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A Policymaker's Guide to Road User Charges

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A national "road user charge" system would ensure that everyone who drives on America's roads contributes their fair share of the infrastructure costs.

KEY TAKEAWAYS

- As cars and trucks become more fuel efficient and electrified, gas taxes are becoming unsustainable as a way to pay for America's surface transportation system.
- An RUC system would solve that problem by using technology to log miles traveled and charge vehicles accordingly. It would collect adequate revenues from highly fuel-efficient vehicles and implement pricing based on actual costs imposed on the system.
- Opponents have voiced a number of concerns with the concept of an RUC system, from privacy issues to the share of costs rural drivers would pay. But a careful analysis reveals the lion's share of these concerns are either overblown or wrong.
- Congress should pass legislation to establish a national RUC system and include a transition period for automakers to adjust to the technology and for DOT to develop a national payment system.

OVERVIEW

It is time for Congress to implement a national road user charge (RUC) system to pay for the nation's surface transportation system. As the congressionally mandated National Surface Transportation Infrastructure Commission stated in its final report to Congress, the ideal funding "framework should cause users and direct beneficiaries to bear the full cost of using the transportation system to the greatest extent possible." And to do that, the commission endorsed an RUC system. While many states are now implementing RUC pilot programs, a national program requiring all new vehicles and all heavy trucks to pay through an RUC system is the only way to effectively implement such a system.

This report first describes what an RUC system is and summarizes the benefits of a national RUC system that states could opt in to. It then reveals the most common concerns about an RUC system to be either overblown or wrong. These concerns include:

- **Privacy:** An RUC system actually is more privacy-protective than tolling systems, because no information other than charges are passed onto governments.
- **Rural Drivers:** When it comes to differential effects on rural and low-income households from an RUC system, rural drivers actually would fare better under an RUC system than under a gas tax.
- **Environmental Impacts**: Some object to an RUC system over fears of its ability to charge electric vehicles (EVs) reducing EV adoption and hurting the environment. But a revenue-neutral RUC system actually would lead to a reduction in vehicle miles traveled, thereby helping to decrease carbon emissions.
- **Double Taxation:** Some worry that an RUC system will lead to double taxation or increased taxes overall. But an RUC system could be designed such that drivers do not have to pay a gas tax. And any system—whether an RUC system or a gas tax—can be used to increase, decrease, or maintain the amount of revenues currently being raised.
- **Travel Diversion:** Some argue that pricing roads would divert trips to non-priced roads, but an RUC system is actually the solution to that problem because it prices all roads.
- **Administrative Costs:** Some argue that an RUC system would be expensive and complicated to implement. But the fact that new vehicles today are the equivalent of "mobile smartphones"—highly sophisticated and connected electronic systems—implementing an RUC system on this "platform" should be relatively easy and inexpensive.

- **Trucking Industry** The trucking industry generally opposes an RUC system, particularly one related to truck weight. However, their arguments against it—save one—are either wrong or overblown. Their argument that an RUC system could lead to higher charges on trucks is valid, precisely because trucks now impose more costs on the system—particularly pavement damage—than they pay in taxes and fees, and an RUC system could be designed to make trucks pay not only by the mile but by axle weight and the type of road they are on, thereby increasing net economic welfare.

In short, most of the concerns raised against a road user charge system are overblown or simply mistaken. Moreover, as a "technology platform," an RUC system would enable a new range of services, including pay-as-you-go insurance, easy parking payments, congestion pricing, and more private provisioning of roads—all of which would improve the performance of the overall U.S. surface transportation system. As such, a road user charge system is a solution whose time has come.

It is time for Congress to implement a national road user charge system (RUC) system to pay for the nation's surface transportation system.

To move forward, Congress should pass legislation directing the U.S. Department of Transportation (DOT) to take the lead in establishing a national RUC system that utilizes the Global Positioning System (GPS) and includes both passenger vehicles and commercial trucks. Passing legislation to implement a national RUC system would require a transition period of at least three to five years as automakers develop a standard for the RUC technology—and as DOT funds the development of a national payment system. During this period, electric-vehicle adoption will grow, further weakening the gas tax as a sustainable funding method for the highway trust fund.

WHAT IS ROAD USER CHARGING?

