Tax Analysis of Vehicle-Miles Traveled

Gabriel Morey

America's transportation infrastructure faces three challenges: a shrinking Highway Trust Fund, poor physical conditions, and a need to shift to cleaner modes of transport. Despite these growing needs, the main tool used to fund transportation projects in the United States—the federal fuel taxes—have not been raised since 1993, even as inflation, improving fuel efficiency, and increasing electrification have chipped away at the tax yield (C. Davis 2021). Replacing federal fuel taxes with a vehicle-miles traveled (VMT) tax could both increase revenue for needed infrastructure projects and reduce VMT. This paper analyzes VMT taxes across four dimensions: administrative feasibility, behavioral distortion, revenue yield, and equity. It finds a consensus among researchers that VMT taxes can reduce driving, although they may also produce a substitution effect toward less fuel-efficient vehicles. They can provide adequate yield for governments and are as equitable as fuel taxes. On the fourth dimension—feasibility—VMT taxes appear to be somewhat less efficient for governments to collect, but advances in collection technology may solve that issue. This paper recommends that the federal government replace fuel taxes with a VMT tax and couple it with increased fuel-economy regulations or sales taxes on fuel-inefficient cars.

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Gabriel Morey is a third-year Masters of Public Administration student focusing on Urban Policy and Public Budgeting. Gabriel studied public policy at the College of William and Mary, where he co-founded and led a joint student-staff cycling advocacy organization. That experience led him to a career in transportation, and he currently serves as the Intelligent Transportation Systems Coordinator for DASH bus, the public bus system in Alexandria, Virginia. His seeks to become the CEO/General Manager of a transit agency. When not in class, Gabriel can be found gardening, running, or wandering in the woods. He lives in Alexandria, Virginia with his wife Sarah and their two cats, Arthur and Electra.

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PROBLEM DEFINITION

America faces three growing transportation crises: the insolvency of the Highway Trust Fund (HTF), a backlog of deferred maintenance across various modes of transportation, and a need to reduce greenhouse gas emissions.

First, the HTF is the federal government's main source of funding for roads and transit, spending around $46 billion per year on transportation projects (CBO 2020, 1; Peterson Foundation 2020). As explained in an August 2020 web briefing by the Peter G. Peterson Foundation, the HTF is actually composed of two funds: the Mass Transit Account and the Highway Account. The Mass Transit Account receives between 10 and 20 percent of the HTF's annual $36 billion in revenues ($5 billion in FY 2019) and funds capital investments in transit (J. Davis 2020). The Highway Account supports most of the federal government's investment in interstate highways, U.S. highways, and other non-local roads (CBO 2020, 11). However, the Highway Fund also contributes to non-car projects (e.g., bike, pedestrian, and transit projects) through programs such as the Congestion Mitigation and Air Quality Improvement Program (J. Davis 2020; FHWA CMAQ 2016).

Since 2001, expenditures from the Highway Trust Fund have exceeded revenues. Without action the HTF will be exhausted by 2022. One reason the fund has failed to generate sufficient revenue is that the federal fuel taxes on gasoline and diesel have not been raised from their 1993 levels of 18.4 cents per gallon for gas and 24.4 cents per gallon for diesel. Together, these two taxes provide 82 percent of the HTF's annual revenue, or $36.5 billion in 2019 (CBO 2020, 4). Increased fuel efficiency is another reason for the decline in revenue. According to the Union of Concerned Scientists (2017), since 1975, Congress has required automakers to adhere to a Corporate Average Fuel Economy (CAFE) standard that sets a minimum level of the automaker's efficiency, weighted by sales. However, in 2007 Congress raised the CAFE standard for cars and trucks from 27.5 and 22.5 miles-per-gallon, respectively, to 35 miles-per-gallon for both by 2020 (UCS 2017). The combination of stagnant tax rates, increased fuel efficiency, and inflation have degraded the purchasing power of the two fuel taxes by over 30 percent (Wang and Miao 2018, 33). The erosion of the fuel taxes will worsen as the vehicle fleet electrifies.

