Funding on Empty

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Funding on Empty

Why Ohio needs new solutions for infrastructure funding, and potential alternatives to the motor-fuel tax.

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Denison University Research Project
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Abstract

Motor-fuel tax revenues have been stagnant or declining nationwide, and the purchasing power of those revenues has continued to decrease. Transportation and infrastructure are important backbones of the American economy, and as cars become more fuel-efficient and electric vehicles become more and more commonplace, gas tax revenues may continue to fall. A change in how roads are financed may occur. This research is to answer whether the gas tax is still a viable means of funding transportation finance in Ohio, and if not, what alternatives could work?

The research was conducted by looking at existing research through a thorough literature review that provides a bigger picture of the issues facing the motor-fuel tax today. This extensive literature review revealed many things to me about the motor-fuel tax. The history of the gas tax and why it was chosen as the staple of transportation finance because of its easy and cheap implementation. I also learned why the gas tax is important, and the negative consequences deteriorating roads can have on an economy. One of the major damages to the gas tax is from increasing fuel efficiency—which has decreased the purchasing power of gas tax revenues by almost two-thirds. This points to a severe need for a change in how transportation finance is done.

This project concluded with an analysis made up of three parts. First examining electric vehicle fees (EV fees) and pilot programs. Pilot programs have been implemented by several states to study mileage-based user fees (MBUFS) as an alternative to the gas tax. The EV fee portion includes evaluating if Ohio’s current fee is adequate for capturing road usage. The second section examines the potential indexation of the gas tax to inflation to increase revenues. Lastly, it will take the pilot programs done by several states to determine if there is a future in MBUFS as an alternative to the gas tax. This analysis evaluates alternatives to the gas tax, and concludes with recommendations for Ohio’s best path forward.
The Gas Tax Problem

The declining conditions of Ohio’s infrastructure, primarily its roads and highways, have been in the news frequently. To deal with these problems, Ohio’s governor, Mike DeWine pressed the State Assembly to raise the state gas tax by 18 cents, and to index the tax to inflation for the future. He was not entirely successful. House Bill 62 increased the gas tax by 10.5 cents per gallon, to 38.5 cents, and the diesel tax by 19 cents, to 47 cents a gallon, effective July 1, 2019. The bill did not index the tax to inflation. But the increased revenue will be used to fund state and local highway and street improvements.

An increase in the gas tax was a response to a long-standing problem for the Ohio Department of Transportation (ODOT) and its ability to maintain and improve Ohio’s roads. Jerry Wray is a former director of ODOT and the only two-time appointed director in Ohio’s history. Director Wray made a plea for more funding for ODOT. He and other professionals point out that Ohio’s highways are essential to keeping and creating new jobs (Wray, 2016) (Wachs, 2006). In addition, ODOT faces continual budget shortfalls, which continue still despite the gas tax increase. Director Wray warns that budget shortfalls force high-priority projects to face serious completion delays. The longer construction jobs are postponed, the more added costs they will accumulate as well. Is, and if so why, is the revenue of the gas tax insufficient to serve state needs in Ohio? What alternatives might be able to compensate for the falling gas tax revenue? This case study will aim to answer these questions by reviewing academic and practitioner literatures, and by reviewing the experience of other states. Section One provides a case study of the gas tax in Ohio, which provides the context and details about the issues faced by Ohio. The next section provides a literature review of the theoretical and practical issues of the gas tax. Section Three describes the case study approach used in this research to identify a
Ohio Case Study

Like many other states, Ohio has struggled with falling gas tax revenue due to a variety of factors. Across the nation professionals and government officials are looking for suitable replacements or supplements to the gas tax. This case study will describe the history of the gas tax in Ohio and describe when it first began to receive criticism on its performance. Then it will describe the underlying issues in Ohio which are causing the gas tax to be less viable. Lastly, this case study will set up how this issue is not just in Ohio, but that it is occurring on a national level.

In 1919 the very first gas tax was introduced to fund public roads in Oregon. Ohio’s first tax on motor fuel was enacted at a rate of 2 cents per gallon six years later in 1925. The gas tax was quickly adopted across the country rapidly for several reasons. It was an effective means of assessing motorists for their use of highways, since at the time gasoline consumption correlated directly with miles traveled, vehicle speed, and vehicle weight, and the cost to build and maintain roads was known to be a function of these factors (Brown, 2001). Other options, like fees on vehicle miles traveled or ton-miles traveled, although better recorders of road usage, were not feasible at the time because of technological and administrative limitations in the 1920’s. Another advantage was that the gas tax applied to everyone who drove through a state, not just the citizens of the state. This made the gas tax a very equitable option. In its early years, the
gasoline tax was politically popular. The petroleum industry, automobile industry, construction industry, and driving public all embraced the tax because of its direct link to more and better roads (Brown, 2001).

The gas tax has faced critics since its inception, although more recently the criticism has been more grounded due to the declining revenues. Early on, there were fears that high taxes on gasoline would limit or encourage drivers to move on from gasoline. These fears were not widespread however and were mainly held by those in the petroleum lobbying community. Favor for the gas tax really started to dwindle during the Great Depression, when gas tax revenues were diverted to help with unemployment and public welfare. In this paper the diverting of gas tax funds will be referred to as “fungibility”. Up until that point it was just assumed gas tax revenue should be used to fund roads, so there was no requirements or stipulations of how the money should be spent. Soon after, any legislation raising the gas tax met the same public view as all tax increases typically do- disapproval. Ever since, gas tax increases happen occasionally as they are truly necessitated but are often infrequent and are not indexed with inflation (see Figure 1). Ohio’s history of gas tax increases is brief, considering it covers a 95-year span. Counting the recent gas tax increase in 2019 by the DeWine administration, the gas tax has only been raised 6 times since its beginning in 1925 (As seen in Figure 1 below).

To remain effective, the gas tax needed periodic increases due to the problem of inflation. Most often motor-fuel taxes are structured as a fixed cent-per-gallon rate (like in Ohio). However, 22 states have variable-rate gas taxes that adjust, to some degree, with inflation or prices without regular legislative action (NCSL, 2020). Since Ohio’s gas tax is not indexed to inflation, it doesn’t automatically adjust. When gas tax revenues start to lose their value, the Ohio Legislature has to initiate a new bill to further raise the gas tax in order to keep up with
inflation. Vehicle Miles Traveled (VMT) are directly linked to gas tax revenues. The more individuals drive, the more fuel they consume, which contributes more the gas tax revenue. VMT has changed a lot since the establishment of the gas tax. For example, in 1956 national VMT was estimated at 750 billion, but in recent years has climbed as high as 3 trillion. In fact, what VMT means for road conditions has changed a lot just since 2003. The weight of vehicles (especially large shipping trucks) and the speeds at which vehicles can travel have continued to increase in recent years. Due to this increased and tougher usage of roads, the damage to roads increases.

While recorded VMT has not increased by much over the last 20 years (see Figure 2), the rate of deterioration to roads has continued to grow. When coupled with inflation it is understandable how quickly the gas tax rate can fall behind what is needed to maintain and grow our roads. This boils down to less money in revenues but more to pay for than ever before.

In the past, the highway system has proved to be a powerful tool in the growth of the American and Ohio economy, and the highway system relies on gas tax funds to keep it running. So why is there any concern as to the strength of the gas tax today? Below Figure 3 helps to explain part of the problem in Ohio. Figure 3 considers real gas tax revenues 1994-2014 and suggests real gas tax revenues have decreased over time by 7.3% for the overall period, and by 3.8% more recently. There are many reasons this may be happening; increased fuel efficiency, rising number of electric vehicles, bigger and faster vehicles, and inflation are all possible problems. Figure 3 displays Ohio’s tax revenues have been stagnant, while accounting for inflation.

Declines in revenue mean that Ohio has few funds available for new construction. According to ODOT, 93% of their construction money was targeted to solely to preservation work (ODOT 2015 Annual Report and 2016-2017 Business Plan). While raising the gas tax is a
short-term solution to declining tax revenues, it may not be a viable or equitable solution in the long-term. In 2017 the American Council of Engineering Companies of Ohio (ACEC of Ohio) published a research paper on gave the organization’s position relative to highway infrastructure condition and funding. They point out that “According to ODOT, 93% of ODOT’s time, money and labor are devoted to preserving and improving the more than 43,000 miles of roads and 14,000 bridges on the state system” (ODOT Facts Book 2016). This means that little of what ODOT does is dedicated to growth, which Director Wray pointed out was vital for jobs in Ohio. The ACEC of Ohio offers up a variety of potential solutions in the closing of its paper: The increase of vehicle registration fees, further raising of the gas tax, allowing Transportation Improvement Districts (TIDs) to generate their own revenue, a vehicle mile tax (VMT), and/or to eliminate gas tax spending on bike paths or other non-highway resources. Several of these will be evaluated later in this paper, but the ACEC gave a semi-comprehensive list of the popular alternative transportation financing tools.

Ohio’s gas tax has faced declining revenues, due to increased fuel-efficiency, inflation, the increased movement to and choices in electric vehicles, the development of large truck fleets, and the failure of the Highway Trust Fund (HTF) to adequately fund itself. One example of the increasing wear and tear on Ohio’s roads without equivalent gas tax revenues is an ODOT projection of trucking capacity. Total freight volumes are expected to escalate from 1.4 billion tons in 2007 to 2.0 billion tons in 2040. The subsequent demands for capacity creation will put further stress on Ohio’s network of interstates and other roadways. It is also important to understand what is going on with the traffic and roads in Ohio is the vehicle makeup. Average weight of a vehicle is increasing as S.U.V.s and pickup trucks now make up 70% of the market nationally. Like trucking, this also contributes to the further deterioration of roads, but since fuel
efficiency is rising at the same time, the costs to manage Ohio’s roadways is outpacing the gas tax revenues.

Since the creation of Ohio’s gas tax in 1925, there have been many changes on Ohio’s roadways that affect the effectiveness of the gas tax. Ohio is dealing with increased fuel efficiency, increased vehicle weight, increased road deterioration, increased alternative fuel vehicles, and declining gas tax revenues. These factors are important because the situation in Ohio is reflective of the issues facing the gas tax across the whole of the United States. Many states are encountering transportation budget shortages, including at the federal level. There is also a clear need for more funding, not less. In its recent report on America’s roadways and bridges, the American Society of Civil Engineers graded a D for our highways and a C+ for our bridges. They also pointed out the need for another $79 billion per year in new investment. This raises a series of questions that motivate this research project and will be investigated. Is the motor-fuel tax still an effective user-fee for Ohio transportation funding needs? If not, what are some viable alternatives that could be implemented in Ohio? In search of these answers, there are further questions to be raised. What data can give insight into the viability of the gas tax? What factors determine viable alternatives to the gas tax? These must be investigated to answer the Ohio question.
Literature Review

The issues with the motor fuel tax presented in the Ohio case study are not unique to Ohio but are reflected on a national scale. The motor-fuel tax is the primary source of funding for all road and highway infrastructure in the United States. Section A of this literature review discusses the economics of the gas tax and other user fees as well as the potential regressivity of user fees; Next, Section B illustrates the current failures of the gas tax as described in the transportation finance literature, and why it may no longer operate as a user fee. Finally, Section C suggests possible alternative funding mechanisms or solutions, as well as describes the ways these different options might be evaluated.

