transportation needs. To address the current and future fiscal challenges posed by the potential decline in fuel tax revenues, several national commissions and expert groups have begun to examine alternative funding sources such as distance-based fees (DBFs) as a potential long-term replacement for the motor fuel tax.

In a DBF system, users pay a fee based on vehicle miles traveled (VMT) – which are a proxy for the usage of the roadway system. Several states across the United States are examining the implementation of DBFs, with Oregon and Utah leading their implementation.[1] The Minnesota Department of Transportation is currently conducting a DBF demonstration in collaboration with two shared mobility providers. This demonstration aims to develop an alternative transportation funding strategy, ensuring the long-term solvency of the state highway fund.

In this report, we lay out a framework for DBF pricing schemes and discuss potential DBF rates. We consider pricing schemes for DBF that conceptually divide the fee into three key components: a baseline fee, efficiency add-ons fees, and other adjustments. The baseline fee is such that, in the short run, DBF revenues equal those from the current motor fuel tax levied by the State of Minnesota. In this way, the pricing scheme would ease a transition from the motor fuel tax system to the DBF system. In the long run, the rate structure has the potential to catch up with increasing long-term transportation needs, through indexing, periodical updating, or some combination of both. The baseline fee could be further augmented with efficiency add-ons and other adjustments to account for additional policy considerations, such as environmental or social-equity concerns and vehicle size/weight. To illustrate some of these issues, we conduct financial analysis with data from shared mobility partners and provide examples of multiple rate-setting options. Actual pricing decisions -regarding how the baseline rate is selected, what efficient add-ons to incorporate, and what additional adjustments to put in place- are ultimately made by policymakers.

This report is organized as follows. Section 2 provides an initial approach to the DBF pricing scheme. Section 3 presents a financial analysis based on the data provided by the demonstration partners. Lastly, Section 4 presents technical notes regarding the data shared by SM providers.

[1] Oregon allows light-duty passenger vehicles registered in Oregon including fuel-powered, electric, and hybrid vehicles in the program; while in Utah, the program is offered to owners of EVs, plug-in hybrid, and gas hybrid vehicles instead of paying a flat fee for alternative fuel vehicles during their annual registration.

2. Pricing Scheme for DBF: An Initial Approach

The proposed framework for DBF pricing aims to ease the transition from the motor fuel tax system to the DBF system and includes three components: a baseline fee, efficiency add-ons fees, and other adjustments. The baseline fee is designed so that, in the short term, it generates the same amount of DBF revenues as the current motor fuel tax. In the long run, the rate structure has the potential to catch up with long-term transportation needs, through indexing, periodical updating, or some combination of both. The baseline fee could be further augmented with efficiency add-ons and other adjustments to account for additional policy considerations.

2.1. Baseline Rate

As a starting point, the DBF baseline rate is based on the average cost of a mile of travel for vehicles in the state based on MFT receipts. We set the baseline rate by computing the charge per mile traveled that generates the same revenue as the motor fuel tax, while covering the costs of administering the system. In some states, these revenues not only include the motor fuel tax paid for every gallon of fuel purchased, but also the proceeds from a fee levied on electric vehicles (EVs)-and hybrid vehicles- that account for the loss in motor fuel tax revenue. In addition to generating the same revenue, this baseline rate should also account for the of costs administering the DBF system. Revenues from other taxes such as sales taxes and registration taxes are not considered in this calculation since these revenue streams depend on the value of the vehicle (due to vehicle ownership), while motor fuel taxes reflect in a way the use of the roadway system (user fee).

The DBF baseline rate is equal to the total annual MFT revenues plus DBF administrative costs divided by total annual VMT:

$$DBF_t = \frac{MFT\ revenues_t + AdminCost_t}{VMT_t}$$

In the formula for the state of Minnesota, *MFT revenues* stands for the total motor fuel tax proceeds[2] and the proceeds from the $75 annual surcharge levied on fully electric vehicles;[3] *AdminCosts* is the additional cost of administering the DBF system; and VMT refers to total vehicle miles traveled in the state. All of them considered in a given year (t).

This report presents two methods to calculate the baseline DBF rate. First, assuming all VMT contribute the same amount of MFT revenue regardless of the vehicle type (light vs heavy vehicles). Second, assuming a different contribution on MFT revenue from miles traveled by different types of vehicles. This method is more realistic as heavy vehicles use much more fuel per mile than light vehicles, and therefore, pay more motor fuel tax per mile. However, given that detailed data is not available for the calculations, several assumptions have to be considered.

Method I: All VMT contribute the same MFT revenue

Table 2-1 presents annual MFT revenues, annual VMT, and annual revenues from the EV fee in the State of Minnesota, as well as the calculations for baseline DBF rates between 2015 and 2019. The calculations of the baseline DBF rate in the table consider DBF administrative costs similar to the costs of administering the current motor fuel tax system, which are 0.25 percent of the total revenue collected in Minnesota (MMB, 2021).[4] This is a conservative assumption but implies a lower bound of the DBF rate.

[2] The state of Minnesota has a motor fuel tax rate of 28.5 cents per gallon of fuel regardless of the type of fuel. This tax was last raised in 2008. In 2019 the House File 1555 failed to pass the Senate. The bill proposed a 20-cent gas increase phased in over four years and could have indexed the gas tax for inflation on an annual basis after the completion of the phase-in. In Minnesota, the administrative costs of the motor fuel tax are paid out of motor fuel tax revenues.
[3] The fee was effective on January 1, 2018. In 2019 the Senate File 1093 proposed a $200 annual surcharge for all-electric vehicles and a $100 annual surcharge for plug-in hybrid electric vehicles. The bill failed to pass.
[4] Amount based on administrative expenses of $2.194 million and revenue collection of $878.2 million for FY2020.

Table 2-1: Baseline DBF rate for the State of Minnesota – Method I

Year	VMT (1)	MFT (thousands) (2)	EV fee (thousands) (3)	Admin. Costs (thousands) (4)	DBF (¢/VMT)
2015	58,124,883,776	$888,000	-	$2,238	¢1.532
2016	58,856,547,322	$899,000	-	$2,265	¢1.531
2017	59,970,745,402	$911,000	-	$2,296	¢1.523
2018	60,438,313,272	$926,000	$196	$2,334	¢1.536
2019	60,730,981,154	$938,000	$399	$2,364	¢1.549

Notes: *(1) 2015 VMT calculated by authors as the 2014-2016 average. (2) Gross revenues. (3) Calculated by authors as the number of electric vehicles registered multiplied by $75. (4) Calculations assuming DBF administrative costs similar to the costs of the MFT system.* ***Source:*** *Author's calculations. Data from the Minnesota Transportation Finance Database, MnDOT, and Drive Electric Minnesota.*

The literature estimates the costs of administering a DBF system to be higher than the costs of administering the motor fuel tax. Table 2-2 presents the DBF rate for 2019 considering different administrative costs for the DBF system including the baseline administrative costs of 0.25 percent (the current costs of collecting the MFT in Minnesota) and the cost of administering a DBF system estimated by several pilot programs implemented across the U.S., which are estimated to be between 5 and 15 percent of revenue collected (CalSTA, 2017; ODOT, 2017; WSTC, 2020).

Table 2-2: Baseline DBF rate considering Different Administration Costs

Admin Costs (% of MFT revenue collected)	0.25%	5%	10%	15%
Admin Costs (in thousands)	$2,364	$46,900	$93,800	$140,700
DBF (cents per mile)	1.549	1.622	1.700	1.777

Overall, calculations for 2019 show that, on average, all vehicles in Minnesota contributed 1.55 cents per VMT through the motor fuel tax. In addition, if the administrative costs of a DBF system were 10 percent of the total revenues collected, the baseline rate would increase to 1.7 cents per VMT. These rates are similar to the estimated rates initially used in the pilots explored in Oregon (¢1.5 in 2015), California (¢1.8 in 2017), and Colorado (¢1.2 in 2017).[5]

[5] As of 2021, the OReGO program charges ¢1.8 per VMT and the Utah Road Usage Charge charges ¢1.5 per VMT. These two programs are actually collecting revenues from the DBF system.

Method II: VMT contribute different MFT revenue depending on the type of vehicle

This second method to calculate the baseline DBF rate takes into consideration that heavy vehicles use much more fuel per mile than light vehicles, and therefore, contribute more per mile in motor fuel tax. However, detailed data regarding the gallons of fuel consumed and the amount of VMT driven by heavy and light vehicles is limited, and several assumptions are made to calculate the baseline DBF rate. First, heavy vehicles' VMT represents around 8 percent of total VMT driven in the Trunk Highway (TH) route system (MnDOT, 2020).[6] Researchers, with the help of MnDOT staff, assumed that total VMT driven by heavy vehicles in the non-Trunk Highway system[7] was around 4 percent – half the percentage driven in the TH system. These percentages are similar to national trends estimates (FHWA, 2019). Second, there is no information regarding the motor fuel tax contributed by vehicle type. Therefore, it is assumed that light vehicles contribute motor fuel tax paid for the gallons of gasoline consumed, and heavy vehicles contribute motor fuel tax paid for the gallons of special fuels consumed.[8] According to this assumption, of the total revenues from the motor fuel tax, around 80 percent are contributed by light vehicles and 20 percent by heavy vehicles (DOR, 2021).

Table 2-3 presents annual MFT revenues and annual VMT by vehicle type, as well as the calculations for baseline DBF rates between 2016 and 2019. The calculations of the baseline DBF rate in the table consider administrative costs similar to the costs of administering the current motor fuel tax system.