Second, America's transportation infrastructure is in poor shape. According to the American Society of Civil Engineers (ASCE), 43 percent of all public roadways were in "poor to mediocre" condition in 2020, while 7.5 percent of all bridges were structurally deficient (ASCE Report Card 2021). Note that such poor rankings do not mean that highways or bridges are in imminent danger of collapse. For roadways, the ASCE rankings are based on state-level data on road ride quality (TRIP 2018, 6-7). However, poor ride quality—due to potholes or rough conditions, for example—extracts costs in the form of higher maintenance needs for vehicles and higher fuel consumption (10). In fact, the ASCE estimates that such poor conditions cost motorists $130 billion each year on vehicle repairs. Similarly, structurally deficient bridges are stable, but may require weight limits, closures, and increased future repair costs if their maintenance issues are not addressed (ASCE Bridge 2021; TRIP 2018, 9).

The maintenance crisis also affects rail and transit. For example, the U.S. Department of Transportation reported in 2017 that 18.5 percent of transit vehicles, 5.3 percent of transit stations, and 36.4 percent of transit facilities (e.g., offices and garages) had "seriously damaged components in need of immediate repair" (USDOT 2019, 61). Similarly, the Amtrak Northeast Corridor—the busy rail line from Washington, D.C. to Boston—has a backlog of $42 billion in maintenance and infrastructure replacement (NEC Commission 2020, 20). Without increased spending to make up this backlog of deferred maintenance, America's infrastructure will continue to degrade, threatening users' safety, economic vitality, and quality of life.

Finally, climate change has emerged as a threat to prosperity, health, and equity. A recent study from the National Bureau of Economic Research predicts "significant" impacts to productivity, employment, and output in the United States unless emissions are reduced (Kahn 2019, 2). Similarly, the Third National Climate Assessment found that climate change poses immense risks to human health, including increased cases of various lung diseases, higher risk of wildfire, greater spread of disease, and stronger storms (Luber and Knowlton et al. 2014). Worse, the effects of climate change will likely hit hardest on those already vulnerable, such as communities of color, children, and the elderly (Luber and Knowlton et al. 2014).

Reducing driving is one tactic to limit greenhouse gas emissions. As the Environmental Protection Agency (EPA) reports, automobile travel is responsible for 58 percent of all transportation emissions, while transportation itself is now the largest single measurable source of carbon emissions in the United States (EPA 2021). Beyond carbon emissions, driving imposes additional negative externalities—consequences that are not felt by those engaging in the driving, including traffic fatalities, congestion, air pollution from brake dust particulates, and tire-rubber pollution. Reducing driving is therefore a way to address both the immediate concern of climate change while also decreasing other negative effects.

Raising the fuel taxes could solve these problems in the short term but would prove ineffective over the long term, as vehicles shift from combustion to electric propulsion. Similarly, the recently passed federal infrastructure package will inject billions of new spending to fix the most urgent problems but does not address the underlying instability of federal transportation funding (The White House 2021). One alternative to fuel taxes is a VMT tax, which levies a per-mile user charge on drivers. In theory, such a tax could simultaneously reduce driving while funding transportation infrastructure. This paper examines the economic implications of replacing the federal fuel taxes with a VMT tax that is applied to all vehicles traveling on all roads. The first section provides an overview of current VMT taxes in the United States. The second section discusses the technical feasibility and administrative efficiency of a national VMT tax. The third section examines the behavioral distortion of VMT taxes—that is, by how much a VMT tax might reduce driving. The fourth section explores how much revenue a VMT tax would yield compared to similar fuel taxes. The fifth section analyzes the horizontal, vertical, and geographic equity of VMT and fuel taxes. The paper concludes with recommendations for policymakers.

VMT TAXES IN THE UNITED STATES

Taxing miles driven is not a new idea. Four states—Kentucky, New Mexico, New York, and Oregon—already levy per-mile taxes on commercial trucks based on their weight, since heavier vehicles like tractor-trailers deal more damage to roads than passenger cars (CBO 2019, 1). Similarly, Illinois has a voluntary VMT for intrastate trucks, while Rhode Island has added truck tolls to 12 locations on its interstate system (CBO 2019, 6).