Section A: The Economics of User Fees

User fees are fees, taxes, or impost payments paid to a facility owner or operator by a facility user. The gas tax had long been a prime example of a user fee; and has often been described by public finance economists as the ideal for government revenue raising. Finance instruments based on user fees are considered fair because they charge individuals for how much they use, rather than a flat rate. This way, those who use the roads more (and thus contribute to more deterioration) pay more for that increased use, and those who do not drive do not have to pay at all. User fees encourage efficient use of whatever facility by making clear the relationship between costs and benefits of using the facility, which allows users to make informed decisions. The gas tax was in a way, the original user fee (Brown, 2001). It was an effective means of assessing motorists for their use of highways, because gasoline consumption correlates directly with miles traveled, vehicle weight, and vehicle speed, and the cost to build and maintain roads
was known to be a function of these factors. Alternatives, such as fees for vehicle miles traveled or ton-miles traveled, although better recorders of road usage, were not feasible because of technological and administrative limitations in the 1920’s. The gas tax also applied to everyone who bought gasoline in an area, including drivers from other states. For example, in the Rocky Mountain region, out-of-state motorists account for as much as half of all automobile travel (Brown, 2001). Finally, finance instruments not based on user fees may be unfair because individuals who do not use the transportation system are required to subsidize those who do.

Another reason the gas tax was chosen over its alternatives, was the cost of administration. Part of why the gas tax was so popular of a way to raise highway funds was that the cost to administer it was very low, and this remains true today. Gas tax revenues are collected at the same time as fuel is pumped; consumers are often not conscious of paying the gas tax, as it is built into the cost of fuel. Some of the alternatives we will look at for current day were not feasible at the time due to technological limits of the time. One such example is GPS tracking, which wasn’t invented until the 1970’s (NASA, 2017). When considering alternatives, cost of administration will be an important characteristic.

The regressive nature of the gas tax has been debated several times (Chernick and Reschovsky, 1997; Duff, 2004). Although arguments have been made to the severity of this regressive nature, the gas tax is regressive. It takes a proportionally greater amount from individuals of lower incomes. This is certainly worth consideration when analyzing the gas tax, but it must also be stated that user fees as a whole are often criticized for being regressive, and most alternatives to the gas tax being examined nationwide are user fees. One of the potential issues with the gas tax today is that it may no longer be operating as a true user fee.

Economic theory of the motor fuel tax suggests such taxes are regressive in nature, that is
the gas tax places disproportionate burden on the poor. Howard Chernick and Andrew Reschovsky consider the potential regressivity of the gas tax. They question the regressivity of the gasoline tax on the grounds that using annual instead of lifetime income and consumption data can lead to a substantial overestimate of regressivity. Instead they suggest that the regressive nature of these taxes should be evaluated in the middle ground between lifetime and annual incomes. When individuals are grouped into 11-year average income deciles, average gasoline tax burdens are only slightly less regressive than annual tax burdens. The main reason for the similarity of annual and intermediate run burdens is the limited degree of income mobility over an 11-year period (Chernick and Reschovsky, 1997). Considering the regressivity of the gas tax in the long term does reduce the overall regressivity, but only slightly.

David Duff discusses user fees and adopts an even-handed approach to benefit taxation, regarding benefit taxes and user fees as preferable to general taxation for specific purposes but inferior to general taxes for other reasons. Duff divides taxes into two generalized categories; the first being general taxes, mandatory levies that are not related to any specific benefit or service. The other category is user fees (like the gas tax), which are to an extent voluntary levies imposed for particular benefits of public goods and government services (Duff, 2004). Not every tax fits cleanly into one category or the other, but it does encapsulate the large majority of taxes well. An advantage of benefit taxes is their efficiency, a primary goal of traditional tax and public policy. User fees or benefit taxes are a practical approach to efficiency, as it ensures the combination of government spending and the distribution of taxes that fund that spending achieve an economically efficient result. Duff also identifies accountability as another benefit to user fees. By linking the supply of public goods to the costs of maintaining and creating them, it creates
accountability for both the government and for the public. What is being taxed and where the revenue goes to have clear answers.

Duff concludes his research by saying that “user fees are neither the panacea for public finance that some imagine them to be nor the ‘reactionary’ levies that others denounce. On the contrary, as this article has argued, they are simply one method of raising government revenue that may be appropriate in some circumstances and inappropriate in others” (Duff, 2004). He suggests that these types of levies may be regressive, but if so, this can be addressed with compensatory measures designed to offset increased burdens on low-income groups. In general user fees do not work for financing pure public goods that are non-rival and non-excludable. An example of this is military funding. Everyone in a nation benefits from the protection of their nation, and so it would not make sense to pay this on a use basis. Duff also says public housing, police, fire protection, and other social services would be inappropriate for user fee funding. This is because social services are meant to be solely redistributive, which is why benefit taxation is not fit for them. Duff argues transportation, water, and sewage are all especially fitting to be user fees. However, the gas tax may no longer operate effectively as a user fee, which will be discussed in the next section.
Section B: The Failure of the Gas Tax Today

There is a large consensus that the gas tax no longer covers all the direct and indirect costs imposed on the U.S. infrastructure system (Goldman and Wachs, 2003; Parry and Small, 2005; TRB, 2006; Delucchi, 2007; Jerome Dumortier, Fengxiu Zhang, John Marron 2016). There are a variety of reasons. For one, the gas tax may no longer operate as a true user fee, which if true, creates inefficiencies and may add to the potential regressive nature of gas taxes. This is because not all highway users in Ohio, or the United States as a whole, pay the gas tax, or alternatively, users may pay at varying rates. This is a result of more fuel-efficient cars, in particular, the increased use of electric and hybrid vehicles.

Martin Wachs makes a similar point, as he attempts to raise awareness for the gas tax issue. There is a need for tax revenue to be increasing over time, rather than stagnant or decreasing. Wachs says that as the highway system grows, so does the cost of maintaining existing roads. Worsening congestion is a product of having to dedicate funding to maintain the existing roads, with nothing left to expand or innovate (Wachs, 2006). This means that little of what transportation agencies are funding is dedicated to growth. Not having enough funding to take on new projects and improvements hurts job growth and leads to increased traffic congestion. The costs to maintain will only rise, which will lead to shrinking funds dedicated towards new projects. Current gas tax revenue trends are a problem if they cannot fund new projects that decrease congestion, let alone be able to adequately maintain the existing highway system. Wachs overall conclusion is that the gas tax is linked to highway usage but not to expansion or the added costs of congestion, and because of this its stagnant revenues are a severe issue.
The gas tax has been used in America for over a hundred years. To understand the current issues with the gas tax it is important to get a better understanding on the origins of the gas tax, and why it has been such a long-standing mechanism. Katz and Puentes establish in their paper the history of the gas tax at a national level, how the gas tax has been the clear leader for funding highways since its inception, that there is a lack of funding for highways today, and that bond usage as a means of financing highway spending has increased rapidly in the last 20 years (Katz and Puentes, 2005). Increased debt-funding of highways is a clear indicator that transportation agencies are having to get creative with funding to keep revenues up. A severe problem for transportation finance is that the purchasing power of the declining revenues has continued to decrease (see Figure 4). Figure 4 begins in 1993 because that is the last time the federal gas tax was raised. The purchasing power dropping 64 percent since then is a clear indicator that fuel efficiency and other factors are eroding the gas tax, not only in states like Ohio but at a national scale.

Jonathan Williams points out that the Highway Trust Fund (HTF) was established under Eisenhower as a temporary funding instrument but is (Williams, 2007). It was established to build the interstate system Eisenhower advocated for, and although it was meant to be a temporary system, it is still in use today. Part of the reason for this is that it took much longer to complete the construction on the highway system than the Executive branch or Congress had thought. The HTF has come under much scrutiny since the Great Recession, due to its new reliance on government transfers mentioned in the Ohio case study (John Paul Helveston, 2017). The HTF is a funding mechanism that collects the federal gas tax and other fees, and then disperses those fees to each state according to their contributions, as a way of supplementing state highway funding. Part of the reasoning for this fiscal federalism is that many highway
projects extend over state lines, and when it comes to a discussion of who pays it is easiest to have a Federal branch of transportation that oversees such projects, although a large percentage of the funds are just redistributed to state’s based on their contributions. Jeff Davis asks if a never-ending series of bailouts of the HTF by general revenues is the best way to fund future infrastructure investments? Ever since the Great Recession the HTF has been receiving transfers from general revenue to help maintain its commitments to supplementing state transportation budgets.

Starting in 2008 the Highway Trust Fund (HTF) began receiving transfers from general revenue (Figure 5) so that it could continue to meet its commitments to states’ funding. Ever since the Great Recession the federal gas tax revenue has not covered the HTF’s commitments, and thus it has had transfers from the federal government. The HTF’s commitments are largely supplementing state transportation budgets with the federal gas tax revenue. While some were already advocating moving on from the gas tax, these transfers have raised national awareness in the political and transportation communities that the gas tax is not preforming as strongly as expected.

Every state receives a portion of its funding from the HTF. In 2018, ODOT received $2.04 billion from the HTF, and it generated $1.9 billion in state gas tax revenue (ODOT Annual Statement, 2018). Highway Trust Fund contributions annually account for a major portion of Ohio’s infrastructure finance, which explains the concern Ohio, and many other states have, with the deterioration of revenues (specifically fuel-tax revenues), in the HTF. The Oregon DOT (also shorthanded as ODOT) received 23 percent of its funding from 2017 to 2019 from the federal government as well (Oregon Department of Transportation, 2019). The decline of the HTF’s revenues poses a serious risk to many states. Davis finds in his paper that revenue for the HTF is
projected to be approximately $39 billion per year over the next decade, and in 2014 the HTF's spending commitments totaled $51 billion (Davis, 2014). That is a $12 billion dollar deficit in the first year alone. There is clearly a funding issue with the gas tax, both at the state and federal levels (Katz and Puentes, 2005; Puentes and Tomer, 2008; Duncan and Graham, 2013; John Paul Helveston, 2017).

There have been no major efforts to raise the federal motor fuels tax since President Clinton’s administration. With the HTF consistently needing transfers to stay afloat, it would seem logical to raise the federal gas tax to compensate. Important to note though, President Clinton succeeded in getting his deficit reduction plan approved by Congress yes, but only after Al Gore cast the tie-breaking vote to pass the raise. This detail is important because it illustrates another issue with the gas tax that is shared by many other taxes. Opposition to increases. Both at the state and federal level it is commonly hard to raise the gas tax. Colorado is another such example, the last time their gas tax was raised was 24 years ago. This is a smaller, but still contributing factor to the decline of gas tax revenues.

Some argue that gas tax revenue being diverted to non-highway uses is a problem for transportation funding. Jonathan Williams gives numerous examples of gas tax revenue being spent on public education, museums, and graffiti removal (Williams, 2007). This may be a contributing factor to problems in some state’s transportation financing. Figure 6 shows the percent of state gas taxes and vehicle fees that are diverted to non-highway uses. While it is clear that many states divert there funds to other causes, this graph shows that reducing spending on non-highway projects is not a real option for states like Indiana, Ohio, or West Virginia, regardless of it being a problem for some states. Low fungibility means there is little money not spent on maintaining or improving roads by the state government. However, this may also point
back to an inefficiency with the Highway Trust Fund. That inefficiency is that it may be overcontributing to funding in states that may not be allocating those funds to transportation projects at all or using the federal funds to open up their own highway funds for other uses.