[6] VMT in the Trunk Highway system account for around 60 percent of total VMT. The Trunk Highway route system includes interstates, U.S. highways, and MN highways (for these last two routes it includes both numbered and non-numbered roads).
[7] VMT in the non-Trunk Highway system account for around 40 percent of total VMT. Non-Trunk Highway routes include county state-aid highways, municipal state-aid streets, county roads, municipal streets, township roads, state forest and park roads, and Indian Reservation roads.
[8] Special fuels refer to diesel (Minnesota Department of Revenue, 2021; Minnesota Department of Revenue, 2019). In Minnesota, the tax rate for diesel fuel is 28.5 cents per gallon (Department of Revenue, 2021).

Table 2-3: Baseline DBF rate for the State of Minnesota – Method II

	Light Vehicles			Heavy Vehicles		
Year	**VMT**	**MFT (1) (2)**	**DBF (¢/VMT)**	**VMT**	**MFT (1)**	**DBF (¢/VMT)**
2016	55,070,990,370	$720,621,953	1.31	3,785,556,953	$180,643,527	4.77
2017	56,149,884,399	$730,240,933	1.30	3,820,861,003	$183,054,787	4.79
2018	56,594,880,703	$742,461,203	1.31	3,843,432,569	$186,068,861	4.84
2019	56,708,570,730	$752,283,946	1.33	4,022,410,424	$188,480,120	4.69

Notes: *(1) The amount includes DBF administrative costs similar to the current costs of the MFT system. (2) The amount includes revenues from the EV fee, calculated by authors as the number of electric vehicles registered multiplied by $75.* ***Source:*** *Author's calculations. Data from the Minnesota Transportation Finance Database, MnDOT, DOR, and Drive Electric Minnesota.*

Table 2-4 presents the DBF rate for 2019 for light vehicles considering different administrative costs for the DBF system.

Table 2-4: Baseline DBF rate for Light Vehicles considering Different Administration Costs

Admin Costs (% of MFT revenue collected)	**0.25%**	**5%**	**10%**	**15%**
Admin Costs (in thousands)	$1,875	$37,500	$74,999	$112,499
DBF (cents per mile)	1.327	1.389	1.456	1.522

Although the baseline rate is designed to be equivalent to the MFT, users will experience a change in their tax payments. Under a scenario where the two systems are in place and the motor fuel tax is credited for DBF payment, users of fuel-efficient, hybrid, and electric vehicles will experience an increase in their tax payments, while users of less fuel-efficient vehicles might experience a potential reduction their tax payments. In the long-term, when only a DBF is charged, users' tax payments will depend on their VMT regardless of their fuel consumption.

A flat baseline fee per mile traveled may ease the transition from the motor fuel tax system to the DBF system. According to other pilots implemented across the U.S., a flat fee per mile is simple for drivers to understand and easy to implement. These characteristics also make the system easy to comply with, and facilitate collection, audit, and enforcement from state agencies, further reducing administrative costs. However, the flat fee concept raises significant equity concerns as it creates winners and losers.

A flat charge per mile traveled also raises several efficiency and environmental equity concerns. On one hand, a flat rate assumes that all vehicle miles traveled cause the same impacts, but they may differ in terms of vehicle type (such as light-duty vs heavy-duty vehicles), vehicle occupancy, and time of travel (peak vs non-peak hours) among others. On the other hand, the rate does not reflect the environmental impacts of the vehicle's power source (fuel vs electricity). To address these limitations, the baseline rate could be augmented with efficiency add-ons and other adjustments. These adjustments are discussed in the next subsections.

2.2. Efficiency Add-Ons

The DBF rate could be adjusted to account for the impact of different vehicle types on the roadway system as well as to address congestion problems. This subsection discusses vehicle-dependent surcharges and congestion fees to address these impacts.

Vehicle-dependent surcharges and congestion fees may promote an efficient use of the roadway system. However, future research would be needed to assess the benefits and costs of their implementation, as well as the trade-offs that may exist. For instance, as more variables are needed for the design of the DBF rate, more detailed data would be needed from the vehicle. Individual users may benefit from a more accurate payment for their use of the roadway system, but it may bring up data protection and privacy concerns. In addition, additional data points might increase the costs for the government agency that collects, audits, and enforces the DBF system.

Vehicle-Dependent Surcharge – The deterioration of the roadway system is caused by many factors including traffic, pavement materials, the environment, and vehicle weight (Wilde, 2014). Vehicle weight could be an appropriate measure to adjust the baseline rate and there are several ways to account for it including the weight of the vehicle, the weight of the vehicle with occupants or loads (e.g., maximum capacity, average occupancy weight, etc.), and the distribution of weight across axles among others. In addition, these could be considered by groups of vehicles (e.g., light-duty & heavy-duty vehicles) or by vehicle categories (sedans, SUVs, pickups, vans, buses, and types of trucks).

To illustrate the vehicle dependent surcharge for the state of Minnesota, we consider the Equivalent Single Axle Load (ESAL) factors and the pavement damage costs as follows:

$$DBF_{VD} = ESAL\ factor * pavement\ damage\ costs$$

The ESAL is a measure of the damage to the pavement incurred by vehicle loads. In particular, it establishes a pavement damage relationship for axles carrying different loads (Peterson, 2011; Wilde, 2014).[9] In addition, we used the estimates of Zhao & Wang (2015) for the pavement damage costs. The authors estimate that these costs vary between $0.005 to $0.04 per ESAL-mile. We used an average of $0.03 for the calculations. Table 2-5 provides the ESAL factor by vehicle type and the vehicle-dependent surcharge.

Table 2-5: Comparison of vehicle impacts to the roadway system by vehicle type

	Vehicle Type	ESAL Factor			Vehicle Dependent Surcharge (¢/VMT)
		Concrete	Asphalt	Average	
1	Motorcycle	0.0007	0.0007	0.0007	0.00
2	Car	0.0007	0.0007	0.0007	0.00
3	Van/Pickup	0.0052	0.0052	0.0052	0.02
4	Bus, truck with trailer	0.74	0.57	0.66	1.97
5	2 axle single unit	0.24	0.25	0.25	0.74
6	3 axle single unit	0.90	0.61	0.76	2.27
7	4+ axle single unit	0.90	0.61	0.76	2.27
8	3 & 4 axle semi	0.61	0.60	0.61	1.82
9	5 axle semi	1.64	0.99	1.32	3.95
10	6+ axle semi	0.83	0.69	0.76	2.28
11, 12, 13	Twin Trailer Semi	3.06	3.15	3.11	9.32

***Notes:** Author's calculations. **Source:** ESAL Factor from Peterson (2011) and Wilde (2014).*

The higher the impact of the vehicle on the roadway system, the higher the vehicle-dependent surcharge needed to cover the damage to the transportation infrastructure. Motorcycles and passenger vehicles are selected as the base category and would not pay the vehicle-dependent surcharge. Vans and pickups would pay an additional fee of ¢0.02 per mile traveled to account for the additional roadway damage they impose on the system. This means that in total, per mile traveled, passenger vehicles would contribute the baseline rate, while vans and pickups contribute the baseline rate plus ¢0.02 – which represents a difference of around one percent per mile traveled.

[9] Peterson (2011) provides estimates of the ESAL factor for concrete and asphalt pavements for the 13 types of vehicles in Minnesota. These estimates are similar to those provided by Wilde (2014). These authors, however, differ in the ESAL factor assigned to passenger cars and van/picks. We consider this difference in our calculations.

Depending on the implementation of the surcharges, it might be necessary to revise the baseline fee. A lower fee might be in order as surcharges cover more of the infrastructure costs, targeting the payments to the vehicles that do the most damage to roads.

Approaching the vehicle-dependent surcharge in the form presented above may create additional concerns. For instance, all vehicles grouped in each category are assumed to have the same impact on the roadway system regardless of their actual occupancy/load and vehicle class. One example of this is the great variation in vehicles categorized as car or passenger vehicles, which group compact vehicles, sports vehicles, SUVs, and full-size SUVs among others. However, these differences might not be significant enough to require different pricing.

Congestion fee – Congestion creates externalities that are not reflected in travelers' out-of-pocket costs. Costs associated with congestion include the increase in travel time unreliability; excess fuel usage; increased emissions and environmental damage; higher accident rates and safety costs; higher inventory, maintenance, and operating costs; and loss of productivity (HDR, 2009). In order to develop a DBF system that is efficient and accounts for all costs, the state might consider a congestion-based efficiency adjustment.

Congestion pricing schemes are currently applied in different settings (Federal Highway Administration, 2008). A combination of a baseline DBF rate and congestion pricing may address congestion problems, address rural/urban inequities, and increase the efficiency of road usage. In particular, the congestion fee could vary by time of day or by timeframes (for example, peak and non-peak hours) and be implemented on a limited number of lanes of a roadway (leaving other travel lanes unpriced), or on all lanes of a roadway, or a specific zone. Across the U.S., several states are already familiar with congestion pricing schemes through toll-managed lanes programs, for instance.[10]

2.3. Other adjustments

The DBF rate or the DBF system could be adjusted to address environmental and social impacts. This subsection discusses environmental and income-based adjustments that could be used to address these impacts.

Environmental Adjustment – There is a growing interest regarding the burden of DBFs on owners of alternative-fuel vehicles (e.g., hybrid and electric vehicles). Owners of these vehicles, for instance, contribute relatively less than internal combustion engine (ICE) vehicles through

[10] In Minnesota, for instance, the E-ZPass (previously called MnPASS) provides travel options to busy weekday commuting hours (6-10 am and 3-7 pm) by providing a dedicated lane that free for high occupancy vehicles (HOV), buses and motorcycles, and requires a fee for single occupant vehicles (SOV). The fee is based on traffic levels, the heavier the traffic, the higher the price. The fee ranges between $0.25 and $8 (MnDOT, 2021).

the motor fuel tax. Their contributions, however, could be relatively higher with regards to other roadway funding sources, such as vehicle sales tax or registration fees, due to vehicles' commercial value, which tends to be higher compared to ICE vehicles.