Currently, America's roads are paid for through a variety of means: fuel taxes, tire taxes (for trucks), vehicle registration fees, tolls, general fund revenues (including sales taxes), and others. In the last decade, a number of governments, including some foreign and U.S. state governments, have begun experimenting with collecting revenue directly from drivers on the basis of their travel. There are many terms for this, including mileage-based user fees (MBUF), distance-based user fees (DBUF), vehicle miles traveled tax (VMTT), and road user charges (RUC). The idea is that payments should be based on actual travel. A number of states, including California, Colorado, Delaware, Hawaii, Minnesota, Oregon, Pennsylvania, and Washington, have launched pilot RUC programs, most with partial federal funding, while a number of other states are considering such programs.[1] The U.S. Department of Transportation has funded a number of rounds of state RUC pilot programs, including most recently in April of 2018.[2] A major factor motivating interest in an RUC system is the concern that with the expected rise of more fuel-efficient vehicles, especially EVs, governments will be unable to obtain adequate revenues to support transportation infrastructure.

HOW AN RUC SYSTEM WOULD WORK

An RUC system works by charging drivers by the mile. From a technical and operational standpoint there is no one model for how an RUC system would be designed. The Rand Corporation identified three different approaches. The first relies on odometer checks.[3] For example, drivers could be charged per mile driven when their vehicles are regularly inspected for emissions. There are multiple problems with this approach. First, not all states have emissions inspections. Second, it may have little reference to where the vehicle was actually driven. For example, a driver may live in the suburbs of Virginia but do most of their driving in Maryland, which would receive no revenue. Such a system would maintain the current disconnect between where a person pays a gas tax and what infrastructure they actually use. Third, and most problematic, is an odometer-based system simply being "dumb" and not enabling other uses of prices, including congestion pricing.

The second method Rand identified relies on automatic vehicle identification devices—such as radio-frequency identification (RFID) tags, which would use a vehicle's fuel economy rating combined with the amount of fuel purchased to calculate fees. Not only would this fail to address the challenge of having EVs pay, but it is also simply a more complicated way of calculating and paying a gas tax.

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Rand's third approach relies on onboard units (OBUs) that incorporate a connection to the vehicle's

onboard diagnostic (OBD) port, cellular communications, and a GPS receiver.[4] Every car produced since 1996 coming equipped with what is known as an OBD II (second-generation Onboard Diagnostic) port makes the third approach technically viable.[5] These systems are currently used, for example, to support some auto insurance programs that charge by how customers drive, wherein a "dongle" is inserted into the OBD port to measure travel behavior. If the vehicle is also equipped with a GPS chip (for example, to inform the vehicle's onboard mapping display system), the charges can be based on the actual road the car has traveled on.

Such a system would work as follows. New vehicles would come equipped with an onboard unit, a GPS receiver, and cellular-communications capability. Eventually, perhaps after a decade, older existing vehicles would need to be retrofitted with an RUS-compliant system. In new vehicles, the onboard unit (or the vehicle's mapping system) would contain a database with all the roads in the United States and information on prices for each segment, including by time of day and what entity (local, state, and federal government or private toll operator) would receive the payment. When jurisdictions change road prices, regular updates would be downloaded to the OBUs. The OBU would calculate payments to all the jurisdictions based on the road segments the vehicle drove on and the price of the segment at the time of travel (e.g., $1.30 to Montgomery County, MD; $5.15 to the state of Maryland, and $6.47 to the federal government). At the end of each month, the vehicle's onboard unit would aggregate the various fees and send a payment to the appropriate local, state, or federal agency—or a private-road owner—by automatically charging the vehicle owner's credit card or bank account. For individuals without a credit card or bank account, the total payment amount could be added to their annual or biennial vehicle registration fees.

The only personally identifiable information the entities would receive would be payments—not time of day or roads traveled. Moreover, the default setting for the OBU could be to automatically delete all trip data after monthly payments are made and received, or following some fixed time period after that to enable travelers to check and dispute any charges they believe were made in error. Other complementary systems could also be established—or evolve as technology evolves. For example, a system would need to be developed to enable drivers who have neither a bank account nor a credit card to participate and pay.

BENEFITS OF AN RUC SYSTEM

There are two principle benefits from moving to an RUC system: collecting adequate revenues from highly fuel-efficient vehicles (including electric vehicles) and implementing pricing based on actual costs imposed on the system. Of the two, because the latter is the more compelling reason, any RUC system should enable flexible road use pricing.