Robert Kirk and William Mallet discuss another issue facing the gas tax today. Kirk and Mallet find that expanding fleets of hybrid and electric vehicles are likely to raise equity issues for transportation finance. The issue with expanding electric vehicle fleets is likely to only grow as well. There were only 3 models of electric vehicles in 2010, and in 2017 there were 25 models (Kirk and Mallet, 2020). More and more manufacturers are producing electric and hybrid vehicles to meet demand, and the efficiency and quality of these vehicles is growing as well. According to ODOT’s 2019 Annual Report, as many as 1/3 of all vehicles on the road are projected to be electric vehicles by 2040. This will likely lead to even further revenue declines. Their paper also discusses the issue that improving fuel economy poses to gas tax revenues. Improved fuel economy is slowly reducing the average amount of fuel used per mile of travel. The CBO projects that from FY2021 to FY2026 the gap between transportation revenues and spending will average roughly $18 billion annually. Figure 7 displays the fuel-efficiency problem facing the gas tax. Cars and trucks have continued to improve in miles per gallon of fuel rapidly. This steadily rising MPG poses a serious problem for gas tax revenues. Drivers being able to drive farther on less fuel means an increased need for road maintenance and decreasing gas tax revenues. Together, those two factors pose a significant problem to transportation agencies in how they manage highway infrastructure. The Environmental Protection Agency (EPA) confirms this, as they say manufacturers have made significant improvement in fuel economy and carbon emissions in the last 5 years alone (EPA Automotive Trends, 2019).
The EPA’s automotive trends report (Figures 7 and 8) shows that average fuel-efficiency has increased by 1 mile per gallon over the last 5 years, with some manufacturer’s achieving as many as 2 or 3 mile per gallon improvements to their fuel-efficiency. Since 2004, fuel-efficiency has increased thirty percent. Yet as stated earlier in this paper, the gas tax has not been raised at the federal level since 1993, and while many states have raised their taxes in recent years, they have not been keeping pace with the variety of issues facing the motor-fuel tax as a whole.

**Part C: Alternatives to the Gas Tax**

There are a variety of alternatives offered to the gas tax. Some suggest the more widespread use of toll roads, while others point to a flat fee or supplements to the gas tax such as indexing to inflation. A vehicle-miles traveled tax (VMT) or mileage-based user fee (MBUF) are the most frequently advocated, but there is an assortment of options in the technology and implementation of VMT taxes. These many alternatives must be evaluated on not only how realistic their implementation might be, but the political feasibility of the options as well. On-board computers, global positioning systems (GPS), digital maps, and wireless communications all are technologies that now make it relatively easy and cheap to measure and record vehicle travel by road segment and time of day (Sorensen and Taylor, 2005). This opens the door to many pricing options long proposed by transportation economists but never before deemed feasible or practical. The problems facing these options is the political and public acceptability, namely when it comes to individual’s privacy.

The Oregon Department of Transportation conducted a pilot program to study two strategies entitled “the Oregon Mileage Fee Concept”. The overall goal of this study was to
investigate the feasibility of replacing the gas tax with a mileage-based fee based on miles driven in Oregon and collected these fees at fueling stations. The findings of this test were very positive. The program showed that the new mileage fee could be paid at the pump, with minimal differences in the administration for motorists, compared to how they pay the gas tax. The study was also able to abide by several privacy goals—no specific vehicle point location or trip data could be stored or transmitted, all on-vehicle device communication must be short range, and the only centrally-stored data needed to assess mileage fees were vehicle identification, zone mileage totals for each vehicle and the amount of fuel purchased (Whitty, 2007). One of the key concerns for many when first considering a mileage-based tax was the invasive nature of tracking someone’s driving. These privacy commitments help to reduce that concern with assurances of what information is taken and what it can be used for. Perhaps the most promising finding of this pilot program was the low cost of implementation of the mileage-based tax. Service station capital costs include installing the mileage reading equipment while operating costs include communications of the mileage information with a central database in order to calculate mileage fees and modifications to the station’s point-of-sale system. On-vehicle capital costs will be determined by auto manufacturers and included in the price of new vehicles. ODOT will incur operating costs for auditing and providing technical assistance to service stations and motorists. Auditing should cost $1.0 million annually, a small fraction of the expected annual mileage fee revenue. Also, capital costs were considered as part of the evaluation. ODOT’s economist concluded in 2003 that the estimated $33 million in capital costs for statewide implementation would result in less than a two percent increase in the mileage fee rate, comparable to the existing fuel tax payment of the average passenger vehicle (Whitty, 2007). This means that implementation of the new system would be relatively cheap, especially when
compared to the increased tax revenue to be gained by making the switch from gas tax to mileage-based fees.

The Michigan Ohio University Transportation Center published a paper that specifically looked at the impact electric vehicles were having on the gas tax and the possible implementation of MBUFs as an alternative to the gas tax (Dutta and Patel, 2012). Their study concluded that a mileage-based user fee (MBUF) is the definitive way to provide Transportation infrastructure funding. This is due to several main points that they believe make MBUFs the clear choice for funding moving forward. One such point is fairness. The current tax system charges road users based on fuel consumption, so if the vehicle fuel efficiency was low, drivers would be paying more in taxes compared to drivers with very efficient vehicles. Their conclusion is that it would be unfair to charge different individuals varying amounts for the same amount of road usage. The MBUF system would charge all drivers equally, regardless of the type of fuel and different efficiencies of their vehicles.

The recommendations that came from the Dutta and Patel paper proposed a specific method of MBUF that was reviewed by Allen Greenberg of the USDOT, who is an authority on MBUFs. Greenberg saw this method as an acceptable/doable approach. The approach they suggested was GPS based, which would solely record distance traveled. The billing would be done by mailing invoices based on the time and zone of travel at the end of each month, which is similar to how many Americans handle payment of telephone, gas and electricity bills. Since this paper was published, the digital age has grown even more. A byproduct of that is many bills today are payed digitally, as individuals are relying less and less on physical mail for their billing and payment. So likely an option for digital payment of an individual’s MBUF would be added
to this approach. The notable increase in cost of administration with this approach is because of the need to install on board technology into vehicles to track the mileage.

Tolling is another option which has undeniable merits, proven by its use in 34 different states within America. The International Bridge, Tunnel and Turnpike Association advocates for wider use of toll roads on its website ibtta.org. They point out that it is generally accepted that our iconic highways, such as Los Angeles’ 110 Freeway and the Capital Beltway around Washington, D.C., need major overhauling or reconstruction. The structural problem beneath our crumbling roadways: our method of funding highway infrastructure is failing, and there is little appetite or good reason for increasing the gas tax. Highway tolling is a proven, reliable funding method, but unfortunately federal law does not allow states to use toll roads to rebuild existing lanes of interstate highways.

There are several major points about toll roads that highlight both the benefits and drawbacks of using toll roads. First, a toll road operates as a user fee, not a tax. This makes toll roads efficient and fair, as you only pay for how much you use them. Second, electronic tolling is far improved from the early forms of toll roads. This means no congestion and no delays. All electronic tolling also improves local air quality by reducing idling and congestion. Tolling used to be a barrier to mobility because you had to stop and wait to pay your toll. Third, toll roads maintain privacy. Toll road customers can rest safe knowing their personal information and privacy is respected, and legally protected, by the toll agencies. While tolling has many merits, there is a common issue that has and will likely continue to keep tolling as a minor part of the infrastructure financing hierarchy. The logistics of making most or all roads operate as toll roads is not feasible, due to capital costs, public opinion, legislative opinion, and ease of
implementation or transition. Since roads are generally considered a public good, it is unrealistic to advocate for major privatization.

The gas tax is the central funding mechanism for transportation in the U.S. and nationwide states and researchers are investigating alternatives to the gas tax. This is because it has become clear that while the gas tax has been a great tool for many years, the direction that vehicle technology and public finance are going means moving away from the gas tax in the long term. The analysis of this research will point out why the gas tax is failing, and then identify several alternatives to the gas tax. Then it will identify the best option for Ohio and make specific recommendations for the direction Ohio should go in the future.

Methodology

This research uses a case study approach to evaluate the viability of the motor-fuel tax in Ohio. By analyzing other states’ experience with the gas tax relative to Ohio, it is possible to determine what the future might hold and what policies might be advantageous for Ohio. To choose states that would give insight for Ohio, selection criteria were created that would help capture a variety of states; several that are very similar to Ohio for comparison, and several that are more varied and provide contrast to Ohio. These selection criteria include highway management rankings, gas tax revenue per miles of road, vehicle miles traveled (VMT) per capita, population, geography (compared to Ohio’s), and electric vehicle (EV) market share. All criteria for selection are based on the characteristics of the state. A second set of criteria was also developed, to evaluate the states chosen with the selection criteria. This set of evaluation criteria help analyze different policy approaches compared to Ohio’s. These criteria are primarily policy
decisions such as indexing gas taxes to inflation, EV fees, conducting pilot programs, and fungibility of gas tax revenues. Elements of selection criteria such as EV market share and gas tax revenues will be relevant during evaluation to examine the effects of these different policy decisions.

The selection criteria (see Table 1) helped produce a varied group of states for comparison with Ohio. Some of the characteristics of these states have a great effect on gas tax revenue like geography, population, miles of road, and VMT. Other characteristics such as EV market share, gas tax revenue, and highway condition rankings are impacted by some of the policies that appear in the evaluation criteria. In the analysis portion of this paper, the evaluation criteria will be used to evaluate what policy approaches Ohio should consider adopting, and whether these approaches provide long term solutions or not. The analysis will inform policy recommendations for the state of Ohio moving forward.

The selection criteria were created to capture two types of states: states that are similar to Ohio in categories such as population, gas tax revenue, and miles of road (see Table 2). Pennsylvania and Michigan were both selected because their populations, geographies, and miles of road were all close to Ohio’s. They also have similar market shares of electric vehicles. Since their circumstances are very similar to Ohio’s it makes it easier to compare the differences they have in policy and what the effects of those differences are. The other type of state the selection criteria aimed to capture were states that had little in common with Ohio but have experience with issues that are likely to inform Ohio’s future. These states are California, Colorado, and Oregon. California has the largest EV market share in the nation at 8% as seen in Table 1, which gives a valuable contrast to Ohio at only 1%. Colorado and Oregon both have larger EV market shares than Ohio but are closer in population size and miles of road than California. All three of
these states have also conducted pilot programs, which means they are actively testing alternatives to the gas tax. Having this second grouping of states selected aid the evaluation by getting a broader picture of other situations and circumstances that Ohio is not experiencing yet but could experience in the near future.

The evaluation criteria observe the states seen in Table 2 and help enable analysis of the different policy approaches, to determine what does and does not work in addressing declining gas tax revenues. Some of the criteria selected to evaluate these states are policies that help supplement or refine the gas tax, and others are pilot programs which explore alternatives to the gas tax. To help increase gas tax revenues many states have indexed their gas taxes to inflation. Indexing the gas tax for inflation is important to maintain purchasing power of gas tax revenues; a variety of methods will be considered. Registration fees for alternative fuel vehicles is one example of a method of supplementing gas tax revenues, by generating additional transportation funds when electric vehicle owners register their vehicle; states chosen have taken a variety of approaches. The success of different policy approaches can be evaluated by how gas tax revenues respond. It will also be important to consider EV market share, as this can have an impact on gas tax revenues regardless how high the gas tax is raised. Pilot programs indicate that a state is considering alternatives to replace the gas tax, rather than supplement it. California, Colorado, and Oregon have all conducted pilot studies of different variations of a vehicle-miles traveled (VMT) tax. Analyzing these different pilot programs can also aid in the evaluation of the future of the gas tax in Ohio.

To perform analysis it was vital to select states both similar and dissimilar to Ohio, to see how different policy decisions and approaches are enacted, and also to see how the makeup of the individual state might impact which of these fit best for each state. For example, southern
states such as California do not have to deal with the salting of highways and snow clearing that Ohio does, or at least not to the same degree. Examining pilot studies was a critical part of the analysis, as vehicle-miles traveled tax systems are often regarded as the solution to the gas tax problem. Due to that informal consensus, the analysis was more made more complete because it examined states that performed pilot studies that were more similar to Ohio, such as Oregon, and states that look much different than Ohio, such as California. By doing so, we can see how mileage-based user fees might work in a variety of states and see if their implementation would suit Ohio. The analysis will lean on both the comparison to other states, and the evaluation of topics brought up in both the Ohio Case Study and the Literature Review.
An Analysis of the Future of Infrastructure Funding in Ohio

Ohio is facing several changes that threaten the long-term viability of using the gas tax to fund the state’s transportation related projects. For decades the continually increasing average fuel-efficiency of vehicles in the United States has loomed as a threat on gas tax revenues. However, more recently the rise of electric and hybrid vehicles has accelerated the decline of gas tax revenues. For example, General Motors recently announced they would only be selling electric vehicles by 2035, and Elon Musk’s Tesla is planning to sell its first orders of electric semi-trucks in 2021 (Boudette and Davenport, 2021). This analysis has three parts, it will first examine electric vehicle fees (EV fees) and pilot programs, which are examining mileage-based user fees (MBUFS) as an alternative to the gas tax. This includes evaluating if Ohio’s EV fee is adequate. The second section will examine the potential indexation of the gas tax to inflation to increase revenues. Lastly, it will use pilot programs done by several states to examine if there is any long-term viability in the gas tax, and if there is a future in MBUFS as an alternative to the gas tax.