However, only two states currently have VMT taxes for passenger vehicles in the United States. Oregon began studying a VMT tax with two pilot programs—one in 2006 and another in 2012—on a limited number of vehicles (Jones and Bock 2017, 19-26). The first pilot program involved using GPS trackers and "smart" fuel pumps that could read mileage, while the second program offered GPS tracking or manual odometer reporting to alleviate privacy concerns (20). Notably, this second program used an "open architecture" whereby drivers could select among several private companies that would collect their data and charge the fees (21). The pilots proved that VMT taxes were feasible to administer, so in 2015 Oregon launched the voluntary OReGO program. Taking lessons from the previous pilots, OReGO also used private partners called commercial account managers (CAMS) to give drivers a choice of collection and paying options. As of 2017, the program had 1,111 drivers with 1,307 vehicles. Although this is a small percentage of all drivers in the state, it is a large enough sample to provide lessons on VMT feasibility (25-26; 39). These volunteers agreed to pay 1.5 cents per gallon in exchange for rebates on all fuel taxes (30). Jones and Bock's 2017 evaluation of OReGO—the most recent one available—noted that 96 percent of participants were satisfied with the program. However, since the program was volunteer-only, this satisfaction rating likely contains a high degree of self-selection bias (66).

According to the Utah Department of Transportation's website, Utah's Road Usage Charge program began enrolling voluntary participants in 2020 (UDOT 2019). Participation is limited to drivers of alternative-fueled vehicles (e.g., electric cars, hybrids) who, under a 2018 law, face higher annual registration fees to make up for their lack of fuel taxes. By enrolling in the program, drivers swap the higher registration fee for a charge of 1.5 cents per mile (UDOT 2019). To incentivize enrollment, Utah capped the total annual amount a driver would pay to the amount of the registration fee they avoided paying (UDOT 2019). For example, a driver of a plug-in hybrid could either pay $52 yearly for the car or pay 1.5 cents per mile up for the first 3,466 miles driven per year (which totals $52). Note that participants without fully electric vehicles still pay a fuel tax in addition to their road-usage fee.

Several other states have studied VMTs without fully implementing pilots. For example, starting in 2016, California enrolled a voluntary sample of 5,000 drivers into the California Road Charge Pilot to test a potential VMT (CalSTA 2017, 5-6). The state attempted to create a representative sample of drivers, including rural, urban, suburban, low-income, and commercial drivers (6). Like in Oregon, drivers enrolled in the California program could choose between multiple CAMs, which gave them the option of providing manual or automatic mileage reports (7). However, no payments were ever issued. Instead, the California pilot was a true mock-up, where participants were given monthly "simulated invoices" that they paid using a fake online wallet (10). Several other states are also studying VMTs, including Colorado, Washington, and Hawaii. In fact, Oregon, Utah, Colorado, Washington, and Hawaii are all members of the Western Road Usage Charge Consortium, a partnership of 17 states that shares best practices on VMT taxes with each other (RUC West 2021). To date, only Oregon and Utah actually charge drivers.

FEASIBILITY

VMT taxes face several technical and administrative hurdles, including tracking mileage accurately, collecting payments efficiently, reducing administrative costs, preventing tax evasion, and protecting the privacy of drivers. Table 1, from a 2019 Congressional Budget Office analysis of VMTs for commercial trucks, illustrates several of these tradeoffs between the three major types of collection methods (2).

Table 1: CBO Comparison of common collection methods for tracking and paying truck VMTs. *Note that odometer reporting payment can actually take place electronically, as demonstrated by the California Road Use Tax pilot.*

Characteristics of Assessment Methods for VMT Taxes on Trucks

Assessment Method	Compatible Payment Methods	Potential Road Coverage	Significant Sources of Capital Costs	Relative Enforcement Costs	Compatible With Location-Based Tax Rates?	Current Usage
Periodic odometer reporting	By mail or online	All roads	None	High	No	Used in state VMT tax programs and the IFTA program[a]
Radio-frequency identification readers on road gantries, posts, or collection booths	Through onboard transponder, by mail, or online	Only roads equipped with readers	Purchase and installation of readers and related equipment	Low	Yes	Used in the E-ZPass system and other tolling systems, including Rhode Island's program of tolls for combination trucks; used primarily on bridges, tunnels, and road segments with few access points
Electronic logging devices and other onboard devices	By mail, online, or through the device itself	All roads	Purchase of new or upgraded devices where necessary	Intermediate	Only if devices have high spatial resolution	Widely used by larger carriers to manage fleets; required in most trucks used in Interstate commerce and an estimated one-quarter of all trucks under federal or state hours-of-service rules; increasingly used in the IFTA program[a,b]

Source: Congressional Budget Office.