Enabling High-Mileage Cars and Electric Vehicles to Pay Their Fair Share

Much of the interest among governments in moving to an RUC system is based on the concern that as more vehicles become more fuel efficient, or in the case of EVs, do not consume any liquid fuels, the ability to raise funds from a gas tax will wither. These concerns have been voiced for over a decade, but to date, the improvements in miles per gallon (MPG) have been gradual. According to the Environmental Protection Agency, average MPG per model year have increased 20 percent over the last decade, and alternative-fuel vehicles as a share of production were estimated to be less than 2 percent in 2017.[6] However, it is possible—if not likely—that because of significant expected improvements in battery technology, at some point in the near- to mid-term future, most new passenger vehicles will be powered by electricity. In this case, an RUC system would be needed to prevent a significant decline in federal Highway Trust Fund revenues. If this happens, either transportation funding will decline, or other sources of revenue, such as from sales taxes, income taxes, or property taxes, will be needed to fund transportation. However, if the only purpose of an RUC system is to raise adequate funding, the simplest approach would be to require every electric vehicle to pay a fee based on annual odometer readings. But this would limit the ability of an RUC system being used to make sure prices more accurately reflect imposed costs, and in so doing improve the performance of the surface transportation system.

Ability to Use Pricing

An RUC system could be designed to charge vehicles per mile driven based on a number of factors, including, of course, the number of miles driven—but also the amount of air emissions, vehicle weight, congestion levels on the road, and the type of road used (e.g., designed for heavy trucks).

Incorporating these costs is the only way to account for the externalities—the costs imposed on others by market actors—introduced by driving. For example, drivers on a congested road impose costs on other drivers by slowing one another down. Economists have long argued that the most efficient way of addressing externalities is to incorporate them into the prices market actors pay. This leads to more efficient behavior and an increase in societal welfare. It is also why many economists have long supported road pricing as the optimal way to internalize these externalities. Until now, however, the transaction costs of internalizing the externalities significantly exceeded the benefits. Setting up tollbooths on every congested road would impose massive costs, for example. But with advanced information technology, this is no longer the case; technology is now up to the task.

Many economists have long supported road pricing as the optimal way to internalize transportation externalities.

Increasing the use of pricing would have a wide range of benefits. This is because motor fuel taxes

are essentially indirect user fees that only partially relate costs imposed on the system to prices paid. In this sense, taxes on motor fuel is not optimal for promoting efficient system use. This is a particularly relevant limitation in urban areas where being able to maximize the efficient use of constrained capacity is critically important. Although users pay more fuel taxes the more they drive, those tax-related costs are not linked to time of travel or facility choices, and do not generally recover the full costs of an individual's travel decisions (for example, total system costs of driving on congested roads is more than that for driving on uncongested ones). Thus, fuel taxes, even at higher rates, are not optimal for influencing efficient system use beyond the extent they can very modestly reduce total driving by raising the costs of driving. But even this effect is severely muted by the relatively low level of the current tax (compared with the total cost of fuel).

Sending accurate price signals better informs travelers about the true cost of their travel choices—that is, taking into consideration the costs for highway travel can help travelers make more efficient decisions about how and when they use existing transportation infrastructure. For example, when road prices are set higher during congested hours (or, conversely, set lower during nonpeak hours), some people will choose to adjust their travel times or choose alternative routes, make fewer trips, use other modes of travel (e.g., public transit, bicycle, etc.), or telecommute. Research on the effects of pricing on travel behavior shows that the benefits could include the following:

Shifting some vehicle trips from peak to off-peak periods: Variable pricing that makes off-peak travel cheaper could lead drivers to reschedule some discretionary trips or alter when they commute. Shifting travel times likely would have the largest effect, reducing peak-time travel by perhaps as much as 25 percent.[7] According to the Federal Highway Administration, widespread use of congestion pricing—which a GPS-based RUC system enables—could reduce the amount of capital investment needed to meet a given set of performance goals for the highway system by approximately 30 percent.[8]