Analysis Part I: Pilot Programs and Mileage-Based User Fees (MBUFS)

Analyzing a series of states’ experience with the gas tax and comparing them to Ohio can identify possible solutions which could help Ohio address the decline of gas tax revenues. This part of the analysis will use the evaluation criteria laid out in the methodology, which are performance rankings, pavement condition, fungibility, electric vehicle (EV) market share, EV fees, and state gas tax revenues (adjusted for inflation). First, this paper will examine Michigan and Pennsylvanina, two states with many key factors in common with Ohio. Though similar to
Ohio in structure, these states have undertaken different policies which may be advantageous for Ohio to follow. Second, the analysis will then consider California, Colorado, and Oregon. These three states have all conducted pilot studies and are much more progressive in their respective approaches to transportation finance. All three states are important to evaluate and to compare with Ohio as they can help forecast the potential future of Ohio’s relationship with the gas tax. Lastly, there will be a summary of the key findings from the analysis and policy recommendations based on these findings.

The goal for the first section of states was to select states that would provide good comparison to Ohio. Michigan and Pennsylvania were selected for their similarities to Ohio. The rankings of Michigan, Pennsylvania, and Ohio are relatively close if both overall highway management performance and both rural and urban pavement conditions. Michigan and Ohio are close to each other in revenue per mile (Michigan at $5,762,856 in 2019 and Ohio at $7,545,688) but Pennsylvania’s revenue per mile ($13,325,716) in 2019 was almost double Ohio’s. This is surprising as Pennsylvania falls close to Ohio in both miles of road and in population, and this discrepancy may be due to their different approaches to supplementing the gas tax, which will be discussed below. All three states are relatively similar in geography and climate as well, another commonality that makes these states fit for comparison. One last similarity in these three states is their electric vehicle market share. Michigan, Pennsylvania, and Ohio all have roughly one percent market share of electric vehicles, which is a stark contrast to some of the other states studied here. However, each of these three states take differing policy approaches in how they manage transportation funds.

The key difference between Ohio and the comparison states of Michigan and Pennsylvania is indexation of the gas tax. Michigan indexes its gas tax to the consumer price
index (CPI), it does not have to actively manage the rate of its gas tax. Pennsylvania indexes its gas tax by a percentage of the wholesale price of gas. Due to this Pennsylvania does have to manually adjust its gas tax rate occasionally, but like Michigan, indexing their gas tax helps to prevent the decrease of the purchasing power of gas tax funds. Ohio does not index its gas tax, which means the rate of the gas tax must be actively managed by the state government, or else transportation funding will fall. As discussed in the Ohio case study, Ohio has raised its gas tax recently. Hiking a gas tax can be tricky sometimes though, which can be observed later in this paper with Colorado, who has failed to raise its gas tax for 24 years. Since raising the gas tax can be politically hard, Michigan and Pennsylvania have an advantage in maintaining the purchasing power of their gas tax revenues when compared to Ohio.

Ohio has been proactive with one method of raising gas tax revenues. This is the addition of an electric vehicle fee (EV fee). As the market share of EVs rise, it makes sense to charge them a registration fee to help cover the amount of money those drivers would be paying in gas taxes if their vehicles were not electric. Every state in this study besides Pennsylvania has enacted an EV fee, and there is a bill in Pennsylvania’s legislature currently that will add them to that list if passed. Ohio charges $200 for the annual registration of an electric vehicle, while Michigan only charges $135. Some states are opposed to high registration fees on electric vehicles, as they want to actively encourage these vehicles to become more commonplace. However, while Ohio’s EV fee is steeper than Michigan’s, it has a slightly higher percentage of electric vehicles on the road.

An article from the New York Times talks about the electric vehicle (EV) “take over” that is impending. States like Ohio need to be aware of just how near in the future electric vehicles may make up a considerable percentage of all vehicles on the road. Figure 9 is from this
Times article, and it shows that for almost all cars on the road to be electric by 2050, new plug-in sales would need to quickly ramp up to 100 percent in the next 15 years. While 100 percent sales may seem unrealistic, GM has already committed to selling only EVs by 2035. Not only that, but this figure also demonstrates that the growing sales and market share of EVs will cause them to make up a significant portion of vehicles on the road. Figure 10 contains the more accurate case to likely occur. If electric vehicle sales gradually ramped up to 60 percent over the next 30 years, as analysts of IHS Markit project, then around 40 percent of cars on the road would be EVs by 2050. If electric vehicles make up anywhere near 40 percent of the driving public, it will have an undeniable and significant impact on gas tax revenues, forcing states’ hands into action regarding transportation finance. Therefore, a proactive solution is necessary, to ease the transition into the inevitable. Several tables created for this analysis will demonstrate what the impact of EV fees are and put into perspective how the use of electric vehicles and more fuel-efficient vehicles affect the amount of gas tax paid.

Table 3 gives an estimate of what the average driver not driving an electric vehicle pays in gas taxes and compares it to the state’s EV fee. This calculation was made by taking average individual VMT, dividing by the average fuel efficiency, and multiplying by the gas tax rate. This produces an estimate of how much the average driver pays in gas taxes every year. Each state’s gas tax rate (as of 2019) is listed. Some do not come out to even numbers and some may even have multiple decimal places. This is because sometimes legislators raise gas taxes to a specific price, and sometimes they raise gas taxes by a percentage. Percentage changes can result in non-round numbers. Also, California’s gas tax was historically split into two parts, but was recently combined. Other parts of this paper add both portions of California’s gas tax rates together for one single rate. For most of the states, estimates from the specific state were able to
be used to complete calculations. For average fuel efficiency, California is the only state from this group that has its own calculation and standards on vehicle fuel efficiency. For VMT it was possible to gather estimates for each state, although some are more of approximations than others. Each state department of transportation records this data differently, which can cause variations in accuracy. Despite these flaws, this data allows a good approximation that makes analysis of electric vehicle fees and the gas tax possible. In each of the states on the table, electric vehicle drivers tend to pay less in taxes than those driving gas-powered vehicles. In Ohio that discrepancy is just $30, but for states like California and Pennsylvania the margin of difference is much more significant. For example, Californians who pay the EV fee pay $234.66 less in taxes on average. Regardless of the margin, the set levels for EV fees in these states produce less tax revenue than the gas tax on average. As a result, as more drivers move to electric vehicles there will be an overall decrease transportation funding, unless the EV fee rates are changed.

Table 3 adds another dimension to comparing the gas tax to EV fees, showing gas taxes paid but multiplying the VMT by 1.5 and .5 to show how the tax discrepancies are affected by how much driving a motorist does. Table 3 displays how the distance drivers drive on a yearly basis can affect how much they end up paying in gas taxes. Comparing this to each state’s EV fee further illustrates the inefficiencies in allowing drivers to pay an EV fee. It will result in some individuals payments not correlating to their amount of road usage. No matter if you drive a lot or a little, with the EV fee you pay a flat rate. The way the gas tax is better is that it at least proportionally tracks road usage, just not as accurately as it has in the past, due to the rise of alternative vehicles and the increase in fuel efficiency. The column showing 1.5 the VMT represents more active drivers’ average cost in gas taxes. The next column shows half VMT,
which represents less active drivers, who subsequently pay less in gas taxes. In California, Colorado and Pennsylvania, their complete range of gas tax expenditures, whether a more active (1.5 VMT) or less active (0.5 VMT) driver, still pay more in taxes that those paying an EV fee. In states such as Ohio and Michigan however, a less active driver might be able to pay less in taxes by driving a gas-powered vehicle rather than paying the EV fee. For example, based on VMT the range for estimated gas taxes paid for Ohio is $115 to $345. This means for electric vehicle owners who don’t drive much the $200 fee is not a bargain but for those who drive more miles on average, they are getting a discount on their driving cost. Meanwhile, California’s and Colorado’s low-end gas tax paid estimate is still more than their respective EV fees, meaning that, whether intentionally or not, there is a tax incentive to drive electric vehicles. The reason for analyzing this is that it illustrates the issues in determining the adequacy and viability of using EV fees as a source of revenue for Ohio roads. While the previous table displayed that often an electric vehicle fee is not keeping up with gas tax revenues, it becomes even more notable in Table 4. This table not only shows that the EV fee allows drivers of electric vehicles to not pay an equal share when it comes to financing the roads they use, it also shows that the drivers on the high VMT end could save $400 or more in California just by driving an electric vehicle.

California had wanted to push its fuel efficiency standards well past it’s current average of all vehicles at 25.2 miles per gallon (MPG). The regulation they had in place was that all new vehicles in California by 2026 would have to have an average MPG of at least 54.5. However, when President Trump took office in 2016, he rolled back the national fuel efficiency standards to 40 MPG by 2026 and made it so no state could have stricter fuel efficiency standards. President Biden rolled this back upon his election, and so now California’s standards can revert
to the 54.5 MPG requirement. Table 5 illustrates this change, with the first row displaying California’s average tax cost per driver if fuel efficiency standards are at 54.5, and the second row showing the same but with Trump’s cutback to 40. The difference on average in revenues between the Trump fuel standards and California’s fuel standards is more than $50 less revenue per driver (which alone is half of their electric vehicle fee in 2019). This table exemplifies how severely increased fuel efficiency can affect gas tax revenues. So, while this is a victory for California in terms of environment protection and standards, it will even further drastically impede their gas tax revenues in the following years. Increased fuel efficiency can deteriorate gas tax revenues very quickly, and California already has the highest tax rate on motor-fuel in the United States.

While Michigan and Pennsylvania worked well as comparison states to Ohio, it is also important to see what the difference in approach is for states who differ greatly from Ohio as they can help forecast what Ohio might expect to deal with in the future. California, Colorado, and Oregon are all three much different than Ohio, and these states differ with each other to an extent as well. The unifying characteristic between these three states is in policy approach- each state has implemented a pilot program studying a vehicle miles traveled (VMT) tax system. These states different approaches to transportation policy can help give further guidance to possible approaches to improving or replacing the gas tax in Ohio. Pilot programs have started to emerge in some states as professionals and practitioners point to the dwindling gas tax revenues. The pilot programs enact trials of the VMT tax, through different methods of tracking miles driven by drivers and charging them directly for road use this way. Another problem is that the gas tax may no longer be operating as a true user fee. The VMT tax is a way of returning
transportation funding to a truly user fee system. Neither Ohio, nor Pennsylvania and Michigan have enacted a pilot study to examine possible alternatives to the gas tax.