Many focus group participants in several studies indicated their concern about the additional burden of the DBF systems on owners of alternative-fuel vehicles. According to research findings, a DBF system would impose a penalty on those users who cause less environmental damage (Weatherford, 2012; Agrawal, Nixon, & Hooper, 2016). Other studies note that a DBF system may discourage ownership of hybrid or other fuel-efficient vehicles rate (Zhang, McMullen, Vallury, & Nakahara, 2009; Weatherford, 2012). According to them, it is believed that owners of hybrid or fuel-efficient vehicles would pay more than individuals with fuel-inefficient vehicles. However, this may be addressed by setting DBFs rates so that those with fuel-efficient vehicles pay less (Zhang, McMullen, Vallury, & Nakahara, 2009).

A potential adjustment to the DBF rate includes a transitional tiered rate based on the vehicle powertrain. In this structure, the rates could be lower for electric and hybrid vehicles than for ICE vehicles. The tiered-rate system, in the short term, would account for the environmental benefits of alternative-fuel vehicles. The lower rates for electric and hybrid vehicles could be gradually increased over a period of time (between 5 and 10 years), considering the increasing adoption of hybrid and electric vehicles. After the transition period, all VMT would be charged at a specific rate regardless of vehicle powertrain.

Other potential adjustments to the DBF system include short-term and long-term adjustments. Short-term adjustments include providing credits or discounts to owners of hybrid and electric vehicles during a transition period (5 to 10 years), which could be gradually reduced considering the increased adoption of these vehicles. Long-term adjustments could include adding a surcharge in addition to the DBF to account for the environmental impact of the vehicle; either a surcharge based on vehicle emissions or type of vehicle, or continue charging the motor fuel tax but at a lower rate.

Income-Based Adjustment – Studies focused on the motor fuel tax system have found that the burden the motor fuel tax imposes on low-income individuals is higher than the burden on high-income individuals (Poterba, 1991; Williams, 2007). For instance, according to Williams (2007), Americans earning less than $10,000 on an annual basis paid 2.5 percent of their income in gas tax, while those earning $150,000 or more paid about 0.2 percent. With the potential of implementing DBF systems, there is growing interest in designing a less regressive and socially equitable system. Two potential adjustments have been discussed. The first is to provide credits or subsidies to low-income drivers. The subsidy could be provided to drivers that already qualify for another income-based program. The second approach is to charge travelers based on their income level, for instance, based on the submission of income tax returns.

3. Financial Analysis

The Minnesota Department of Transportation (MnDOT) partnered with two shared mobility (SM) providers to demonstrate a Distance-Based Fee system in the state of Minnesota. The collaboration with SM providers not only contributes to improving the administrative and political feasibility of a DBF system,[11] but also provides a useful context to study the future of transportation funding.

Vehicles in the SM providers' fleet are different from the average vehicles currently used in the State of Minnesota. SM providers not only have internal combustion engine (ICE) vehicles that are relatively new and therefore more fuel-efficient than the average vehicle in Minnesota,[12] but they also have and are adopting alternative energy source vehicles.[13] These factors are particularly relevant as they are closer to what the characteristics of the State fleet will be in the coming years.

This section presents simulations of the SM providers' contributions to the roadway system under the current motor fuel tax system and a hypothetical distance-based fee system at the State level.

Data and Assumptions

Each SM provider shared two datasets for the analysis. The first dataset reported monthly fuel purchases and total gallons of gas purchased linked to fuel cards attached to a vehicle. The second dataset reported the miles traveled of each of SM providers' vehicles, along with some vehicle information such as model, make, and year. Both datasets were monthly and covered data between April 1, 2020, and March 31, 2021. As part of this study, we merged these datasets by pairing gas purchases to specific vehicles whenever possible.

[11] With this collaboration there is potential for higher administrative feasibility as SM providers already use existing in-vehicle technologies and reduce collection points. Similarly, there is potential for higher political feasibility since SM providers already have systems or policies in place that could address privacy and data protection concerns.
[12] The current average age of vehicles in Minnesota is 11.8 years (Alliance for Automotive Innovation, 2021), which relates to an average vehicle fuel-economy of 23.5 (EIA, 2021), while the SM providers' fleet has an average vehicle fuel-economy of 31.
[13] During the demonstration, the fleet included hybrid vehicles. In addition, SM providers may have considered converting their fleet to a fully electric fleet.

The fleet of shared mobility providers reported VMT and gallons of fuel purchased during the twelve months of the demonstration. VMT correspond to miles traveled during customers' reservations and by SM provider staff to support services offered. To prevent double-counting VMT from reservations that started in one month (*t*) and ended in the following month (*t+1*), VMT were capture from reservations that ended in a particular month. As SM providers could not identify the miles driven in Minnesota from those out-of-state, all VMT are assumed to be driven in the state of Minnesota. Similarly, all gallons of fuel purchased were included in the analysis, including some transactions that occurred in Wisconsin (accounting for 0.9 percent of the total gallons reported). Duplicated observations -same transactions reported in two different months- were deleted from the sample to prevent double counting. Outlier observations were also deleted. Overall, the fleet of shared mobility providers reported 529,076 VMT and 17,819 gallons of fuel purchased during the twelve months. Table 3-1 presents VMT and gallons of fuel purchased aggregated per month.

Table 3-1: Monthly VMT and Gallons of Fuel Purchased

Month	VMT	Gallons of Fuel
Apr-20	27,018	1,128
May-20	42,885	1,496
Jun-20	49,065	1,436
Jul-20	63,752	1,858
Aug-20	58,079	1,849
Sep-20	56,771	1,440
Oct-20	52,770	1,814
Nov-20	43,427	1,446
Dec-20	42,858	1,501
Jan-21	29,797	1,066
Feb-21	8,466	959
Mar-21	54,187	1,827
Total	**529,076**	**17,819**

With vehicle information provided by SM providers, researchers created new variables to conduct the analysis. In particular, researchers created a variable to capture the vehicle's powertrain. All vehicles in the sample were considered internal combustion engine (ICE) vehicles, except for some Toyota Prius that were considered hybrid (HYB) vehicles and a Chevy Bolt that was considered as an electric vehicle (EV). Table 3-2 presents the VMT and gallons of fuel purchased by vehicle powertrain. ICE vehicles drove 90.9 percent of the VMT and purchased 91.7 percent of fuel gallons. On average, an ICE vehicle drove 7,175 VMT and purchased 243.99 gallons of fuel, while a hybrid vehicle drove 6,037 VMT and purchased 143.92 gallons of fuel.[14]

Table 3-2: VMT and Gallons of Fuel Purchased by Vehicle Powertrain

Vehicle Type	VMT		Gallons of Fuel	
	Value	%	Value	%
ICE	480,733	90.9%	16,347	91.7%
HYB	48,299	9.1%	1,151	6.5%
EV	44	0.0%	-	0.0%
Vehicle not identified (1)	-	0.0%	320	1.8%
Total	**529,076**		**17,819**	

Notes: *(1) A SM provider reported gallons of fuel purchased with spare credit cards, which could not be traced back to a vehicle.*

Revenues from the motor fuel tax system and a hypothetical DBF system are calculated for the financial analysis. Revenues from the motor fuel tax system are calculated using the Minnesota motor fuel tax rate of 28.5 cents per gallon. Similarly, revenues from a hypothetical DBF system are calculated using rates identified in Section 2 under different scenarios. For this financial analysis, all VMT and all gallons of fuel purchased are assumed to be in the State of Minnesota. In a future implementation of a DBF system, however, the VMT and fuel purchases considered for the DBF payment, and a motor fuel tax credit would depend on the policies each state adopts.

3.1. Current Contributions through the State Motor Fuel Tax

During the twelve months, SM providers contributed $5,078.37 through the motor fuel tax - on average $423.20 per month (Figure 3-1). Given the miles reported by SM providers, researchers calculated an average motor fuel tax contribution of 0.96 cents per vehicle mile traveled. This contribution differs significantly between ICE and hybrid vehicles. Hybrid vehicles contribute almost half of what ICE vehicles contribute (0.68 and 0.97 cents per mile, respectively).

[14] Usage patterns per vehicle could be observed in Figure 4-3 (the figure presents an outlier that was not included in this analysis).