Reducing total vehicle trips and trip distances: Increased cost transparency and higher prices at peak times could lead drivers to combine trips (e.g., run several errands per trip rather than take several trips) and plan their trips more carefully (e.g., consider closer destinations). There is a growing literature on behavioral economics that consumers respond better to direct and visible signals. As a hidden tax, the impact of a gas tax on driver behavior is limited. As such, one advantage of tolling and pricing is their impact on consumers is visible. In terms of comprehensive pricing approaches, even a flat road user charge would likely achieve some system-efficiency benefits. For example, Oregon's road pricing pilot project, wherein users were charged according to their number of miles driven, and presented a bill when they bought gas at the pump, resulted in a 12 percent decrease in vehicle miles traveled—even though the charge per mile was, on average, equivalent to what a person would pay for the same travel through motor fuel taxes.[9] Oregon found that even without additional charges for congestion, the increased transparency of system costs influenced driving decisions. Individuals respond to instant pricing, or to seeing the costs of a given activity while it is in progress. And having the current fees for each vehicle displayed on its dashboard in real time would allow motorists to make more rational transportation choices—just as

smart electricity meters in household appliances allow families to control how much they pay for power. In contrast, when individuals pay fees in a lump sum, those charges cannot be as powerful a real-time price signal.

Increasing mode shift: Pricing can lead drivers to choose different modes of travel, such as carpooling, transit, and bicycling/walking, or to telecommute.[10] For example, by raising the cost of driving during peak periods, the economics of public transit become more favorable. Research that looked at how drivers in Portland responded to the Oregon mileage pricing pilot project found that program participants who lived near transit facilities reduced the peak hour miles they drove, presumably by taking transit for some trips.[11] Public transit could also benefit from reduced roadway congestion through road pricing, which could lead to faster and more reliable bus transit services, thus increasing performance and making transit more attractive to a broader array of the public.

Improving reliability: Pricing that curbs demand in a meaningful way can improve travel-time predictability and reliability by reducing the uncertainty of delays. It can also lead to gains in economic productivity as travelers—including commercial travelers—would need to build in less of a travel buffer to ensure they are not late.

Reducing commercial services travel time: Commercial services whose operations require them to move about in congested metropolitan areas face severe productivity losses as congestion increases. While road pricing could add to the direct cost of commercial services travel (depending on the relative prices paid through road pricing versus current fees and fuel taxes), improved infrastructure and reduced congestion would likely more than offset these added costs through higher productivity. The Eddington Commission in the United Kingdom estimated the effects of congestion pricing on freight and found commercial services industries would be net beneficiaries.[12] It also noted that businesses, in particular, accrue significant net gains from road pricing and that these cost savings get passed on to consumers in the form of lower prices. As this reflects business users placing a relatively high value on their own time, the value of the time savings and reliability benefits from road pricing will generally exceed the cost of the charges. This is also true for freight traffic—although the Eddington Commission found that the positive impacts of road pricing on freight would be significantly lower, but still positive.[13] Notably, the benefits calculated do not take into account public revenues used to expand road capacity potentially leading to higher benefits for all users.

A benefit from a GPS-based RUC system would be to better align the costs heavy trucks impose on the transportation system with the prices they pay.

Serving as a platform for other traffic and vehicle applications: A GPS-based RUC system would also serve as a technology platform to enable a wide array of other applications, such as pay-as-you-drive insurance and automatic payments for on-street parking. Pay-as-you-drive

insurance sends clearer signals to drivers about the costs they bear, and leads to reduced driving. An RUC system platform would also enable automated parking-charge systems (eliminating the need for parking meters). As the Rand Institute wrote, "Drivers could pay for the actual time that they occupied the space, with no more need to 'leave extra time on the meter.'"[14] Such a system could enable widespread adoption of applications that automatically and anonymously track and transmit information regarding road conditions (such as potholes, or slick roads in winter) to local public works departments. And as a platform, a wide range of other consumer-friendly applications could very well develop.

Providing information to better guide traffic management and transportation investment: A GPS-based system could provide valuable information to improve traffic planning and better guide future investment decisions. This could signal planners as to where more capacity —that people are willing to pay for—is needed. Travelers could also voluntarily opt to have their onboard systems transmit detailed travel data (stripped of personally identifiable information) to traffic planners and managers, in part to improve local traffic management operations.[15]

Reducing road damage from heavy trucks: Another benefit of deploying a GPS-based RUC system would be the ability to better align the costs heavy trucks impose on the transportation system with the prices they pay. A truck RUC system could be designed such that trucks over a certain size and weight would be required to have an onboard unit installed (in new trucks the OBU would be mandatory) that would identify where the truck is, the time of day and day of week, and the charge for the segment of roadway the truck is traveling on. In addition, trucks would be required to have axle weight sensors installed to measure their weight per axle. Trucks would pay based on a number of different factors: the truck axle weight (heavier trucks would pay more); emissions per mile ("dirtier" trucks would pay more); types of roads (trucks would pay more to travel on roads not designed for heavy trucks); and total miles driven. They could also be charged according to the amount of congestion, with higher prices for driving on roads that are normally congested (e.g., metropolitan freeways or city centers during rush hours). The system could be set up to collect and remit both state and federal taxes. The benefits would ultimately be a decrease in pavement damage, reduced air emissions, and less road congestion.