The second group of states examined here have been much more progressive when it comes to transportation funding. California, Colorado, and Oregon each have implemented pilot programs to test the feasibility of alternatives to the gas tax. This policy approach is due to an issue common to all three states. All three states have dealt with decreasing gas tax revenues. Before examining each state’s pilot program, this study will illustrate how declining or stagnant revenues drove these states to the search for an alternative. Figure 11 is a table of California’s gas tax revenues adjusted for inflation from 1994 to 2014. Governing created their graphs using data from the U.S. Census Bureau and then adjusting the numbers for inflation in 2014 dollars. California eliminated its state sales tax on gasoline in 2011 but simultaneously hiked per-gallon gasoline excise taxes. The drastic spike of 2011 is due to the hike of gas taxes that compensated for eliminating the state sales tax on gasoline, which were two distinct taxes. The state government raised their gas tax again in 2013, which explains the increase in revenues from 2013 to 2014. If solely tracking revenues in 1994 and then in 2014, the result would be a large growth in gas tax revenues. However, that would be misleading. Especially since 2004, every year (excepting hikes of the tax) revenues consistently trended downwards. The only reason gas taxes in California have grown over two decades is that they have been propped up with multiple gas tax hikes and having the tax indexed to inflation. Simply put, after every gas tax hike, revenues begin to fall again a year later. While there are many contributing factors to this declining revenue, the decline of revenue is the reason for California exploring alternatives to the gas tax.
Next, Colorado’s gas tax revenues from 1994 to 2014 show a similarity to California. Figure 12 is also produced by Governing, using U.S. Census Bureau Data. This graph has an upward trend up to 2001, afterwards the graph works down until 2014 where the revenue amount is almost the same as it was in 1994. Except for an unexplained rise in tax revenues in 2007, gas taxes have been gradually declining in Colorado since 2004. The revenues in this graph are adjusted for inflation in 2014 dollars. Colorado has failed to raise its gas tax since 1991. Even more damaging to Colorado’s transportation funding is that their average vehicle miles traveled has gone from 847.49 miles in 1991 to 1,234.57 miles in 2014 (Colorado DOT, 2014). This means while revenue has fallen back down to early 1990’s levels, the road usage has increased greatly, resulting in greater need for road improvements and maintenance. The similarity to California is in Colorado’s downward trending gas tax revenues. Like California, it has overall increased its revenues since 1994, but is now set on a downward path. Even if Colorado did pass a gas tax hike, it could be argued it would continue to decline again after jumping up for one year. The motivation for their pilot program is undoubtedly caused by the need for more funding to maintain their infrastructure. Research conducted by the Southwest Energy Efficiency Project (SWEEP) concluded that Colorado missed out on up to $7 billion in transportation funding since 1991, largely because the state has not raised its gas tax to keep up with inflation. The paper also noted that Colorado voters rejected ballot initiatives in 2018 and 2019 that would have generated additional funds for transportation. As a result of those failed initiatives, state legislators were forced to fill gaps in transportation investment by transferring money from the general fund. This need for better transportation funding is the motivating factor behind Colorado examining alternatives to the gas tax.
Lastly, Figure 13 shows gas tax revenues in Oregon from 1994 to 2014. The graph shows revenues in 2014 were lower than they were in 1994 (after adjusting for inflation in 2014 dollars). Oregon last raised its gas tax in 2011, yet after 2012 revenues began to decline again. These declining gas tax revenues show that Oregon, unlike its companions California and Colorado, have actually declined below their 1994 level in 2014. Not only have they fallen below 1994 levels, but without the spike created by their tax hike in 2011, they would be even further below previous levels. Oregon has a clear need for a better transportation funding mechanism, and that is why Oregon is also conducting research into alternatives for the gas tax.

While California, Colorado, and Oregon have all conducted pilot programs, they have also approached other elements of transportation funding policy differently. California has indexed its gas tax to CPI, similarly to Michigan. Colorado and Oregon have not instituted an indexation in their states. The lack of indexation especially hurts Colorado, as they have not been able to raise their tax rate since 1991. However, all three states have instituted EV registration fees. California has its fee set at $100, Colorado’s is at $50, and lastly Oregon with its fee set at $110. EV registration fees have a larger impact for transportation funding in these states than they did for Ohio, Michigan, and Pennsylvania. That is because EV market share is much larger in California, Colorado, and Oregon. Oregon and Colorado both have 3% EV market share, which is 3 times the size of Ohio’s market share. California’s EV market share is higher still, at a nation high 8%. California also has the highest fuel efficiency standards in the nation. When taking these two factors into account, it is apparent that these states, especially California, are dealing with some issues that even further decline gas tax revenues.

Though pilot programs instituted in each of these three states vary, they are similar in their overall goal of evaluating the viability of different forms of a VMT tax. These studies take
the theory of replacing the gas tax with mileage-based user fees and put it to the test in the real world. Next this paper examines each states pilot program individually by using a set of similar criteria to each study, such as number of vehicles, length of study, and mileage recording methods.

California’s pilot program included 5,000 vehicles, the largest experiment of its kind at the time. Its test run lasted for nine months through March 2017, and it incorporated trucking companies along with individual motorists from every county in the state. Transport Topics, an organization the reports on transportation in America, said that “California gave participants seven ways to track their mileage, including odometer checks, permits for a set number of days, permits for a certain allotment of miles, plug-in devices, smartphones and in-vehicle telematics like OnStar or Acura Link” (Transport Topics, 2017). Permits allow drivers to pay up front and continually drive until they reach either the mileage or time limit set. At the expiration of the permit, drivers would need to renew or move to a different payment method. Smart phones and in vehicle telematics are both very convenient as they are already built into the driver’s phone or car. They use GPS to track mileage and have options that do and do not track the driver’s location, at the driver’s discretion. The wide array of options gave users a choice on how much privacy they desired. Privacy is one of the chief concerns when evaluating mileage-based user fees (MBUFs). Interesting to note, more than half of the participants in California’s study chose options that tracked their location regardless of having options that provided more privacy. This is viewed as a positive sign to the acceptability of a range of alternative measurement systems.

California made several conclusions at the end of their pilot program. The program used four different third-party vendors to collect mileage data and to issue invoices. This simulated how the infrastructure of a VMT tax might work if implemented. Another method tested in the
study was the ability to offer no-tech, low-tech, and high technology reporting and recording methods, to test viability and potentially to give users more choice in what system and privacy levels they are comfortable with. There were many different available options for payment and recording during the pilot program. Buying a time permit for unlimited driving during a set period of time was one option that required no-tech. Another no-tech option was manual recording of the odometer, with an inspection every 3 months or so. There is some concern of tampering with this option. Automated reporting with no location was a low-tech option that has the privacy of the low-tech, but the ease of automatic recording of mileage. This could be done with a plug-in device, or through use of a smart phone. Both mechanisms could also be used to record mileage with location, the high technology option. Feedback at the conclusion of the program was very positive, users reported being very happy with whichever recording method they chose. Despite these positives, the study did also conclude that while all the mileage reporting methods the program tested proved to be feasible, they are not yet ready to compete with the simplicity and public approval of the gas tax. While their system is not yet ready to implement, conducting a pilot program is a necessary step if a state is to make a switch from the gas tax to an alternative.

Colorado also has implemented a pilot program. In Colorado gas tax rates have remained the same for 24 years, but they recently finished a four-month test with 150 drivers that explored different ways of tracking mileage for motorists. This test was motivated by their declining gas tax revenues driving them to search for alternatives. Similar to California, Colorado concluded that the road charge system it tested can be feasible as an alternative to the gas tax. Another conclusion made based on their study was that the technology-based systems were highly accurate and the most convenient option for users, while the manual option experienced low
compliance over the course of the pilot. The test drivers who chose technology recording options had 93% satisfaction compared to just 55% satisfaction for those that chose the manual option (CDOT Executive Summary, 2017). There were several concerns the study identified as well. These were factors such as how they would charge mileage on non-public roads, or how they would handle capturing mileage for out-of-state drivers. California also identified out of state driver’s being a concern, although they believe developing a partnership with nearby states would enable them to capture the large majority of out of state motorists. This would likely erase the out of state motorist issue, so long as other states began moving in the direction of a VMT tax system and were willing to cooperate with each other. Colorado’s pilot program was deemed a success and is a promising step in the direction of moving on from the gas tax.

Lastly, Oregon conducted a pilot program of their own. They aimed to develop what they called the Oregon mileage fee concept. Their research was like Colorado’s and California’s as they are aiming to develop their own version of a VMT tax. The scope of Oregon’s testing was smaller than California’s in size but lasted a full year. They tested the technical and administrative feasibility of the road charge concept. Their program included 285 volunteer vehicles with 299 drivers, all based around Portland. Part of the limit to the program is that it could not capture the range or urban and rural environments to the extent that California and Colorado did. The motivation behind Oregon’s program was to replace the gas tax as they had identified major concerns with it. Oregon’s DOT identified a couple of these issues, saying that the gas tax does not directly link to the burden vehicles place on the roads and therefore do not operate as user fees. That would mean the roads funding is no longer connected to its equivalent use, which leads to inefficiencies in the funding of highway management. Typically, as seen by declining revenues, this inefficiency is leading to state departments of transportation being
underfunded. The other key problem identified was revenue erosion. Fuel-efficiency improvements have reduced gas tax payments per vehicle mile traveled, and fuel efficiency continues to rise. This motivated a pilot program to test how an alternative to the gas tax might operate.

The conclusions of Oregon’s study were very promising. One of these conclusions was the viability of paying a mileage-based tax at the pump. This would result in minimal difference in process or administration for motorists, compared to how they pay the gas tax. Like the gas tax, collection of the mileage fee can be embedded within routine commercial transactions, with the bulk of it pre-paid by the distributor in the form of the gas tax. The research also concluded that the potential for evasion of this tax is low. Tampering with the on-vehicle device would result in automatic payment of the tax. That is thanks to a failsafe built into the mileage recording device. The difference between what is already paid in gas taxes and mileage fees will likely be small, providing little incentive to try to evade the mileage fee.

One of the other positive conclusions of the study was that the projected cost of implementation and administration of the mileage fee system they tested was low. The Oregon DOT would incur operating costs for auditing and providing technical assistance to service stations and motorists. Management should cost roughly $1.0 million annually, an insignificant amount compared to expected annual mileage fee revenue. This study concluded MBUFs tend to be more expensive to administer than the current gas tax system, with the cost estimated at approximately five percent of collected revenue, compared to the current cost of the gas tax of two-to-five percent of collected revenues. However, the Oregon pilot study estimated that most of a MBUF program’s costs come from the initial capital expenditures needed to get started. These included the equipment, software, and installation costs. If the Oregon pilot is indicative
of what administrative costs might be, then a MBUF program would still net gain in revenues significantly when compared to the gas tax in the long-term.

Examining both the similar and dissimilar states to Ohio gives valuable insight in how Ohio might handle its gas tax situation. Michigan and Pennsylvania show what different management methods might work in supplementing gas tax revenues for Ohio, especially because of how similar their characteristics are. However, turning to states that are dissimilar to Ohio provides insight as well. California is ahead of the curve when it comes to transportation, as it experiences problems Ohio may in the future (such as an 8% market share of EVs), and also is actively testing alternatives to the gas tax with its pilot program. These differences help to forecast what Ohio may face in the future and point to several recommendations that could work for Ohio.

The discrepancy in fungibility between Ohio and its comparison states Michigan and Pennsylvania may explain why Ohio scores better overall in the Reason Foundations rankings of state highway management. However, this points to a lack of flexibility for Ohio when compared to Pennsylvania and Michigan. Those two states still have the option of cutting back on fungibility to secure more highway funds. Fungibility being so low in Ohio is seen as a positive when it comes to good highway management but may also be considered as a warning sign when it comes to decreasing gas tax revenues. Fungibility management is one option already closed to Ohio when it comes to supplementing or supporting gas tax revenues.
Analysis Part II: Gas Tax Revenues, CPI, and the Gas Price Index

To better understand the role of inflation in gas tax revenues, it is helpful to understand how gas tax revenues evolve. Gas tax revenues depend upon the demand for gasoline and the tax revenue rate. The demand for gasoline can vary due to the price, to weather conditions, and the health (or lack thereof) of the economy. The gas tax rate is set by legislative action and does not change unless new legislation is passed, or it is indexed to change in tandem with an inflationary measure, such as the CPI index or the oil and gas price index. However, overtime the purchasing power of the tax rate can erode because of inflationary pressures. This is vital because *ceteris paribus* inflation increases the amount of money needed to maintain Ohio’s roadways and bridges. So, while inflation may not be directly related to VMT, adjusting for inflation could potentially close this gap, making the gas tax more efficient and able to manage roadway funding more effectively. Figure 14 displays Ohio’s gas tax revenues from 1994 to 2019. The case study done on Ohio earlier in this paper describes the history of the gas tax in Ohio. Drawing back on that, the largest increase in Ohio’s gas tax rate was back in 2005, and that is the most significant period of growth in Figure 14. The state legislature had modified the motor fuel tax in 2003 gradually raising the rate from 22 cents per gallon to 28 cents by July 1st, 2005. Outside of this anomaly, growth in gas tax revenues in Ohio have remained consistent but sluggish.