Assessment methods may be used in combination.

IFTA = International Fuel Tax Agreement; VMT = vehicle miles traveled.

a. Under IFTA, fuel taxes paid during trucks' operations in the 48 contiguous U.S. states and 10 Canadian provinces are reallocated among those jurisdictions on the basis of the fuel consumed in each one. Most reporting under IFTA is based on odometer readings.

b. Hours-of-service rules regulate the working hours of truck drivers.

Source: Congressional Budget Office (2019)

OVERVIEW OF TRACKING AND COLLECTION METHODS

As Table 1 outlines, there are three ways to log VMT: manual odometer readings, radio-frequency identification (RFID) readers, or onboard GPS-trackers.

Odometer readings often require participants to submit reports of their mileage to the state and then pay either online or through a check. Manual reading programs require little start-up capital but suffer from high evasion rates and therefore incur high enforcement costs (CBO 2019, 2). However, one of California's CAMs used a device that plugs into a vehicle's on-board diagnostic port to send mileage readings (but not location) back to the CAM for billing (CalSTA 2017, 8).

An automatic program like California's would cost more to set up but would save on enforcement over time. Unfortunately, California does not provide any estimates of how much each onboard device would cost. The closest analog cost comes from the CBO (2019, 16), which reports that electronic logging devices for commercial trucks can cost anywhere between $128 to $419 per vehicle. According to the Bureau of Transportation Statistics (2020, 15), U.S. residents, businesses, governments, and other entities owned around 273.6 million vehicles in 2020. Using this figure, the aggregate cost of outfitting electronic logs would range anywhere from $35 to $115 billion dollars, although the cost would likely be shared between the government, drivers, and the CAMs. Finally, no odometer-based system can tell where driving occurs, so all mileage driven—even on private roads that do not use federal tax money—is taxed (CBO 2019, 2).

RFIDs are sensors that are read passively by tolling gantries (such as E-ZPass), which minimize enforcement costs and automate collection. Notably, RFID systems are capable of charging variable rates to drivers depending on the type of road and the level of congestion on the road (CBO 2019, 2). However, these systems are capital-intensive and therefore only practical on limited-access roads such as interstates because gantries must be placed at regular intervals (2). Even so, the CBO reports that creating such a tolled highway system would cost upwards of $55 billion (16). If we use the Bureau of Transportation Statistics figure of 273.6 million vehicles, this cost would equal $201 per vehicle, but only to cover three percent of total lane-miles in the United States Extending a RFID system to all roads would likely require an unsustainable amount of start-up costs.

Finally, GPS trackers allow for automatic collection and data reporting across all roads. They offer lower enforcement costs compared to odometers but require a capital expenditure for each vehicle—about $250 per vehicle in Oregon's tests, or $68 billion for all 276.6 million vehicles (Wang and Miao 2018, 33). However, just like with automatic odometer readings, the costs of outfitting vehicles could be shared between the government, drivers, and CAMs. GPS-based VMTs can also differentiate between taxable and non-taxable driving—for example, using a truck on one's farm versus driving that truck to the grocery store. Overall, GPS-based systems often fit a "happy medium," combining the lower evasion rates and road differentiation of RFID systems without the associated costs of gantries.

Note that figures of startup costs among all three types of VMT technology are estimates, not predictions. The per-unit actual cost for a nationwide, mandatory system will likely be different than a voluntary, statewide pilot, especially if open architecture reduces costs through competition among CAMs. However, even if the exact costs are not equal, the basic distribution of startup costs—with RFIDs having the highest, GPS a middle, and manual readings the lowest cost—are likely to hold true because the relative strengths and weaknesses of each technology do not change at scale.

ECONOMIC INCIDENCE AND ADMINISTRATIVE COSTS

Economists differentiate between the statutory and economic incidence of who pays a tax. Statutory incidence is simply who pays according to the law, while economic incidence refers to who ultimately bears the burden of the tax. The person or entity who takes the economic incidence of a tax is often not the same as the person or entity who bears the statutory incidence (Nechyba 2015, 674).