Improving air quality: Motor fuel taxes generally provide a weak proxy for capturing the costs of environmental damage. As an indirect user fee, fuel taxes do bear some relationship to air emissions. While vehicles with poor fuel efficiency pay more in fuel costs and fuel taxes, the added costs from pollution normally exceed the added revenue from higher fuel consumption. Moreover, emissions are not directly related to fuel consumption. Vehicles with higher emissions per gallon of fuel consumption pay less than they should relative to other cleaner vehicles.

Enabling private investment in expanding road capacity: Private companies can often build, maintain, and operate highways more effectively and efficiently than government agencies. There are a handful of private toll roads operating in the United States, including the Dulles Greenway (VA), Tuscaloosa Bypass (AL), Detroit International Bridge (MI), Northwest Parkway (CO), and the Orchard Pond Parkway (FL). But the biggest challenge facing the expansion of private roads is their having to "compete against free." In other words, drivers pay a gas tax to drive on

the toll road, but drivers on public roads only pay a gas tax. Implementing a nationwide RUC system would create a more-level playing field on which all drivers would pay to use all roads, but not have to pay a gas tax—thereby enabling more private providers to offer road services where market forces make sense.

CONCERNS ABOUT A ROAD USER CHARGE SYSTEM

Concerns are raised whenever there is a major change in public policy—and transitioning from a gas tax to an RUC system is no different. However, most of the concerns are simply unwarranted.

Privacy

Perhaps the single biggest criticism of the RUC system is that it violates travelers' privacy. This perception has not been helped by a number of advocates of RUC systems persisting in using the term "tracking" (as in "the system tracks your travel"). In reality, an RUC system can and should be designed to be completely privacy protective. In fact, such a system would be much more privacy protective than transponder-enabled tolling systems (e.g., E-ZPass) that make a record of every vehicle that passes their readers.

There are so many misperceptions surrounding RUC systems and privacy because few understand how the technology would work. The most important thing to know is, for passenger vehicles, the GPS system is one-way—not two-way—just as it is on smartphones. In other words, the car knows where it is thanks to the GPS, but the GPS itself does not know where the car is. There is no external tracking involved. However, millions of new vehicles coming equipped with GPS has not led to a techno-panic because most owners are aware the GPS signal is one way and therefore cannot track them. The OBU or other recording device that manages an RUC system would use the GPS signal to record where the car is traveling. Then, at the end of the month, mileage totals could be organized according to jurisdiction owed, and the OBU would ping the driver's account to dispense payment to a central authority, which would then distribute the money to the relevant entities. This would work in precisely the same way multiagency toll networks such as E-ZPass currently work—except the RUC system would transmit only the vehicle ID and the payment, and no trip information. This transmission could occur through either a Bluetooth connection at the gas pump or a cellular connection inside the vehicle. As previously noted, other equally privacy protective ways of paying could be established for the unbanked.

An RUC system can and should be designed to be completely privacy protective.

An alternative would be to set up the system as a two-step process in which an initial message transmits each vehicle's ID and total amount owed, and a subsequent message gets sent without the vehicle's ID but includes the number and time of day of miles traveled in each jurisdiction. The billing agency would then aggregate all the anonymous messages for all drivers and allocate the total revenue to each jurisdiction accordingly.[16]

For data stored on the OBU, the default setting should be for data older than a certain number of days to be deleted once the RUC system tax bill has been paid. Some consumers may want to retain this data—perhaps, for example, to interact with apps that might be developed to help drivers analyze their driving patterns. This should be an opt-in choice drivers make. But either way, the detailed trip data would never be shared without the vehicle owner's affirmative consent.

Privacy fears do remain a stumbling block to widespread implementation, even though they are based on a misperception of how these systems actually work. Certain advocacy groups that reflexively oppose new information technology solutions could exploit these fears.[17] However, more education and pilot programs can overcome them.