Several states have used CPI or gas prices to index their gas taxes to maintain the purchasing power of the tax rate. As described in the literature review, this is one of the ways legislators today are trying to bolster gas tax revenues from their national stagnation and decline. However, these approaches are only an estimate of the changes in the cost of the resources which might not accurately reflect differences in road usage. The following analysis compares changes in Ohio’s gas tax revenues to both CPI and gas price changes, to examine how they are related
and if they might be effective means for strengthening gas tax revenues. For this analysis the formula gas tax revenues equal gallons purchased multiplied by the gas tax rate (cents per gallon) was used. The equation was developed to evaluate changes in gas tax revenue over time. Gas tax revenues vary by changes in the gas tax rate and in the number of gallons purchased. The number of gallons purchased depends upon prices, and a variety of other factors such as income, which explains the clear drop in each graph following the Great Recession.

The Consumer Price Index (CPI) is a measure of the average change over time in the prices paid by urban consumers for a market basket of consumer goods and services. CPI is calculated by averaging price changes of a set list of consumer goods and services. Changes in the CPI are used to gauge the change of the cost of living. The CPI is one of the most frequently used statistics for identifying periods of inflation or deflation. Average price data for automotive fuel/gas prices is commonly available on its own but is accounted for inside of CPI. According to the Bureau of Labor Statistics, changes in gas prices have more of an impact on short-run movements in the Consumer Price Index than anything else, although they only account for six percent of CPI calculations (Crawford, 2013).

Some states adjust their gas tax rates by the CPI, others use an index of oil and gas prices. For example, Michigan indexes their gas tax rate to changes in CPI, while California indexes their gas tax to both CPI and changes in gas prices. Figure 15 compares the percent changes in both CPI and an index of the prices of gas and oil in the United State. As might be expected, CPI is more volatile as it tracks the changing inflation rate or more goods and services, some of which may be more sensitive to changes in the economy. This illustrates what Crawford wrote above about how large of an impact gas price changes have on overall CPI. The impact of the Great Recession (2007-2009) is clearly displayed. As a result of the Great Recession CPI can be
seen changing negatively in 2009, while gas prices dropped in percent change by a much smaller margin. Based on the graph, either CPI or gas prices could be used to effectively index the gas tax and help it to match increased demand or roadway usage. CPI would likely offer a more variable change in the gas tax, while the changes if indexed to changes in gas prices would be more consistent. This is inferred by the smaller fluctuations in percentage change in gas prices.

While it displays correlation to both measures, the changes in Ohio’s gas tax revenues seem much more closely tied to changes in CPI than in gas prices. Gas price percentage growth is consistently around 2%, with little variation outside of that range. The CPI rates are closer to 3% on average, but they also experience drastic falls in growth, becoming negative briefly due to the Great Recession. The CPI’s more drastic changes is because it is made up of a series of consumer goods and services that track the changes in prices of goods. As a reaction to the Great Recession consumer spending drastically fell, which caused producers and service providers to drop prices to meet the reduced demand.

The impact of indexing Ohio’s gas tax to CPI or gas prices would both function differently but would both likely help Ohio’s tax revenues to grow faster than they do currently. If indexed to gas prices, which do not change as significantly to Ohio’s gas tax revenues, it would likely cause Ohio’s gas tax revenues to grow at a more consistent pace, rather than fluctuating so greatly. In the case of CPI, indexing the gas tax would result in still less fluctuation, but not to the degree that indexing to gas price changes would. While the CPI index achieves greater highs than the gas price index at points, it also has much lower lows, and is less consistent. These observations point towards gas prices as being a better index for Ohio’s gas tax as it would help to achieve more consistent and greater growth in revenues. However, there is still an argument to be made for indexing to CPI. While it could cause tax revenues to decline on
occasion due to its variability, what it really does when it is decreasing revenues is lowering the gas tax rate. Since CPI growth tends to turn negative only in severe economic crises, it could be argued it is a perfect time for a tax break for citizens dealing with economic hardship. This might be true especially considering how the gas tax does place a disproportionate burden on the poor.

The final graph (Figure 16) shows nominal gas tax revenues (in millions of dollars), along with two indexed gas tax revenues for comparison of the impact of two methods of indexing Ohio’s gas tax revenues. The brown solid line displays Ohio gas tax revenues indexed to CPI inflation, and the blue solid line displays the same but indexed to the gas and oil price index. This graph displays that gas tax revenues would be higher if indexed to inflation, and as discussed already there would be benefits to either or both forms of indexation. That does not include the exception of 2008, where CPI rates would have decreased the tax rate temporarily due to the financial recession. Unfortunately, the graph also displays how indexation does not make drastic improvements to revenues, and while it does increase them consistently, it by no means can truly alleviate the declining purchasing power of the tax revenues, especially with the growth of electric vehicle sales, and examples such as General Motors recently declaring they would only be selling electric vehicles by 2035. With these factors in mind, it appears indexation could operate as a temporary buffer rather than a final solution.
Conclusion: Ohio’s Next Steps

Ohio has faced several issues that have caused a decrease in the purchasing power of gas tax revenues, especially when considering the correlating increases in vehicle miles traveled. A large part of this is due to increased fuel efficiency, although the tax rate only being raised twice since the early 1990’s has not aided the tax rate in keeping up with inflation either. Headlines like GM moving to all electric vehicles by 2035 drives home the other issue; more and more vehicles on the road are not using motor-fuel. If this is not addressed, state departments of transportation such as Ohio’s will either be strapped for cash and further road deterioration will occur, or their state legislature will divert more funds to them from elsewhere, reducing funding for other essential programs. Ohio needs to look to new options for measuring and taxing roadway usage.

The first section of the analysis explored the effectiveness of electric vehicle registration fees as a supplement to transportation funding, applying it to Ohio and several other states. That section of the analysis highlighted that the current average combustion engine driver still contributes more to transportation funding than an EV fee paying individual by roughly $30 in Ohio, although this gap is wider in many states. For example, in California an estimate of motor-fuel drivers’ VMT who drive less than average, still would tend to pay $50 or more in taxes towards roads than their electric vehicle counterparts, even if the EV drivers drive much more than average (Table 3).

The same section also explored pilot programs. Several states have conducted pilot programs examining mileage-based user fees (MBUFs also known as VMT tax) as an alternative measure of road usage. States such as Oregon and California have explored and implemented different versions of a VMT tax in small scale, with positive results. California’s study was more
robust, testing 5,000 vehicles with their system. While Colorado’s program only tested 150 drivers, it demonstrates a good starting point for smaller or wary states who want to evaluate alternatives to the gas tax system. These pilot programs demonstrate the ability of MBUFs to track road usage, maintain privacy, tax equally, and most importantly concerning this research, could keep transportation financing revenues stable, and even increasing. This is because MBUFs are not affected by the energy source, or the energy efficiency of vehicles. There would be no need to regularly raise the VMT tax rate to keep up with improved fuel efficiency, which can have a large effect on tax revenues (as seen in Table 5). The operate more fairly because they tax each driver based on how much they drive, meaning that it would operate as a true user-fee.

In the Ohio Case Study we identified the gas tax was chosen to finance transportation due to technological limitations of the time, and because it operated as a user-fee, taxing each driver based on how much they used the road, albeit indirectly by taxing the price of gas. As motor-fuel vehicles have become more efficient, and more electric vehicles hit the pavement, the gas tax has become a less accurate measure of usage, and thus can no longer be considered a true user-fee. Using the technology of today, it is possible to have a direct user-fee, in the form of a vehicle miles traveled tax system. As shown by the multiple successful pilot programs, the technology and apparatus are already available to implement this type of tax.

The second section of the analysis studied gas tax indexation, or different methods of keeping tax rates up with inflation, without the need of legislative action, which can be slow due to political gridlock. The two most common methods of this were examined, being indexation to the Consumer Prices Index, and the Gas & Oil Prices index. This method of increasing gas tax revenues performs more like a bandage than a permanent solution. Figure 16 shows that unfortunately, indexation does not drastically raise revenues, so it by no means can truly alleviate
the declining purchasing power of the tax revenues. While the gas tax rate could be raised with this and other legislative methods, none of them solve the underlying issues of the different rates of fuel efficiency and different fuel sources. These issues cause individuals to be taxed unequally, and not accurately capture their road usage. Indexation does not turn the gas tax rate back into a user-fee. While in the short run it could immediately raise revenues, it has no long-term viability in accurately capturing the demand for road usage.

The best path forward for Ohio can be identified, at least in a broad manner, by using the preceding analysis. First, Ohio must recognize that the motor-fuel tax is no longer operating as a user fee and is not accurately capturing the demand for road usage. The gas tax has become increasingly divorced from road usage because of more fuel-efficient vehicles driving farther on a gallon of gas than ever before and alternative vehicles not even using motor-fuel for propulsion. Once the deteriorated connection between the gas tax and vehicle-miles driven is accepted, serious alternatives can be evaluated and implemented.

The second step is that Ohio must find a more accurate measure of roadway usage and demand for usage. While this could come in the form of toll roads or alternative-vehicle fees, a mileage-based user fee would immediately and accurately measure road usage by individuals and allow the government to tax the driving public more efficiently and fairly. Some of the advantages of using a MBUF is that it would serve as an extremely accurate measure of roadway usage, and could more efficiently and fairly replace both the motor-fuel tax and alternative vehicle fees, as the method of propulsion is not a factor of MBUFs. Also, as the Oregon pilot study showed, while the cost of administration is higher, the net gains in revenue far surpass the gas tax system. Charging drivers per mile results in drivers paying proportionally for the exact amount of the road that they use.
To accomplish the implementation of a mileage-based user fee, it may be valuable for Ohio to conduct a pilot study such as California, Oregon, and Colorado have done. This would provide a testing period and potentially serve as a bridge to implementation of a mileage-based user fee. While this is not necessarily the only path to implementing a MBUF, it would put Ohio in the leading group of states looking to the future of transportation financing, rather than falling behind or resisting the change, which would undoubtedly be problematic for the driving public, legislators, and state government employees. Ohio must look to alternatives to the motor-fuel tax, and the implementation of MBUFs are the leading candidate for an accurate measure of roadway demand that would increase transportation funding revenues. A MBUF that used GPS tracking to a secure database, and billed individuals for their usage on a monthly basis just as any other utility, is clearly the best and most realistic option when it comes to replacing the gas tax with a system that would accurately measure and tax individuals’ road usage. If Ohio does not follow these steps, or a similar approach, the gas tax will continue to show cracks and inefficiencies that will hurt Ohio’s roads, drivers, and economy. The worse roads become, the more they cost drivers. The costs associated with auto repair greatly outweigh the typical range of gas tax paid per year (typically between $200 and $300 annually, Figure 4). These steps would not only help Ohio avoid the side effects of an issue that has been forecasted and predicted for decades, it would establish Ohio as a forward-thinking state that is prepared for the future as new technologies continue to change the way Americans live their lives.
Figures and Tables

Figure 1:

Source: Cleveland 2019

Figure 2:

-ODOT 2017 Annual Report pg. 36
Figure 3:

Ohio
Inflation-adjusted change since 1994: -$144,821,000 (-7.3%)
Inflation-adjusted change since 2000: -$91,890,000 (-4.8%)
Years since raising gas tax: 9.6 years as of February

Figures were adjusted for inflation and shown in 2014 dollars.