Fuel taxes provide a good example of mismatched statutory and economic incidence. The statutory incidence of the fuel taxes falls on around 1,300 fuel wholesalers nationwide, who are responsible for remitting the tax to the federal government (CBO 2019, 7). However, these wholesalers pass the tax on to gas stations, who then pass it on to consumers, so the economic incidence of the tax—the person ultimately footing the bill—is the driver. In the case of the fuel taxes, the mismatch in incidence is beneficial to the government, as it allows fuel taxes to influence consumer behavior (e.g., by reducing driving) while remaining easy to collect because the government only has to enforce the taxes on 1,300 sellers.

In contrast, VMT taxes typically have both a statutory and economic incidence on every driver, making it more difficult to collect and enforce taxes. To remain efficient, taxes should aim to keep their administrative costs within 10 percent of gross receipts (Jones and Bock 2017, 49), meaning VMT taxes must overcome the burden of their statutory incidence to remain effective. However, the pilot programs indicate that an administratively sustainable VMT tax is possible. For example, the CBO (2019, 22) found that Oregon's truck program (separate from OReGO) costs $20 per truck to administer, which would translate to an administrative burden of only 8 percent of gross tax receipts for a national truck VMT program, excluding start-up costs. However, passenger VMT pilots have not been cost-effective. The 2017 report on OReGo found that the program barely broke even in its first year, but that adding more users—and not rebating fuel taxes, which will disappear in a mandatory program—would generate a positive cash flow (Jones and Bock 2019, 49). The Oregon Department of Transportation concludes that to make OReGO mandatory, it must reduce administrative costs, for instance by partnering with the DMV to use their existing car registration records for participants (49).

Enforcement of taxes constitutes a significant portion of administrative costs. Comparisons among existing VMT taxes illustrate this difficulty. The CBO's 2019 analysis of truck VMT taxes found that evasion rates range from a low of 7 percent in Oregon and Kentucky, to 30 percent in New Mexico, to a high of 50 percent in New York (29). Notably, the states with the lowest evasion rates use GPS tracking, while the higher-evasion states rely on manual readings (29). RFIDs, as noted above, also enjoy low evasion rates. Oregon and California's partnership with private collectors partially nullifies this issue by outsourcing the collection to third-parties. Similarly, the 2017 evaluation of Oregon's program offered several technically feasible solutions for reducing evasion, such as assessing high registration fees for motorists caught evading the tax (Jones and Bock 2019, 53). Overall, it appears that the more highly automated the process is—whether RFID, GPS, or automatic odometer—the lower the evasion rate and administrative cost to the state.

PRIVACY

GPS-based systems often raise privacy concerns. States with GPS-based VMT pilots have attempted to overcome these concerns in a variety of ways. As noted, both California's mock-up program and Oregon's OReGO offer an open model where users can select one of several CAMs to tally miles using a variety of onboard devices or manual readings from the odometer (Jones and Bock 2019, 27-29). This open architecture allows drivers to pick the technology they are most comfortable with—from fully automated GPS location tracking to manual reads—and ensures that a private company rather than the state government handles any sensitive location information (40). As of December 2021, the MyOReGO website showed that participants in Oregon could select between two private, GPS-based CAMs or a manual system run by the state. California's program provided even more options. There, participants could select between three manual and four automated options (CalSTA 2017, 8). Notably, 62 percent of participants in the California program chose a location-based method (10). In contrast, Utah's program only offers one account manager, and only provides a GPS-location option (UDOT FAQ 2021).

In addition, programs have taken steps to bolster information security. For example, the MyOReGO website notes that all user data is destroyed after 30 days upon bill payment. More importantly, automated data collection does not require GPS. For example, several of California's GPS options use odometer status from the vehicle's onboard electronics system, but no location information is required (CalSTA 2019, 7). Similarly, most programs that use CAMs have protections in place that do not allow the state to view location data (see: UDOT FAQ). One downside of these automated mileage-only systems is that all miles—even those on private roads or out of state—are counted, but this may not be as large a concern for a federal-level tax.