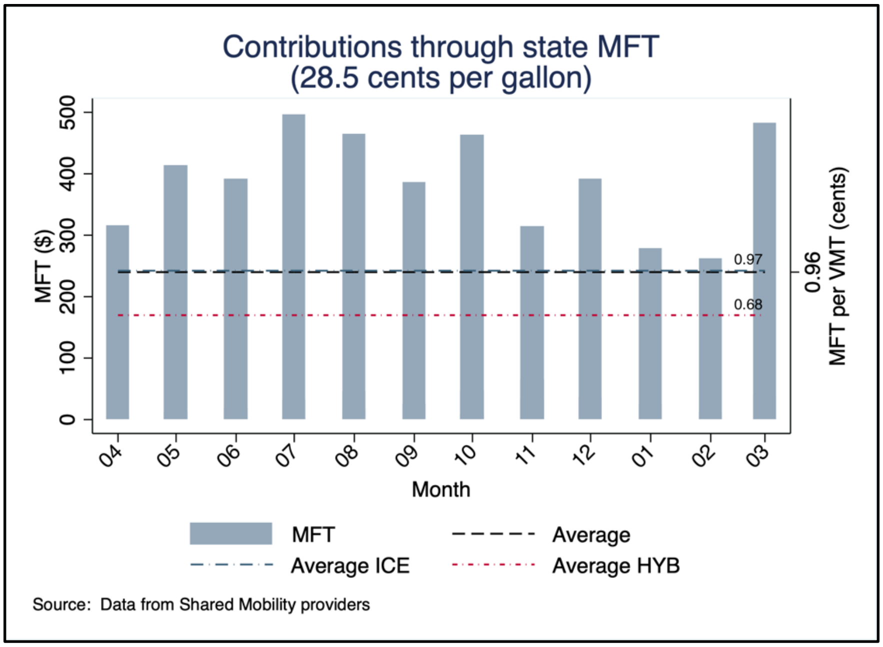

Figure 3-1: Total Contribution through State Motor Fuel Tax

Given fuel purchases and miles traveled by vehicle, it was possible to estimate the average fuel efficiency of ICE and hybrid vehicles. Researchers used these estimates to create hypothetical situations, assess changes in MFT revenues with increasing fuel efficiency, and their implications.

First, researchers assessed what would have happened if the SM providers' fleet were only composed of ICE vehicles or only composed of hybrid vehicles - similar to those used in the demonstration. Figure 3-2 presents the results. To travel the same VMT in a fleet composed of only ICE vehicles, the SM providers would have to use 17.36 percent more gallons than they actually used, and thus would have contributed more through the motor fuel tax (a total of $5,853). On the contrary, if the fleet were only composed of hybrid vehicles, the SM providers would have used 28.7 percent less gallons of fuel to drive the same amount of VMT, and thus their contribution through the motor fuel tax would have been much lower (a total of $3,554).

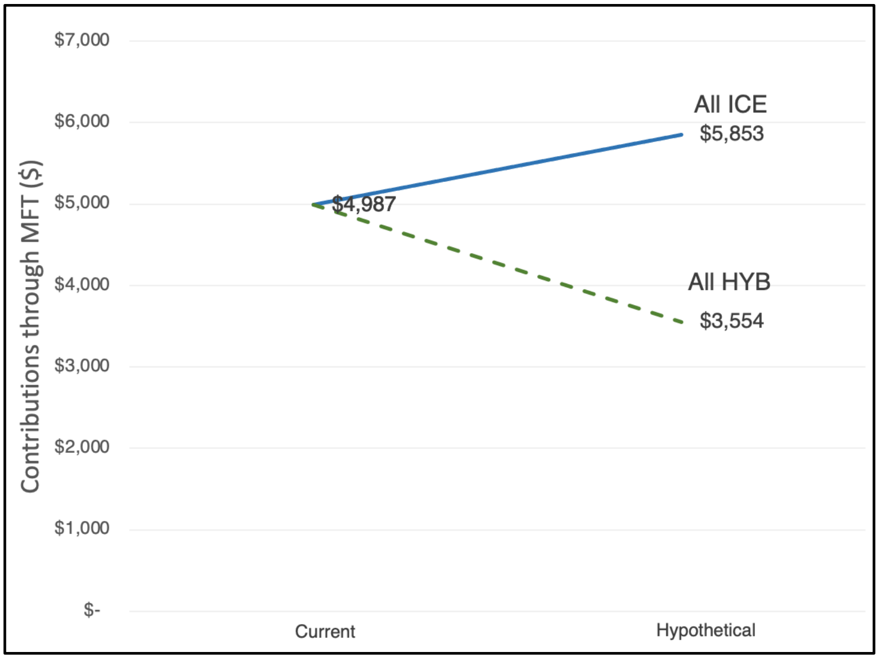

Figure 3-2: Potential SM providers' Contributions with Different Fleet Composition

Second, researchers assessed what would have happened if all vehicles in the state were as efficient as vehicles in the SM providers' fleets. We estimated the gallons of fuel needed to drive the current VMT driven at the state level (60,7 billion VMT) for a fleet of ICE vehicles and hybrid vehicles similar to those in the SM providers' fleet. The results are shown in Figure 3-3. If all the current state VMT would have been driven by a fleet of ICE vehicles, the revenue from the motor fuel tax would have decreased to $534 million, which represents a reduction of 43 percent. Similarly, if all the current state VMT would have been driven by a fleet of hybrid vehicles, the revenue from the motor fuel tax would have decreased to $378 million, which represents a reduction of 59.8 percent compared to current revenues.

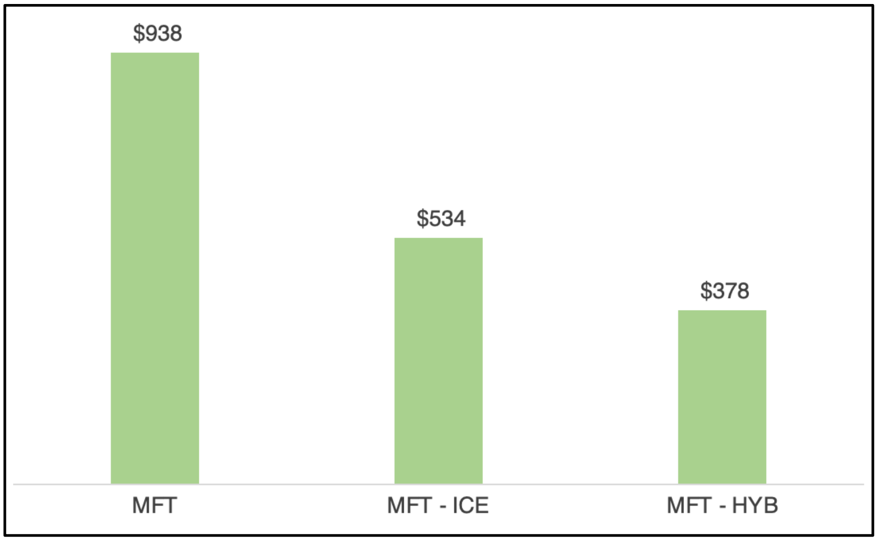

Figure 3-3: Potential MFT with changes in Vehicle Fuel-Economy (in millions)

Third, researchers assessed what would have happened if light vehicles in the state were as efficient as vehicles in the SM providers' fleets. We calculated the gallons of gasoline needed to drive the current VMT driven by light vehicles for a fleet of ICE vehicles and hybrid vehicles similar to those in the SM providers' fleet. For these estimates, we assumed that the MFT contribution of heavy vehicles would remain the same. Figure 3-4 shows the results. Similar to the previous scenario, the total revenues from the motor fuel tax would have decreased but at a lower rate. If the current VMT driven by light vehicles would have been driven by a fleet of ICE vehicles, the revenue from the motor fuel tax would have decreased 39.8 percent, while if the current VMT driven by light vehicles would have been driven by a fleet of hybrid vehicles, the revenue from the motor fuel tax would have decreased by 57.5 percent.

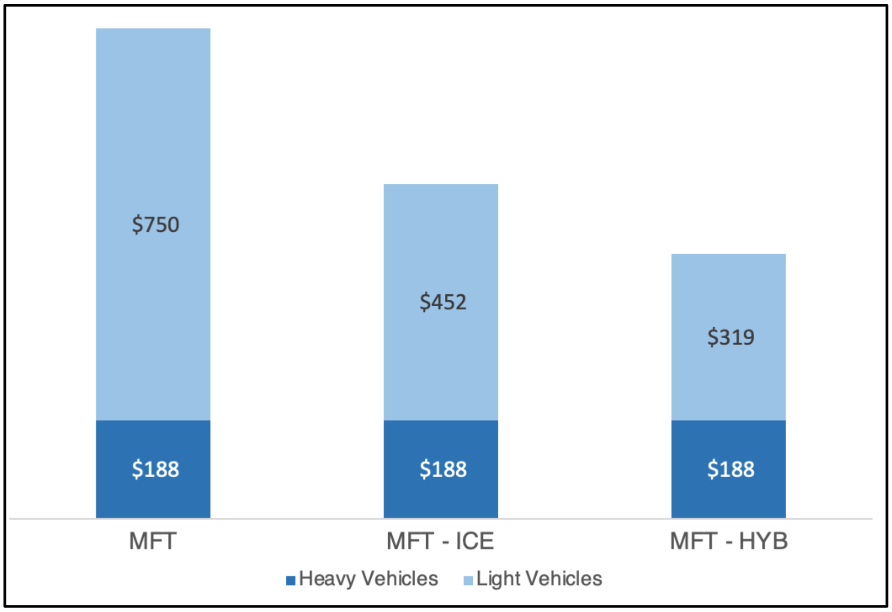

Figure 3-4: Potential MFT with changes in Vehicle Fuel-Economy of Light Vehicles (in millions)

The results shown in Figure 3-3 and Figure 3-4 only present what would have happened to the revenues from the motor fuel tax if VMT were driven by fuel-efficient ICE vehicles or hybrid. The inclusion of a portion of VMT driven by full-electric vehicles would have further reduced motor fuel tax revenues. However, the magnitude of the reduced amount is uncertain as we need to account for the $75 EV fee the EVs contribute to the system. Overall, this analysis highlights the role of increased fuel efficiency in determining the revenues from the current motor fuel tax. The reduction in revenues can be substantial even without hybrid or electric vehicles because of the impact of more fuel-efficient ICE vehicles.