SOURCE: Governing calculations of U.S. Census Bureau Annual Survey of State Government Tax Collections data.
Figure 4:

Purchasing Power of Federal Gas Tax Rate Has Fallen by Nearly Two-Thirds Because of Inflation and Fuel-Efficiency Gains

Cumulative Decline in Value of 18-Cent Gas Tax Rate Since 1993

Source: Institute on Taxation and Economic Policy (ITEP) analysis of data from the Federal Highway Administration (FHWA), Energy Information Administration (EIA), and Congressional Budget Office (CBO).

Figure 5:
Federal highway fund revenues and expenditures in real dollars


Figure 6:
Source: The Cato Institute (Federal Highway Administration)

Figure 7:
Adjusted Fuel Economy, Weight, and Horsepower for MY 1975-2013

Source: 2019 EPA Automotive Trends, pg. 7
Figure 8:

Figure ES-1. Estimated Real-World CO₂ and Fuel Economy

Source: 2019 EPA Automotive Trends, pg. 3
Table 1:

<table>
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<tr>
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<tbody>
<tr>
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<td>12</td>
<td>23</td>
<td>15</td>
<td>3,603,684</td>
<td>8,863</td>
<td>4.21</td>
<td>Larger, varied</td>
<td>3%</td>
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<td>Colorado</td>
<td>36</td>
<td>28</td>
<td>47</td>
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<td>9,506</td>
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<td>43</td>
<td>47</td>
<td>45</td>
<td>19,163,379</td>
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<td>39.51</td>
<td>Dissimilar, and warmer, less seasonal climate</td>
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<td>42</td>
<td>34</td>
<td>5,762,856</td>
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<td>Pennsylvania</td>
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<td>32</td>
<td>32</td>
<td>13,325,716</td>
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<tr>
<td>Ohio</td>
<td>18</td>
<td>29</td>
<td>31</td>
<td>7,545,688</td>
<td>10,253</td>
<td>11.69</td>
<td>N/A</td>
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Sources: Federal Highway Administration, ODOT Annual Reports, U.S. Census Bureau, National Conference of State Legislatures, EPA Annual Report, Reason Foundation State Rankings, and the U.S. Department of Energy

Table 2:

<table>
<thead>
<tr>
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<td>Oregon</td>
<td>No</td>
<td>110</td>
<td>Y</td>
<td>3%</td>
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<tr>
<td>Colorado</td>
<td>No</td>
<td>50</td>
<td>Y</td>
<td>3%</td>
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<td>California</td>
<td>Yes</td>
<td>100</td>
<td>Y</td>
<td>8%</td>
</tr>
<tr>
<td>Michigan</td>
<td>Yes</td>
<td>135</td>
<td>N</td>
<td>1%</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>Yes</td>
<td>None</td>
<td>N</td>
<td>1%</td>
</tr>
<tr>
<td>Ohio</td>
<td>No</td>
<td>200 (100 for hybrids)</td>
<td>N</td>
<td>1%</td>
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</table>

Sources: Federal Highway Administration, ODOT Annual Reports, U.S. Census Bureau, National Conference of State Legislatures, EPA Annual Report, Reason Foundation State Rankings, and the U.S. Department of Energy
Table 3: Projected Electric Vehicle fee compared to average gas tax paid per year per individual.

<table>
<thead>
<tr>
<th>State</th>
<th>Annual Average Vehicle Miles Traveled</th>
<th>Average Fuel Efficiency (MPG)</th>
<th>Gas Tax Rate (cents per gallon)</th>
<th>Estimated Gas Tax Paid (Dollars Per Year)</th>
<th>Electric Vehicle Fee</th>
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<tbody>
<tr>
<td>Ohio</td>
<td>14050</td>
<td>23.5</td>
<td>38.5</td>
<td>230</td>
<td>200</td>
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<td>California</td>
<td>13500</td>
<td>25.2</td>
<td>62.47</td>
<td>335</td>
<td>100</td>
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<td>Colorado</td>
<td>13664</td>
<td>23.5</td>
<td>22</td>
<td>128</td>
<td>50</td>
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<tr>
<td>Michigan</td>
<td>13268</td>
<td>23.5</td>
<td>41.98</td>
<td>237</td>
<td>135</td>
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<td>Pennsylvania</td>
<td>11243</td>
<td>23.5</td>
<td>58.7</td>
<td>281</td>
<td>0</td>
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</table>

Sources: Federal Highway Administration, U.S. Census Bureau, National Conference of State Legislatures, and the U.S. Department of Energy

Table 4: Electric vehicle fee compared to average gas tax paid per year per individual, with vehicle miles traveled ranges of 0.5 and 1.5.

<table>
<thead>
<tr>
<th>State</th>
<th>Gas Tax Paid Per Year</th>
<th>Gas Rate Based on Vehicle Miles Traveled (0.5)</th>
<th>Gas Rate Based on Vehicle Miles Traveled (1.5)</th>
<th>Electric Vehicle Fee</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ohio</td>
<td>230</td>
<td>115</td>
<td>345</td>
<td>200</td>
</tr>
<tr>
<td>California</td>
<td>335</td>
<td>167</td>
<td>502</td>
<td>100</td>
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<tr>
<td>Colorado</td>
<td>128</td>
<td>64</td>
<td>192</td>
<td>50</td>
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<tr>
<td>Michigan</td>
<td>237</td>
<td>119</td>
<td>356</td>
<td>135</td>
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<tr>
<td>Pennsylvania</td>
<td>281</td>
<td>140</td>
<td>421</td>
<td>0</td>
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Sources: Federal Highway Administration, U.S. Census Bureau, Ohio Department of Transportation, National Conference of State Legislatures, and the U.S. Department of Energy
Table 5: Changes in Average Gas Tax Paid Based on Changes in Average Fuel Efficiency

<table>
<thead>
<tr>
<th>Gas Tax Paid Per Year</th>
<th>Electric Vehicle Fee</th>
<th>California Average Individual VMT</th>
<th>Proposed Fuel Efficiency Standards by 2026</th>
<th>California Gas Tax Rate (cents)</th>
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<tbody>
<tr>
<td>$154.74</td>
<td>100</td>
<td>13500</td>
<td>54.5</td>
<td>62.47</td>
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<tr>
<td>$210.84</td>
<td>100</td>
<td>13500</td>
<td>40</td>
<td>62.47</td>
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</table>

Sources: Federal Highway Administration, U.S. Census Bureau, National Conference of State Legislatures, California State Legislature, and the U.S. Department of Energy

Figure 9:

Source: New York Times
Figure 10:

Source: New York Times
Figure 11:

California
Inflation-adjusted change since 1994: +$2,028,610,000 (50.3%)
Inflation-adjusted change since 2000: +$1,882,158,000 (45.0%)
Years since raising gas tax: 1.6 years as of February

California passed a gas tax "swap" that took effect in 2011. It eliminated the state sales tax on gasoline but...

Figure 12:

Colorado
Inflation-adjusted change since 1994: -$1,258,000 (-0.2%)
Inflation-adjusted change since 2000: -$100,958,000 (-13.5%)
Years since raising gas tax: 24.1 years as of February

Figures were adjusted for inflation and shown in 2014 dollars.

Figure 13:

Oregon
Inflation-adjusted change since 1994: -$53,969,000 (-9.5%)
Inflation-adjusted change since 2000: -$139,228,000 (-21.4%)
Years since raising gas tax: 4.1 years as of February

Figures were adjusted for inflation and shown in 2014 dollars.

Figure 14:

Ohio Gas Tax Revenues From 1994-2019

- ODOT Annual Reports, U.S. Census Bureau
Figure 15:

Figure 16: 

Potential Gas Tax Revenues if adjusted for Consumer Price Index or Gas Price Index


Footnote: To calculate the potential revenues with indexation to CPI and gas prices, several steps were followed. First, gas tax revenues were divided by the tax rate for any given year to get gallons purchased. Second, gallons purchased were multiplied by the gas tax rate times 1 + the inflation rate to achieve an indexed value of tax revenues.
Appendix:

<table>
<thead>
<tr>
<th>Date</th>
<th>Title</th>
<th>Author</th>
<th>Data</th>
<th>Summary</th>
</tr>
</thead>
</table>
| 1997 | Who Pays the Gasoline Tax? | Howard Chernick and Andrew Reschovsky |     | •Research question- who pays the gas tax, is it regressive and how does tax incidence affect the regressivity?  
•Purpose/motivation- show that the gas tax disproportionately affects low income households and individuals.  
•Key Findings- can't ignore burdens on low income individuals from reliance on gas taxes. Gasoline taxes could be increased without hurting low income individuals if providing efficiency benefits and compensation for those who are low income. |
| 2001 | Reconsider the Gas Tax: Paying for What You Get | Jeffrey Brown |     | •Research purpose- reviewing the origins of the gas tax to see how to develop an equitable and efficient successor.  
•Key Findings- Benefit of gas tax was that it worked as a user fee, and the cost to administer it was very low. Many of the alternatives offered |
<table>
<thead>
<tr>
<th>Year</th>
<th>Title</th>
<th>Author(s)</th>
<th>Summary</th>
</tr>
</thead>
</table>
| 2004 | Benefit Taxes and User Fees In Theory And Practice                    | David G Duff                   | • Argument- user fees (benefit taxes) are preferable to general taxes in some instances, and inferior in other instances.  
• Key Findings- user fees have efficiency and fairness benefits but have the potential for regressive incidence. Recommends new and restructured user fees/benefit taxes for transportation funding specifically. |
| 2005 | New Technology for an Old Dilemma                                     | Paul Sorensen and Brian Taylor | • Purpose- Give a general background of the motor fuel tax replacement options, and the feasibility (politically) of these options.  
• Suggests that electronic tolling of road use may be coming faster than many thought possible. |
<table>
<thead>
<tr>
<th>Year</th>
<th>Title</th>
<th>Author(s)</th>
<th>Source</th>
<th>Summary</th>
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</table>
| 2005 | Fueling Transportation Finance: A Primer on the Gas Tax | Bruce Katz, Robert Puentes | Highway Statistics: Federal Highway Administration (FHWA) | • Purpose - Primer on gas tax, gives background information on transportation funding.  
• Key Findings - Gas tax receipts are beginning to plateau. VMT is increasing faster than fuel consumption. |
| 2006 | A Quiet Crisis in Transportation Finance   | Martin Wachs    | • Purpose - raise awareness of this "quiet crisis", and advocate solutions.  
• Key findings - Erosion of user fees, more specifically, the gas tax is no longer working as a user fee as it had in the past.  
As the highway system grows, so does the cost of maintaining what we have, let alone build new projects.  
Worsening congestion is a product of having to dedicate funding to maintain, with nothing left to expand or innovate.  
Increased borrowing through bonds is one solution to the shortcomings of the motor fuel tax.  
Electronic tolling also a possible solution. |
<table>
<thead>
<tr>
<th>Year</th>
<th>Title</th>
<th>Author(S)</th>
<th>Abstract</th>
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</thead>
</table>
| 2007 | Paying at the Pump: Gasoline Taxes in America | Jonathan Williams | • Purpose - Make the argument that gasoline tax revenue should not be diverted to projects that are only tangentially related to transportation and tend to be politically motivated.  
• Main Arguments - Gas tax revenue spent on public education, museums, graffiti removal, and parking garages. HTF was established under Eisenhower as a temporary instrument, but is still in use today. New technology is changing the equation for transportation funding. Need more oversight to ensure revenue from gas taxes is used to build roads, and not diverted for other causes. |
| 2008 | The Road... Less Traveled: An Analysis of VMT Trends in the U.S. | Robert Puentes and Adie Tomer | • Purpose - Analyze trends of VMT in the U.S.  
• Findings - VMT plateau from 2004 to 2008. Passenger vehicles (cars and personal trucks) dominate the share of VMT. Reduced driving hurts transportation revenue streams. If VMT trends continue, there will have to be changes in how |
<table>
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<tr>
<th>Year</th>
<th>Title</th>
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<td>2009</td>
<td>Performance Driven: A New Vision for U.S. Transportation Policy</td>
<td>National Transportation Policy Project</td>
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<td>2009</td>
<td>The Surface Transportation Authorization Act of 2009</td>
<td>Committee on Transportation and Infrastructure</td>
</tr>
<tr>
<td>2009</td>
<td>Paying Our Way- A new Framework for Transportation Finance</td>
<td>National Surface Transportation Infrastructure Financing Commission</td>
</tr>
</tbody>
</table>