ECONOMIC DISTORTION OF A VMT TAX VS FUEL TAXES

Most taxes distort prices, incentivizing consumers to substitute other goods and services for the taxed one. This substitution effect in turn creates deadweight loss—a loss of economic and tax efficiency measured as the difference between what the tax yields and how much it could yield if consumer behavior didn't shift in response. By this definition, deadweight loss has two negative effects. First, it reduces the revenue the government can collect by shifting some consumers away from the taxed sector or product. Second, deadweight loss decreases economic efficiency because consumers shift away from their preferred use of capital (Nechyba 2015, 286).

However, this second effect of deadweight loss assumes that the taxed sector is efficient, with no market failures. If there is a market failure like a negative externality, taxing the good or service responsible is an efficient way to minimize the externality. Such taxes are called Pigouvian taxes (747). As mentioned above, driving produces several negative externalities including particulate pollution, collisions, and greenhouse gas emissions. Because of these negative effects, policymakers may seek to use VMT and fuel taxes as Pigouvian taxes, triggering a substitution effect in drivers toward alternatives such as walking, biking, public transit, and teleworking. Note that besides inducing a substitution effect away from driving, most taxes also create an income effect, or a reduction in consumption because of lost wealth. However, we can safely assume that gasoline and driving are "normal" goods, meaning consumption of them rises as income increases (or as prices fall) and vice-versa. With that assumption, the income effect will likely move in the same direction as the aforementioned substitution effect, so that any increase in the cost of driving will reduce the amount of driving (286).

The extent to which a tax can reduce economic activity depends on the price elasticity of consumers. Economists typically define price elasticity as responsiveness of consumers to a change in price. Put more formally, price elasticity is the percentage-change in consumption in response to a one percent change in price (637). Generally, the greater the price elasticity, the more consumers will shift their behavior from changes in price, which is desirable for a Pigouvian tax but unwanted for a tax that seeks to raise revenue efficiently (678). Unfortunately, researchers do not have a consensus on the average price-elasticity for driving. Brian Weatherford (2011, 22) uses data from the 2001 National Household Travel Survey to find that price-elasticity for driving ranges between -.51 and -2.84, with a mean value of -1.48. In other words, for every 1 percent increase in the cost per mile, we can expect an average 1.48 percent decrease in miles traveled. In contrast, Langer, Maheshri, and Winston (2017, 36) use panel data on individual drivers in Ohio from 2009 to 2013 to estimate the price elasticity of driving given automobile age, socioeconomic status, and other parameters. They find that, on average, a 1 percent increase in cost-per-mile only reduces miles traveled by .117 percent, making driving highly inelastic, although the actual value varies depending on socioeconomic variables. Wang and Miao (2018, 37) are less rosy. Using 2011 NHTS data similarly to Weatherford, they estimate that if each state implemented a VMT tax equal to the state and federal fuel taxes, VMT per driver would only decline by 0.11 percent nationwide. However, they do not provide estimates for similar increases in fuel taxes, making it difficult to judge which tax would further distort driving behavior.

Because Langer, Maheshri, and Winston (2017, 40) use panel data, they have fairly robust estimates and can use their elasticity results to project the reduction in miles driven for two scenarios. In the first scenario, they estimate the effect of a VMT tax of 1.536 cents per mile and a gasoline fuel tax of 31.2 cents per gallon, values chosen because they are found to reduce fuel use by 1 percent. They found the VMT tax would reduce total miles driven by 30.6 billion miles (0.92 percent of the 3.261 trillion miles driven in 2019) while fuel taxes would reduce driving by 29.5 billion miles (0.90 percent) (41). The second scenario they tested was for a VMT tax of 1.99 cents per mile and a fuel tax equivalent of 40.8 cents per gallon, chosen because both are projected to raise $55 billion, an amount roughly equal to the annual amount appropriated for transportation in the 2015 FAST Act (35). Again, the VMT tax reduces driving only slightly more—by 39.1 billion miles compared to 38.0 billion (41).