There are several conversations regarding converting the current SM providers' fleet to an all-electric fee in near future. With the available data, researchers considered a fourth scenario to assess the revenues the government would have received if all the vehicles of the fleet would have been fully electric. Figure 3-5 presents the monthly contributions in MFT by SM providers' fleets and what would have been the monthly contributions from an EV fee for all vehicles. Overall, if it was an all-electric fleet, SM providers would have paid less than what they currently contribute to the roadway system through the MFT. On average, every vehicle would have contributed $6.25 every month through the EV fee, while currently contributing $7.42 through the MFT (that is 16 percent less every month).

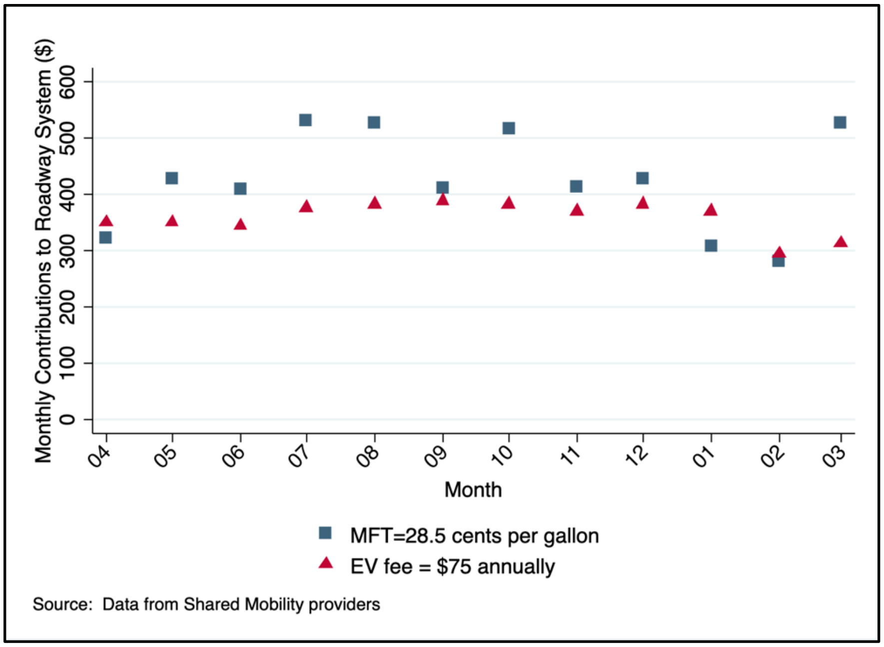

Figure 3-5: MFT Contributions vs Hypothetical Revenues from an All-Electric Fleet

During the twelve months, 62 vehicles reported VMT and fuel purchases.[15] If these vehicles were all-electric, they would not have contributed to the transportation system through the motor fuel tax, but they would have contributed through the $75 EV fee. Table 3-3 presents the results. Overall, these vehicles would have contributed a total of $4,650 in a year, which is 8.4 percent less of what they actually contributed through the MFT. With the current fleet, SM providers paid on average 0.96 cents per VMT. However, if the fleet was all-electric, SM providers would have paid, on average, 0.88 cents per VMT.

[15] A total of 76 vehicles reported information throughout the demonstration, however, some vehicles only appeared for one or two months and then were replaced with other vehicles. For the purposes of the calculation, we used the maximum number of vehicles reported in a month, that is 62 vehicles. Not all vehicles may have been used all months, but SM providers would have paid an annual fee of $75 for each of them.

Table 3-3: Current Revenues vs Hypothetical Revenues from an All-Electric Fleet

Current Scenario		All-EVs Scenario	
Number of vehicles	62	Number of vehicles	62
VMT	529,076	VMT	529,076
Gallons of fuel	17,819	Gallons of fuel	-
MFT revenue	$5,078	MFT revenue	$ -
EV-fee revenue	$ -	EV-fee revenue	$ 4,650
Price per mile (cents per mile)	0.96	Price per mile (cents per mile)	0.88

Difference in Revenue	-8.4%

These results suggest that the $75 fee EVs pay may be low to offset the loss in MTF revenue. According to the calculations, the EV fee would have to be $81.9 per vehicle (which represents an increase of 9.2 percent) to generate the same amount of revenue these vehicles contribute through the MFT.

3.2. A State DBF System with a Baseline Rate

This subsection presents the potential contributions under a DBF system considering the rates identified in Subsection 2.1. using the two different methods of calculation. While the first method assumed all VMT contributed the same amount in motor fuel tax, the second method assumed a different contribution from VMT driven by light and heavy vehicles. The data used in this section includes outlier observations as they were included in the revenue reports submitted by SM providers.

Figure 3-6 presents the current contribution of SM providers to the roadway system through the motor fuel tax as well as the potential contributions under a DBF system considering three different administrative costs and assuming that all VMT contribute the same amount in motor fuel tax. The first rate assumes administration costs equivalent to the motor fuel tax system (DBF_1); the second rate assumes administration costs equivalent to 5 percent of the revenue collected (DBF_5); and the third rate considers administration costs equivalent to 15 percent of the revenue collected (DBF_15). Overall, SM providers would have contributed between 60 and 90 percent more in a year under a DBF system compared to their contribution under the MFT. The monthly contribution to the transportation system would have been higher for all months, except for February[16] (month eleventh of the demonstration), when MFT contributions were higher than what they would have to pay under a hypothetical DBF system.

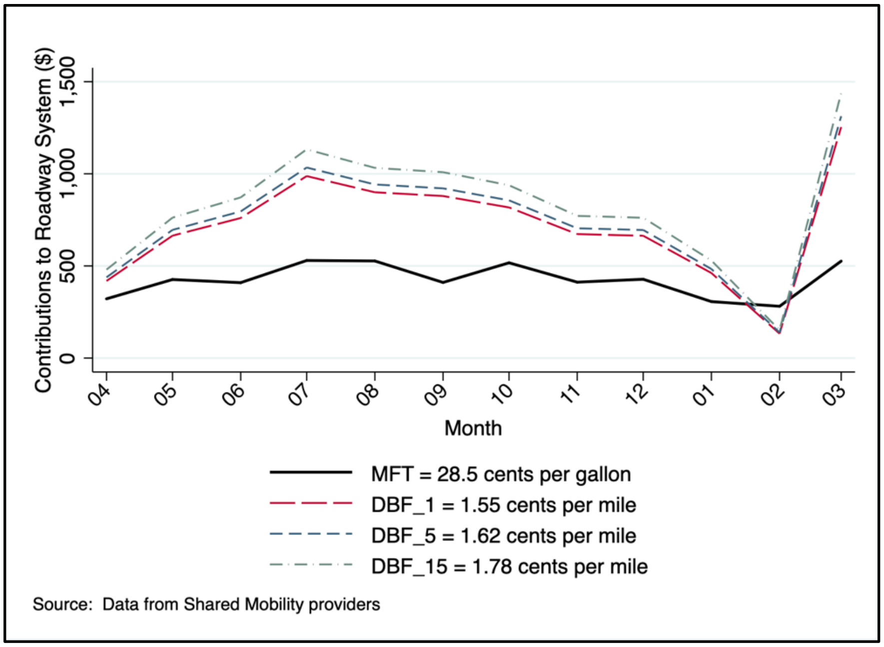

Figure 3-6: Potential Contributions through the MFT and a State DBF System (Method I)

Table 3-4 presents the SM providers' contributions, estimated administrative costs, and the net revenues available for highway purposes using the DBF rates identified by using the first method (Subsection 2.1).

Table 3-4: Hypothetical DBF Revenues - Method I

	MFT	DBF_1 (0.25% costs)	DBF_5 (5% costs)	DBF_10 (10% costs)	DBF_15 (15% costs)
SM Contribution	5,094	8,611	9,017	9,451	9,879
Change (base-MFT)		*69.0%*	*77.0%*	*85.5%*	*93.9%*
-Admin Costs	**13**	**22**	**451**	**945**	**1,482**
Highway Revenue	5,081	8,590	8,566	8,506	8,397
Change (base-MFT)		*69.0%*	*68.5%*	*67.3%*	*65.2%*

[16] During this month there was an issue in the reporting technology of a vehicle that prevented it from reporting the miles in February. It is possible that all miles traveled by the vehicle were reported in March.

The potential contributions under a DBF system with a different rate for light and heavy vehicles are presented in Figure 3-7. Under this scenario, SM providers would have contributed between 40 and 60 percent more in a year under a DBF system compared to their contribution under the MFT.

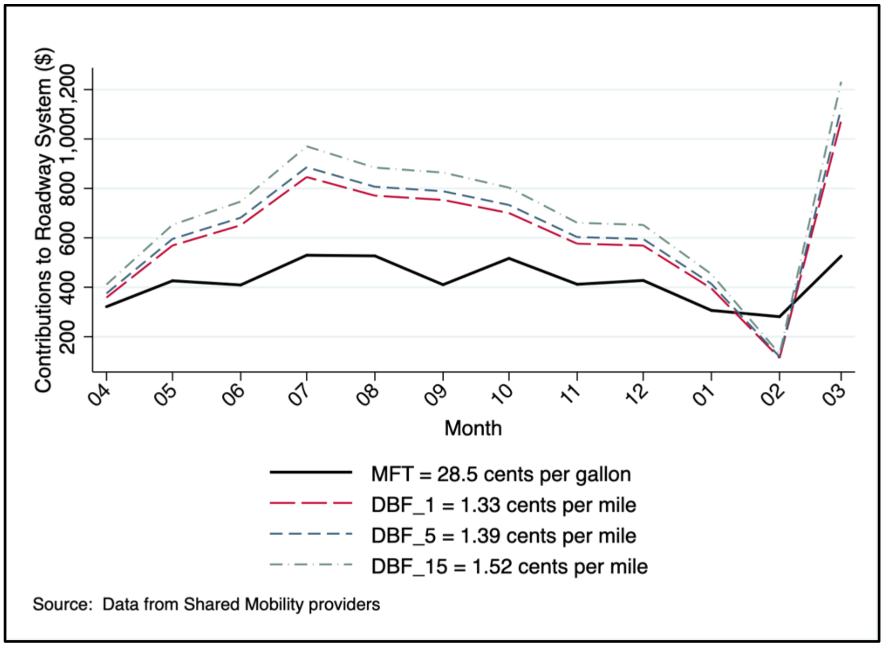

Figure 3-7: Potential Contributions through the MFT and a State DBF System (Method II)

Table 3-5 presents the SM providers' contributions, estimated administrative costs, and the net revenues available for highway purposes using the DBF rates identified by using the second method (Subsection 2.1).