- Findings and recommendations-
  - real highway spending has fallen by 50 percent since the federal HTF was established. Since 1993, the federal gas tax has a loss in purchasing power of 33 percent. The reliance on gas based taxes for funding transportation is not sustainable in the long term and is likely to erode quicker than previously thought.
<table>
<thead>
<tr>
<th>Year</th>
<th>Title</th>
<th>Authors</th>
<th>Purpose</th>
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<tbody>
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<td>2010</td>
<td>Fairness of Transportation Infrastructure policies</td>
<td>Anjala Krishen, Robyn Raschke, and Michael Mejza</td>
<td>• Purpose - to expand the framework for outreach about policy measures designed to address pressing transportation problems, by looking more closely at the underlying mechanism driving the call by researchers for customized messaging strategies to help build transportation policy support.</td>
</tr>
<tr>
<td>2010</td>
<td>Nearly All States Received More Funding Than They Contributed in Highway Taxes Since 2005</td>
<td>U.S. Government Accountability Office</td>
<td></td>
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<tr>
<td>2011</td>
<td>From Fuel Taxes to Mileage-Based User Fees</td>
<td>David Coyle, Ferrol Robinson, Zhirong Zao, Lee Munnich Jr., Adeel Lari</td>
<td>Purpose - The public does not understand why there is an issue with the gas tax. This paper sets the stage for a policy discussion on transportation-related user fees and lays the groundwork for an extensive public outreach effort.</td>
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<tr>
<td>2011</td>
<td>Alternate Approaches to Funding Highways</td>
<td>CBO (Congressional Budget Office)</td>
<td></td>
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<tr>
<td>2011</td>
<td>End of the Highway Trust Fund?: Long-Term Options for Funding Federal</td>
<td>Joshua Schank, Nikki Rudnick-Thorpe</td>
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<td>2013</td>
<td>Road User Fees Instead of Fuel Taxes: The Quest for Political Acceptability</td>
<td>Denvil Duncan, John Graham</td>
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| 2015 | Impacts of Energy Developments on U.S. Roads and Bridges             | McCarthy, Leslie Ann; Park, Seri; Casazza, Paul; and Anthony R. Giancola | • purpose- document the economic impact of heavy truck traffic related to energy development on the nation’s roads and bridges. Strategies used by transportation agencies to minimize and pay for the damage caused by heavy loads are also documented.  
• methods- a review of the literature, a survey of state transportation agencies, and interviews with selected federal and tribal agencies. Follow-up interviews with multiple agencies in five states selected for further study provided additional information. |
| 2015 | Is It Time to Raise the Gas Tax? Optimal Gasoline Taxes for Ontario and Toronto | Joel Wood                                                                 | • Purpose- Determine the proper gasoline tax in the GTHA.  
• Results- recommend an optimal gasoline tax of 40.57 cents, which is much higher than the current 24.7 cents. |
<p>| 2016 | The Road Ahead for U.S. Infrastructure Funding                        | Jerome Dumortier, Fengxiu Zhang, John Marron                          | FHWA, 2014 Annual Energy Outlook by the EIA, CBO                                               |</p>
<table>
<thead>
<tr>
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<tr>
<td>2016</td>
<td>Plug-in vehicles and the future of road infrastructure funding in the United States</td>
<td>Jerome Dumortier, Matthew W.Kent, Seth B.Payton</td>
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</table>
| 2017 | Navigating an Uncertain Future for US Roads                           | John Paul Helveston                        | Federal Highway Administration (FHWA)    | Purpose- Show the failing of gas tax revenue and discuss options for funding that would be politically acceptable  
Findings- Today three technologies are rapidly changing transportation, and thus transportation funding. Electric power trains, autonomous vehicles, and ride sharing. The increase in fuel economy and greater adoption of electric vehicles is further hurting the revenues of the HTF. Since the Great Recession the HTF has relied on transfers for a significant portion of its funding.  
Interesting Facts- 3 models of electric vehicles in 2010, and in 2017 there were 25 models. |
<p>| 2017 | Seasonality Effect on Electric Vehicle Miles Traveled in Electrified Vehicles | Khalid Ahmed and Jimmy Kapadia             |                                         |         |
| 2019 | Vehicle Fleet turnover and                                            | David Keith                                |                                         |         |</p>
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<tr>
<td>2019</td>
<td>Fuel Economy, Electric Vehicles, and the Future of US Infrastructure Funding</td>
<td>Javier Andres Gotschlich Praus</td>
<td>•Purpose- examine how fuel tax policies affect the generation of revenue to maintain the US road infrastructure.</td>
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<tr>
<td>2020</td>
<td>Funding and Financing Highways and Public Transportation</td>
<td>Congressional Research Service: Robert Kirk and William Mallett</td>
<td>FHWA •Findings- expanding fleets of hybrid and electric vehicles are likely to raise equity issues for transportation finance. Improved fuel economy is slowly reducing the average amount of fuel used per mile of travel. The CBO projects that from FY2021 to FY2026 the gap between transportation revenues and spending will average roughly $18 billion annually.</td>
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<tr>
<td>2020</td>
<td>2019 EPA Automotive Trends</td>
<td>EPA</td>
<td>NA</td>
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<td>2002-2013</td>
<td>Ohio Department of Transportation Financial and Statistical Reports</td>
<td>ODOT/Jerry Wray</td>
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<td>2016</td>
<td>Ohio’s $1.6 Billion Highway Budget Shortfall: Where do We Go from Here?</td>
<td>Jerry Wray</td>
<td>• Purpose—Ohio’s highways are essential to keeping and creating new jobs. Advocates more funding for DOT • the state’s highway budget faces a $1.6 billion shortfall, which will force high-priority projects to face serious completion delays</td>
</tr>
<tr>
<td>2017</td>
<td>Funding Ohio’s Transportation System</td>
<td>American Council of Engineering Companies of Ohio</td>
<td>• Purpose—offer ACEC of Ohio’s position relative to highway infrastructure condition and funding and to offer solutions to achieve positive and continuous results for the public and private sectors calling Ohio home. • Potential Solutions—increase vehicle registration fees, temporary solution further raise of gas tax, allow TIDs to generate further gas tax revenue, VMT tax revenue, eliminate spending on bike baths/ other non-highway resources.</td>
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<td>2019</td>
<td>Fatigue Failure Model for Local Roads in Ohio that Use Road User Maintenance Agreements Due to the Increase in Truck Traffic</td>
<td>Gopallawa, Praveen</td>
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<td>2007</td>
<td>Oregon's Mileage Fee Concept and Road User Fee Pilot Program</td>
<td>James Whitty-Oregon DOT</td>
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<td></td>
<td>•Legislative Mandate- To develop a design for revenue collection for Oregon's roads and highways that will replace the current system for revenue collection. •revenue collection system- charge based on VMT</td>
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<tr>
<td>2009</td>
<td>The Short and Long Run Impact of a Mileage Fee on Income and Spatial Equity</td>
<td>Lei Zhang, B. Starr Mcmullen</td>
<td></td>
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<tr>
<td>2018</td>
<td>Survey of Oregon Electric Vehicle and Hybrid Owners</td>
<td>John MacArthur, Michael Harpool, and Daniel Scheppke</td>
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<td>2020</td>
<td>Penny Lane, Literally: Funding Roads One Vehicle Mile at a Time</td>
<td>Courtney Moran and Casey Ball</td>
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<tr>
<td>Technical Lit Review</td>
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<td>2005</td>
<td>Fueling Transportation Finance: A Primer on the Gas Tax</td>
<td>Bruce Katz, Robert Puentes</td>
<td>•Relied on two sets of data from the FHWA-the Highway Performance Monitoring System, and the Traffic Volume Trends report.</td>
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<td>2008</td>
<td>The Road... Less Traveled: An Analysis of VMT Trends in the U.S.</td>
<td>Robert Puentes and Adie Tomer</td>
<td>•Relied on two sets of data from the FHWA-the Highway Performance Monitoring System, and the Traffic Volume Trends report.</td>
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<td>2009</td>
<td>Paying Our Way- A new Framework for Transportation Finance</td>
<td>National Surface Transportation Infrastructure Financing Commission</td>
<td>•Findings and recommendations- real highway spending has fallen by 50 percent since the federal HTF was established. Since 1993, the federal gas tax has a loss in purchasing power of 33 percent. The reliance on gas based taxes for funding transportation is not sustainable in the long term and is likely to erode quicker than previously thought.</td>
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<td>2011</td>
<td>From Fuel Taxes to Mileage-Based User Fees</td>
<td>David Coyle, Ferrol Robinson, Zhirong Zao, Lee Munnich Jr., Adeel Lari</td>
<td>•Findings and recommendations- real highway spending has fallen by 50 percent since the federal HTF was established. Since 1993, the federal gas tax has a loss in purchasing power of 33 percent. The reliance on gas based taxes for funding transportation is not sustainable in the long term and is likely to erode quicker than previously thought.</td>
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<td>2011</td>
<td>End of the Highway Trust Fund?: Long-Term Options for Funding Federal</td>
<td>Joshua Schank, Nikki Rudnick-Thorpe</td>
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<td>road and bridge conditions/damage.</td>
<td>changes in energy supplies due to developments and advancements in energy production/efficiency.</td>
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<td>2016</td>
<td>The Road Ahead for U.S. Infrastructure Funding</td>
<td>Jerome Dumortier, Fengxiu Zhang, John Marron</td>
<td>• Methods- forecast on state and federal tax revenue based on different fuel taxation policies such as indexing to inflation, imposing a sales tax on gasoline and diesel, or using a mileage fee on vehicles.</td>
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<td>Inflation, (increased) fuel efficiency.</td>
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<td>Javier Andres Gotschlich Praus</td>
<td>• Methods- Continuation of previously existing model. Considers how fuel consumption and tax revenue generation is a function of consumer choice of new vehicles entering the fleet, and the</td>
<td>Tax revenue generation</td>
<td>Consumer choice of new vehicles, the amount these vehicles are driven. Fuel consumption measurements.</td>
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Works Cited


Gomez, J., & Manuel Vassallo, J. (2014). (PDF) Comparative Analysis of Road Financing Approaches in ... Retrieved August 19, 2020, from
https://www.researchgate.net/publication/269828321_Comparative_Analysis_of_Road_Financing_Approaches_in_Europe_and_the_United_States


Wray, J. (2016). Ohio’s $1.6 Billion Highway Budget Shortfall: Where do We Go from Here?
Retrieved August 19, 2020, from
http://www.dot.state.oh.us/news/Pages/2012/Ohio%E2%80%99s-%241-6-Billion-
Highway-Budget-Shortfall-Where-do-We-Go-from-Here.aspx

Zhang, L., & McMullen, S. (2009). The Short- and Long-Run Impact of a Mileage Fee on
Income ... Retrieved August 19, 2020, from
https://www.researchgate.net/publication/253557291_The_Short-_-and_Long-
Run_Impact_of_a_Mileage_Fee_on_Income_and_Spatial_Equity