Part of the variation in estimates comes from the highly individual nature of elasticity. Each consumer has their own indifference curves for goods and services, including for cost-per-mile driving. The shapes of these curves are based on their income, age, preferences, location, and other factors. Fuel efficiency is a particularly salient factor. Langer, Maheshri, and Winston (2017, 37), Wang and Miao (2018, 33), Weatherford (2011, 23), and Fitzroy and Schroeckenthaler (2018, 28) all note that drivers of inefficient cars actually see increased utility from VMT taxes because the cost-per-mile charge is typically less than their current gas-tax-per-mile value. So while a VMT tax may reduce overall driving, it may also shift some consumers toward fuel-inefficient cars or at least give those drivers a substitution-effect bump toward driving more. From this mixed evidence, it appears that VMT taxes could reduce vehicle-miles traveled more than fuel taxes, although not for all drivers.

YIELD

Langer, Maheshri, and Winston (2017, 41) also estimate the revenue generated by their two scenarios. For their first scenario (taxes raised to drop fuel use by 1 percent), they estimate that a 1.5-cent-per-mile VMT would raise $42.7 billion in revenue. Meanwhile, increasing the gasoline fuel tax to 31.2 cents per gallon would raise an almost-identical $42.2 billion. Similarly, the tax rates they choose in the second scenario—a VMT of 1.99 cents per mile and a fuel tax of 40.8 cents per gallon—are both projected to raise precisely $55 billion in revenues (41). Notably, their calculations assume a 40 percent increase in average fuel economy between 2016 and 2025.

Fuel economy also matters here. Wang and Miao (2018, 32) find that a 50 percent increase in fuel economy erodes the fuel taxes efficacy by 28 percent, while the same increase in fuel economy actually increases VMT tax revenue by 4.4 percent, likely because gains in economy induce more taxable miles to be driven. Their finding fits Langer, Maheshri, and Winston's estimates where VMT tax revenue is consistently higher than fuel tax revenue when accounting for fuel economy increases. In other words, as fuel economy rises, one can expect the substitution effect to backfire against the goal of reducing the externalities of driving and instead increase the total amount of driving, creating a trade-off between environmental benefits and revenue raised. If government regulations force vehicles to become more fuel-efficient, a substitution effect toward more driving may actually be lower under a VMT tax than the fuel taxes, for as the fleet becomes cleaner the substitution effect toward driving inefficient cars may disappear. In sum, VMTs offer a viable alternative to funding transportation, although achieving the maximum revenue yield conflicts with the goal of reducing driving. Policymakers should consider measures to ensure both long-term stability of funding and clean transportation.

EQUITY

Tax equity is typically measured across two dimensions: horizontal and vertical equity (Lee, Johnson, and Joyce 2013, 135). Horizontal equity means treating similarly situated taxpayers the same, so that those with equal abilities to pay are charged an equal tax (135). Vertical equity is the principal of treating different classes of taxpayers differently—that is, ensuring that tax burdens are "right-sized" for different income groups (135-136). Vertical equity is typically measured by calculating a taxpayer's effective tax rate (dividing the tax paid by income or wealth) and then determining what happens to that effective rate as wealth changes. If the effective tax increases as income increases, the tax is progressive. If the effective tax stays the same across income levels, the tax is proportional. If the effective tax burden decreases as wealth increases, the tax is regressive (135-136).

HORIZONTAL EQUITY OF A VMT TAX

On face value, current fuel taxes are not horizontally equitable because taxpayers with more fuel-efficient cars pay a lower effective rate than taxpayers with less fuel-efficient cars, regardless of income. In reality, low-income Americans are more likely to own older, less fuel-efficient vehicles (Weatherford 2011, 19). Because of this correlation of fuel economy and income, horizontal equity may not be a problem under the current fuel taxes, because drivers in the same income group roughly face the same per-mile charges (19). In contrast, the VMT tax does not pose a horizontal equity challenge on its face nor in practice, since drivers earning the same income face the same per-mile fee to drive.