Table 3-5: Hypothetical DBF Revenues – Method II

	MFT	DBF_1 (0.25% costs)	DBF_5 (5% costs)	DBF_10 (10% costs)	DBF_15 (15% costs)
SM Contribution	5,094	7,377	7,722	8,094	8,461
Change (base-MFT)		*44.8%*	*51.6%*	*58.9%*	*66.1%*
-Admin Costs	**13**	**18**	**386**	**809**	**1,269**
Highway Revenue	5,081	7,359	7,336	7,285	7,192
Change (base-MFT)		*44.7%*	*44.3%*	*43.3%*	*41.5%*

Results in Table 3-4 and Table 3-5 show that as administrative costs increase, contributions from SM providers and the actual revenue available for highway purposes increase. However, the actual revenue available for highway purposes increases at a lower rate. The actual revenue available for highway purposes in both scenarios increases the most with the lowest administrative costs, which highlights the importance of having an efficient fee collection system.

4. Technical Notes: Data from Shared Mobility Providers

The Minnesota Department of Transportation partnered with two shared mobility (SM) providers to demonstrate a Distance-Based Fee system in the state of Minnesota. Each SM provider shared two datasets for the analysis. The first dataset reports monthly fuel purchases and total gallons of gas purchased linked to fuel cards attached to a vehicle. The second dataset reports the miles traveled of each of SM providers' vehicles, along with some vehicle information such as model, make, and year. Both datasets are monthly and cover data between April 1, 2020, and March 31, 2021. As part of our study, we merge these datasets by pairing gas purchases to specific vehicles whenever possible. This section presents a description and analysis of the monthly data reported by SM providers.

4.1. Gallons of Fuel Purchased

We start by analyzing the datasets on fuel purchases. The data contains a total of 1,872 transactions of fuel purchases during the twelve-month demonstration for a total of 17,874.30[17] gallons of fuel, with a monthly average of 1,491.1 gallons.[18]

Most of the fuel gallons correspond to gasoline and were purchased in Minnesota. Of the total gallons reported in the data, 90 percent correspond to unleaded regular, 2.77 percent to unleaded ethanol 10% blend, and 2.36 percent to unleaded plus, among others.[19] Only 4.6 gallons of the total reported are diesel. In addition, almost all fuel gallons were purchased in Minnesota. Only one shared mobility provider (SM-A) reported purchases in Wisconsin,

[17] The total amount of gallons used in this report differs from the total amount of gallons reported in the MnDOT website for the DBF demonstration. Several reasons help explain the difference. First, researchers eliminated duplicated transactions. For instance, some fuel purchases made at the end of May appeared in the fuel reports for May and June. A total of 25 transactions were duplicates, accounting for 210.09 gallons of fuel. Second, 131.8 gallons purchased in Wisconsin are included. Third, researchers deleted transactions not related to fuel purchases (2 observations, 2 gallons).

[18] SM provider A and B had an average of 8.2 and 9.0 gallons per purchase, respectively.

[19] Others include future defined, unleaded plus ethanol (5.7%, 7.7%, and 10% blend), unleaded super, super unleaded ethanol (5.7% and 10% blend), unleaded (4 and 5), and E-85 among others.

corresponding to 0.9 percent of total gallons reported by that provider. Figure 4-1 shows monthly fuel purchases reported by both SM providers during the demonstration. The fuel information is presented in the month in which the transaction occurred and not in the month in which it was reported.

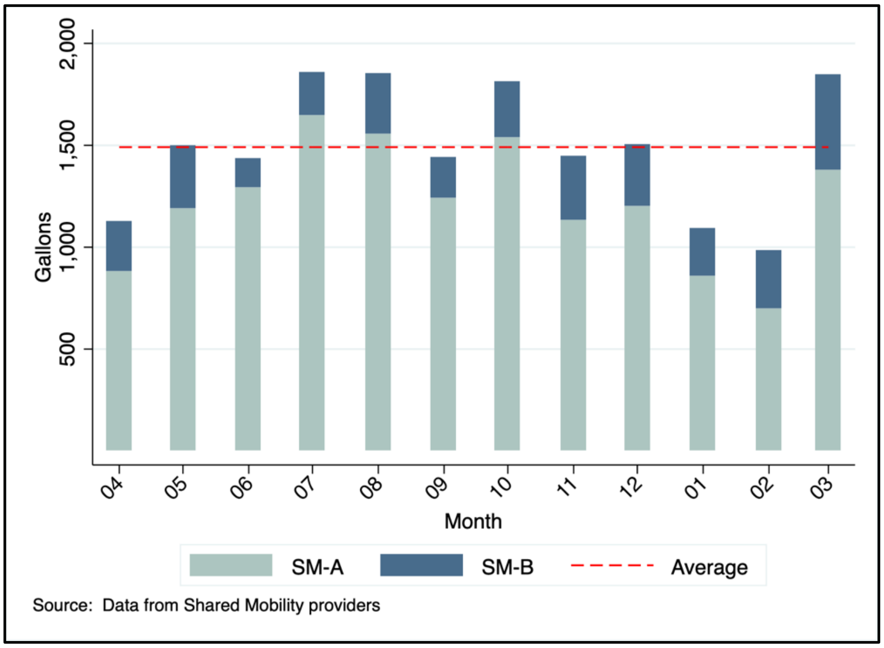

Figure 4-1: Gallons of Fuel Purchased by Shared Mobility Provider

The fuel purchases reported by SM providers do not necessarily represent the total fuel used to power their vehicles. Some situations may create differences in the number of gallons of fuel reported and those actually used. First, SM providers have a fuel card that their customers can use to pay for fuel purchases. However, customers could make fuel purchases for the vehicle out of their pockets and ask for a reimbursement. If a customer fuels the tank of a SM vehicle, the transaction is only included in the data if the customer reports the fuel purchase to the SM provider. Second, there could be problems with the fuel card system/software that prevents the export tool from pulling fuel information from the correct data source. Third, fuel cards could be used to fuel other vehicles outside of the SM provider's fleet. This last situation was not reported by any SM provider during the twelve-month DBF demonstration.

4.2. Vehicle Miles Traveled

The second dataset provided by SM providers included vehicle miles traveled. The data contains a total of 76 vehicles each reporting monthly miles traveled during the twelve-month demonstration for a total of 555,919.15 miles, [20] with a monthly average of 46,326 miles and an average of 7,314.73 miles per vehicle on an annual basis.[21] The individual observations for VMT correspond to miles traveled during customers' reservations as well as miles traveled by SM provider staff to support services offered. In order to avoid double-counting VMT of long reservations (2 or more days), the milage information corresponds to VMT of reservations finalized in each month. For instance, if a reservation started at the end of June and finalized at the beginning of July, all the VMT are reported in July.

Figure 4-2 presents monthly VMT reported by each SM provider during the demonstration. MVT show a seasonal pattern – VMT are low during the winter season and start increasing during spring until they reach maximum levels in summer. A couple of caveats are in order. First, the VMT patterns during the last quarter of the demonstration (January-March 2021) are abnormal. The change in reported miles is linked to the transition to a new technology system by one of the SM providers.[22] Second, one vehicle reported more than 20,000 miles in a trip in the last month of the demonstration. Potentially there was an issue in the reporting technology of this vehicle that prevented it from reporting the miles in February and reported all of them in March.[23]

[20] The total amount of miles used in this report differs from the total amount of miles reported in the MnDOT website for the DBF demonstration. The difference could be to reporting problems from one of the SM providers in February and March.
[21] SM provider A and B had an average of 7,909.34 and 5,944.52 annual miles per vehicle, respectively.
[22] The SM provider went offline for one week (January 25th to February 1st) to install the new technology system. During this week, there were not reservations and no miles driven.
[23] The SM provider is still investigating the potential causes of this issue.

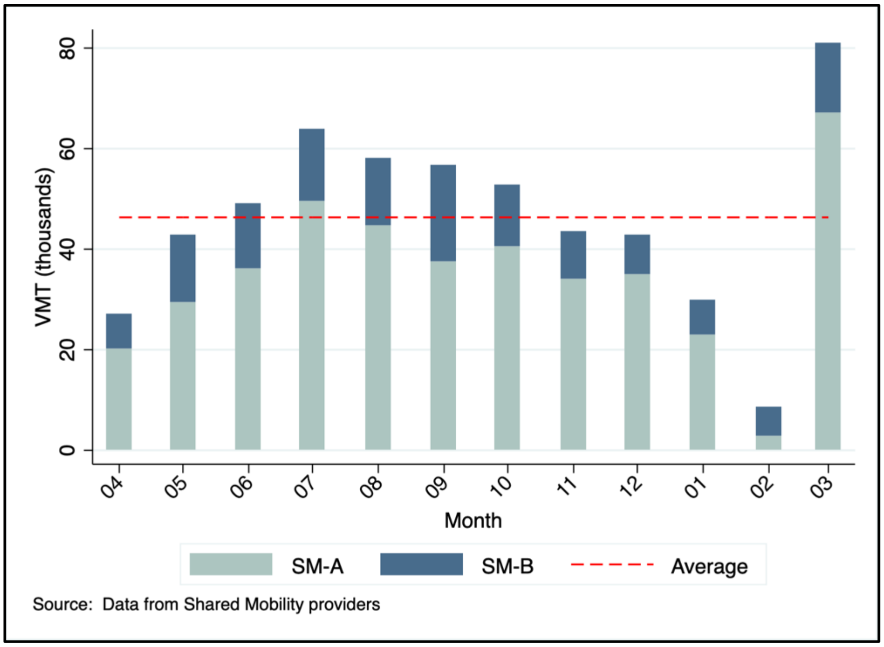

Figure 4-2: Vehicle Miles Traveled by Shared Mobility Provider

4.3. Vehicle Miles Traveled and Fuel Purchases

As part of our analysis, we aggregated fuel purchases and VMT at the vehicle level and merged the two data sets described above. In addition, researchers created a variable to represent the vehicle’s powertrain. All vehicles in the sample are considered internal combustion engine (ICE) vehicles, except for some Toyota Prius that are considered hybrid (HYB) vehicles and a Chevy Bolt that is considered an electric vehicle (EV).

Figure 4-3 shows the distribution of annual fuel purchased versus VMT by vehicle powertrain by shared mobility provider. Overall, gallons of fuel purchased and VMT are positively associated: The more miles are driven, the more fuel is needed. There are few observations along the Y-axis (fuel purchases with no miles traveled) explained by fuel purchases made with spare fuel cards. Unfortunately, it was not possible to trace purchases made with spare fuel cards back to a specific vehicle. When the monthly data is considered, there are several observations along the Y-axis and X-axis. These appear as some vehicles may be fueled the last days of the month and used during the following month or driven during the last days of the month and fueled the following month. This pattern disappears when annual data is considered as the exact timing of the transactions no longer matters.

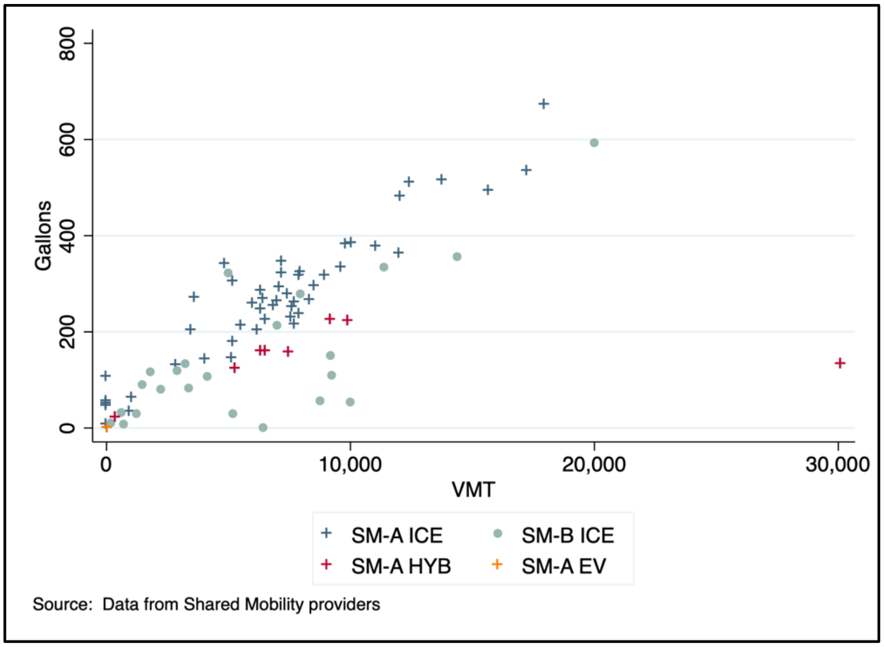

Figure 4-3: VMT and Fuel Purchases by Shared Mobility Provider

Figure 4-3 also shows clear differences between the fuel purchases of ICE and hybrid vehicles. As expected, gallons of fuel purchased are higher for ICE vehicles than for hybrid vehicles for a certain level of VMT. Using data from one of the SM providers (SM-A) and using a simple regression model, we estimate an average difference in fuel efficiency (miles per gallon) of 15.26 (Figure 4-4).

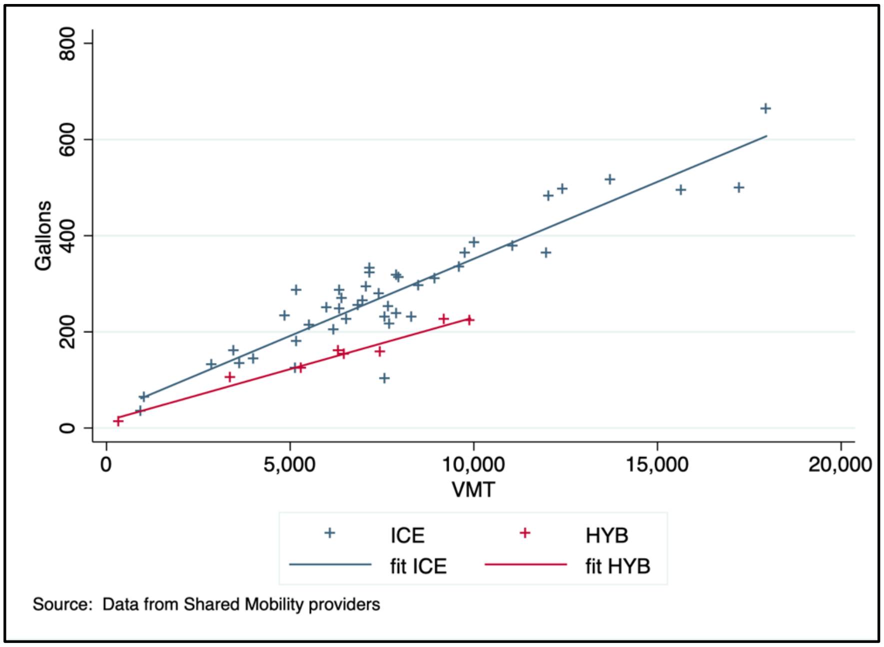

Figure 4-4: VMT and Fuel Purchase by Vehicle Powertrain

The differences in fuel efficiency (miles per gallon) between ICE and hybrid vehicles impact the motor fuel tax revenue that is obtained from each type of vehicle. Using the estimated values for average fuel efficiency, researchers calculated the motor fuel tax revenue ICE and hybrid vehicles generate when traveling a certain amount of vehicle miles. Figure 4-5 presents the results using a tax rate of 28.5 cents per gallon. Overall, hybrid vehicles contribute less through the motor fuel tax than ICE vehicles, and the difference gets larger as more VMT are driven.

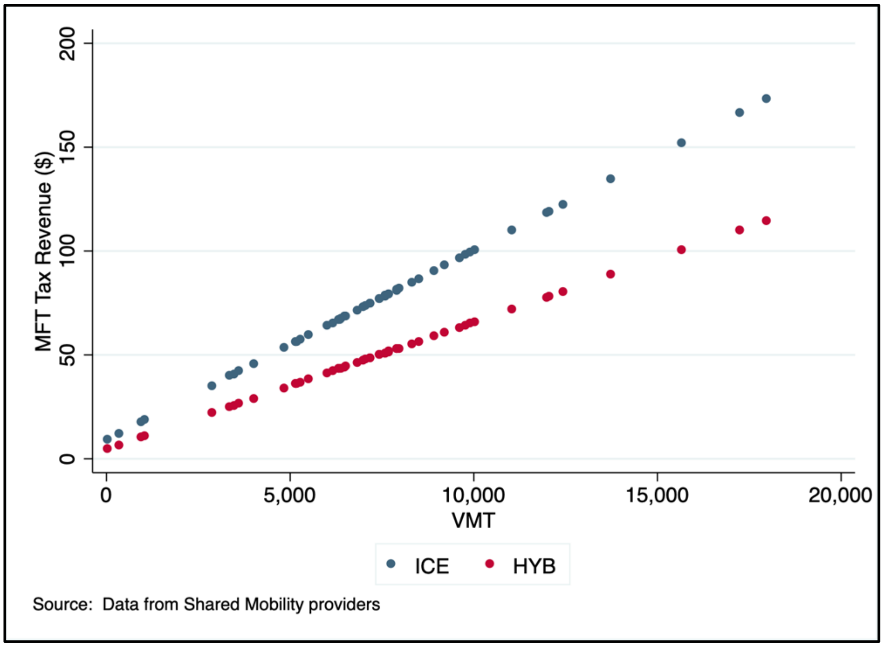

Figure 4-5: Estimated MFT Revenue by Vehicle Powertrain

Appendix A: Federal Distance-Based Fee

A.1. Federal Distance-Based Fee

Following the framework for the baseline rate presented in Section 2, we calculate the baseline rate at the federal level. Table A-1 presents annual MFT revenues and annual VMT in the United States, as well as the calculations for baseline DBF rates considering administrative costs similar to the costs of administering the current motor fuel tax system.[24] At the federal level, there is no fee for hybrid or electric vehicles.