VERTICAL EQUITY OF A VMT TAX

Equity between income groups is the classic measurement of vertical equity. Both the fuel taxes and VMT taxes are regressive since the same per-mile and per-gallon costs apply to all taxpayers regardless of income. However, looking vertically, fuel taxes are more regressive than the VMT tax because—once again—low-income Americans are more likely to own older, more inefficient vehicles (Weatherford 2011, 19). Whereas this fact makes the fuel taxes more horizontally equitable, it also means that poorer Americans also often pay a higher gross tax than wealthy Americans. In contrast, Weatherford finds that a VMT tax would reduce transportation costs for Americans earning under $40,000 per year and increase it for Americans earning over $40,000 per year, indicating a slightly less regressive tax structure than the fuel taxes (22). Similarly, the 2017 report on the OReGO program found that high-income individuals tend to drive more than low-income people, making the VMT tax slightly less regressive (Jones and Bock 2017, 4). Still, both taxes will be regressive unless policymakers explicitly tie the per-mile charge to income.

When discussing transportation taxes, geography becomes another salient difference between taxpayers, given that some people must drive more because of where they live. Typically, people assume that rural drivers will face a higher tax under a VMT tax than under the fuels taxes, because they do not enjoy the same proximity to destinations or alternatives to driving as urban drivers (Jones and Bock 2019, 55). Part of this assumption is true, as Wang and Miao (2018, 36) find that Americans living in urban areas with proximity to transit drive less, while the OReGO study found that rural Oregon residents often drive slightly more than urban Oregon residents (Jones and Bock 2019, 55).

However, the second part of the assumption is not correct, as most studies reviewed for this report found that rural families pay less under a VMT tax than they do under the fuel taxes. Moreover, rural families also pay less than urban families under a VMT (Langer, Maheshri, and Winston 2017, 39; Weatherford 2011, 23; Fitzroy and Schroeckenthaler 2018). The culprit is twofold. First, although rural drivers overall drive more than their urban counterparts, this average does not mean that every rural driver does. For example, in their 2017 study of eight states in the Western Road Charge Consortium, Fitzroy and Schroeckenthaler (2018, 29) find that urban and suburban households in Texas and Washington actually drive more than rural households, albeit rural drivers did rack up more miles than urban drivers in the other six states studied. Second, rural households are more likely to own fuel-inefficient vehicles that see reduced tax burdens under VMT regimes, as discussed above (28). Overall, the models predict that a VMT tax would shift the tax burden away from rural drivers and toward urban drivers

(Weatherford 2011, 24). By this measurement, neither the fuel taxes nor a VMT tax are particularly equitable across rural-urban lines, with VMT taxes falling harder on urban drivers, and fuel taxes falling more on rural communities.

CONCLUSION

VMT taxes offer a viable alternative to traditional fuel taxes when assessed on distortion, yield, equity, and feasibility. Significantly, these taxes can produce yields similar to fuel taxes, providing much needed cash for the Highway Trust Fund. They also appear to be feasible to administer, although with higher enforcement and collection costs than fuel taxes. Finally, they are still regressive taxes, but with a slightly reduced burden on low-income households overall, making them marginally more progressive than fuel taxes. However, VMT taxes have mixed results on environmental protection. They are predicted to reduce driving slightly, but they also may create substitution effects toward less efficient cars, at least in the short run before overall efficiency rises. Finally, if reducing driving is the goal, policymakers should anticipate the efficacy of a VMT tax to wear off over time as consumers shift to other alternatives where available.

With these tradeoffs in mind, this paper recommends several actions. First, policymakers should implement a VMT tax but couple it with increased CAFE regulations, including a tax on fuel-inefficient vehicles. This policy would capture the equity and revenue stability benefits of a VMT tax while minimizing the shift toward less efficient vehicles. Second, the federal government should follow the footsteps of the state pilots and create an open-architecture system with CAMs that serve as the actual interface between drivers and the government. Third, to alleviate concerns about privacy, the government should ensure that at least one of the CAMs provides an option for non-GPS-based taxing. Fourth, to achieve efficiencies with state DOTs that already register vehicles in their states, the federal government should devolve the administration of the tax to the state level by making it mandatory for receiving federal highway aid money. In return, the federal government should ease the creation of the program by developing common standards for CAMs. Fifth, a significant portion of these revenues should be reserved for transit, high-speed internet, pedestrian and cycling infrastructure, and other investments that can shift consumer choices away from driving. Finally, policymakers should begin planning for what comes after the VMT tax—that is, what should they do if the tax is successful at shifting modes of transportation? The federal government's creation of the HTF in 1956 was prescient then—we need the same leadership now to keep American transportation safe, effective, and equitable.

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