Table A-1: Baseline DBF rate

Year	VMT	MFT	DBF-BL (¢/VMT) (1)
2015	3,109,937,118,720	$ 34,607,908,984	1.116
2016	3,188,972,389,632	$ 35,412,080,080	1.113
2017	5,193,928,855,040	$ 36,219,966,848	0.699
2018	3,255,346,633,472	$ 36,489,630,984	1.124
2019	3,276,481,681,664	$ 36,522,343,248	1.117

***Notes:** (1) Calculations assuming DBF administrative costs similar to the costs of the MFT system in Minnesota.*
***Source:** Author's calculations. Data from the Minnesota Transportation Finance Database, and FHWA.*

Table A-2 presents several DBF rates considering different costs of administering the DBF system. Overall, calculations for 2019 show that, on average, all vehicles in the U.S. contributed 1.12 cents per VMT through the federal motor fuel tax. In addition, if the administration costs of a DBF system were 10 percent of the total revenues collected, the baseline rate would increase to 1.23 cents per VMT.[25]

Table A-2: Baseline Federal DBF rate considering Different Administration Costs

Admin Costs (% of revenue collected)	0.25%	5%	10%	15%
DBF (cents per mile)	1.117	1.170	1.226	1.282

[24] We used collection costs equivalent to the costs of collecting the motor fuel tax in Minnesota, that is, 0.25 percent of the total revenue collected (MMB, 2021).
[25] At the federal level there is a different rate for gasoline and diesel fuels. Given that there is not detailed data regarding the number of miles driven by vehicles using gasoline and diesel, the calculations assume all vehicles contribute the same. More detailed data would be needed in the future to determine the motor fuel tax revenue and miles driven by gasoline and diesel vehicles, and thus, the per-mile fee they contribute.

A.2. Current Contributions through the Federal Motor Fuel Tax

During the twelve months, SM providers contributed $3,278.67 through the federal motor fuel tax - on average $273.22 per month (Figure A-1). Given the miles reported by SM providers, researchers calculated an average motor fuel tax contribution of 0.62 cents per vehicle mile traveled. This contribution significantly varies when considering ICE and hybrid vehicles separately. In particular, hybrid vehicles contribute less of what ICE vehicles contribute (0.44 and 0.63 cents per mile, respectively).

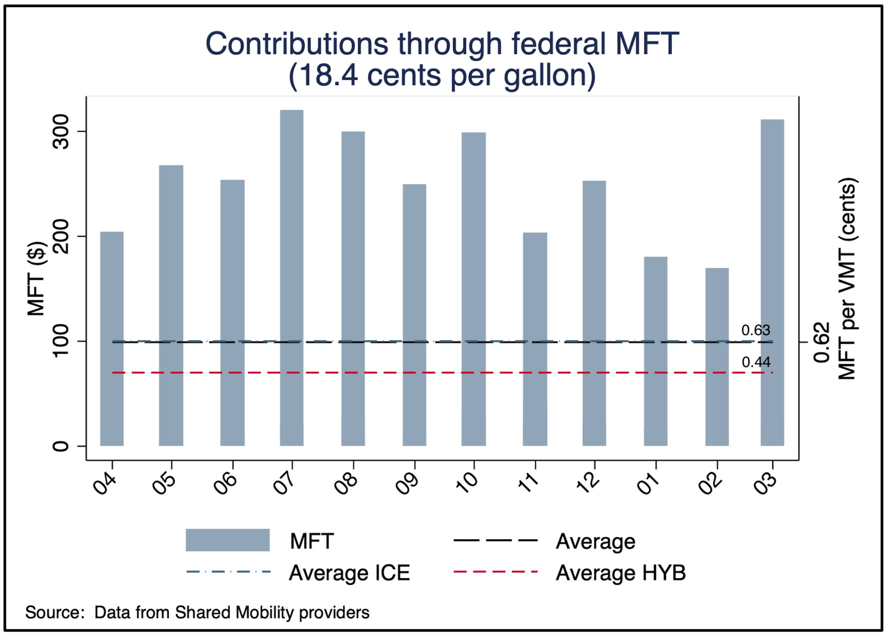

Figure A-1: Total Contribution through Federal Motor Fuel Tax

Researchers assessed what would have happened if the SM providers' fleets were only composed of ICE vehicles or only composed of hybrid vehicles – similar to those used in the demonstration. Figure A-2 presents the results. To travel the same VMT in a fleet composed of only ICE vehicles, the SM providers would have contributed $3,779 through the federal motor fuel tax. On the contrary, if the fleet were only composed of hybrid vehicles, the SM providers would have contributed $2,294 through the federal motor fuel tax.

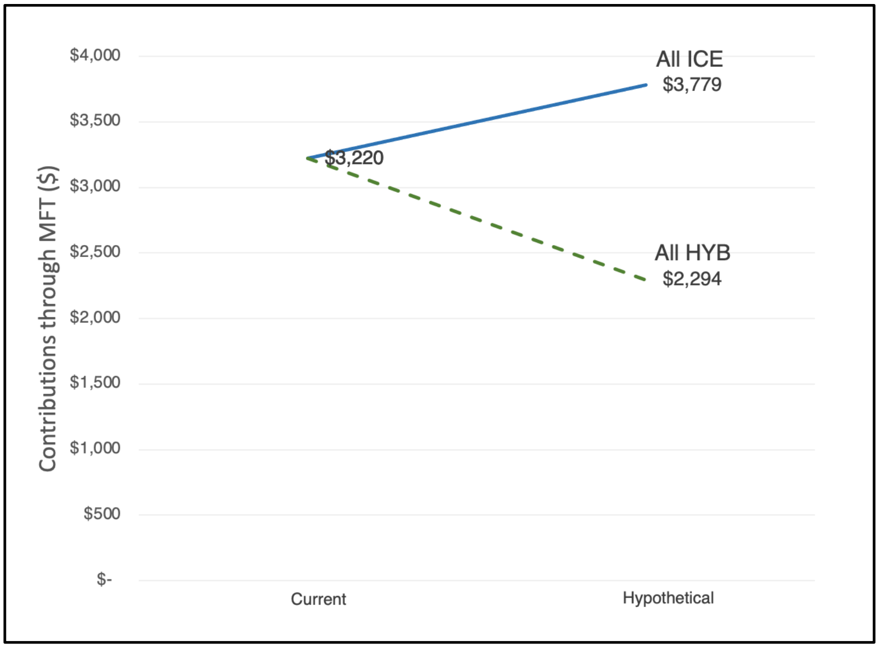

Figure A-2: Potential SM providers' Contributions with Different Fleet Composition

A.3. A DBF system with a Federal Baseline Rate

Figure A-3 presents the current contribution of SM providers to the roadway system through the federal motor fuel tax as well as the potential contributions under a federal DBF system considering three rates identified earlier. The first rate assumes administration costs equivalent to the motor fuel tax system (DBF_1); the second rate assumes administration costs equivalent to 5 percent of the revenue collected (DBF_5); and the third rate considers administration costs equivalent to 15 percent of the revenue collected (DBF_15).

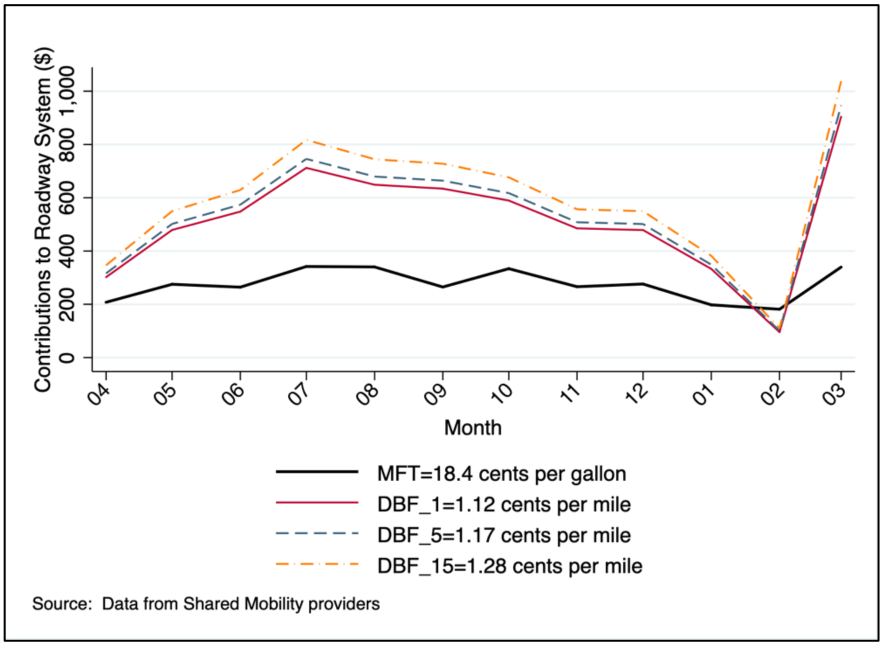

Figure A-3: Contributions through the Federal MFT and a DBF system

Table A-3 presents the SM providers' contributions at different DBF rates, estimated administrative costs, and the net revenues available for highway purposes.

Table A-3: Hypothetical DBF Revenues

	MFT	DBF_1 (0.25% costs)	DBF_5 (5% costs)	DBF_10 (10% costs)	DBF_15 (15% costs)
SM Contribution	3,289	6,210	6,504	6,871	7,127
Change (base-MFT)		*88.8%*	*97.8%*	*108.9%*	*116.7%*
-Admin Costs	**8**	**16**	**325**	**687**	**1,069**
Highway Revenue	3,281	6,194	6,179	6,184	6,058
Change (base-MFT)		*88.8%*	*88.3%*	*88.5%*	*84.7%*

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