Rural Drivers

There is a widespread perception that rural drivers will be disadvantaged by an RUC system because they drive longer distances than urban drivers. Indeed, some rural elected officials and newspaper op-ed pages smaller communities have come out against state RUC pilot programs for this very reason. As one editorial wrote, "Drivers who commute from longer distances would be unfairly hurt by a VMT." On the surface, such concerns seem well founded. Data from the 2001 National Household Travel Survey shows that citizens in rural areas drive 34 percent more miles per year than people in urban areas—and the difference is even greater in rural western states.[18]

However, even with this reality, there should be no difference in how switching to road user charges impacts rural drivers. Consider a driver who commutes 50 miles a day from their small town to a big metropolitan area in a car that gets 20 miles per gallon, and assume they pay a combined state/federal gas tax of 45 cents per gallon for a total tax of $1.12 per day. In comparison, a suburban driver who commutes downtown and drives 16 miles a day would pay 36 cents a day in fuel taxes. If the drivers each paid only a fee of 2.25 cents per mile (and paid no fuel taxes), the rural driver would still pay $1.12 per day, with the suburban driver still paying 36 cents. In other words, on average, rural drivers today pay more in fuel taxes than urban drivers—and would continue to pay more under an RUC system.

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However, given that, on average, rural residents tend to drive older and less fuel-efficient vehicles, an RUC system would result in rural drivers paying relative less under an RUC system.[19] One study found that an RUC system that includes congestion pricing would impact urban and higher-income drivers more than rural and lower-income drivers.[20] Likewise, a Rand study on RUC systems concluded, "On average, then, a flat per-mile fee structure would make rural drivers better off."[21]

Similarly, a study wherein a vehicle miles traveled fee was implemented in Nevada showed that when a revenue-neutral RUC system was put in place, rural drivers actually paid less than under a gas tax.[22]

There is another reason why an RUC system would be beneficial for rural drivers: It enables congestion pricing—and the vast majority of recurring congestion is in metropolitan areas. As such, under an RUC system that uses congestion pricing, metro area drivers will pay more, but also benefit from congestion pricing.

Equity

Some have opposed moving to an RUC system out of concerns it would be regressive and therefore hurt low-income households.[23] And most studies have found that gas taxes are indeed regressive, with lower-income households paying a higher percentage than higher-income households. At first glance, switching to road user charges would lead to distributional impacts that are no different from a gas tax. If low-income households drove cars that got the same gas mileage as upper-income households, switching from a gas tax to an RUC system would have no distributional impacts. But in fact, low-income households tend to drive older, less fuel-efficient cars. This is why one study found that shifting to road user charges would mean that lower-income households would paid less than they would under a gas tax.[24] This is also why a Rand study concluded, "Lower-income households would likewise be better off on average with mileage fees."[25] Similarly, a recent study showed that a with a revenue neutral RUC system fee, higher-income groups had a larger increase in annual costs, while lower-income groups obtained cost savings.[26]

Some point to a Government Accountability Office (GAO) report that argued road pricing may increase equity concerns. But it is important to note that the GAO report was referring to a particular application of pricing: congestion pricing.[27] While the use of congestion pricing would lead to higher-income households paying more overall as a result of driving more than low-income households, it would be somewhat regressive in that the costs paid would represent a lower share of their income than for low-income households. But some of these impacts could be reduced if a portion of the funding were dedicated to public transit, which on average is used predominantly by lower-income households. Other approaches, such as means-tested "lifeline" rates for low-income drivers also could be adopted. Moreover, moving to an RUC system would enable governments to raise more money for transportation from direct user fees, and less from car registrations. This would help lower-income households because they drive fewer miles per year than higher-income households, yet pay the same for their car registration.[28]

Paying Twice, Paying More, and Paying Incorrectly

Another objection relates to payments. Some oppose an RUC system because they fear it would lead to double taxation: once through a gas tax and once through the road user charges. But all the state pilot programs, and surely a federal program, would be designed such that RUC-enrolled vehicles would not be charged a gas tax when they fill up. For example, this can be done by equipping fuel pumps with sensors to detect cars that are paying RUCs so the pumps do not charge the fuel tax.

Others argue that an RUC system will lead to higher overall transportation taxes. But an RUC system is a means, not an amount—and the rate can be set by policymakers to bring in more, less, or the same amount of revenue as through current means (e.g., gas taxes). The amount raised is completely divorced from the means of collection. Moreover, an RUC system fee is no easier to increase than fuel taxes—and may be harder. This is because it is much more transparent, as the technology will allow drivers to know what, when, and where they pay in a way they do not with fuel taxes. As such, transparency improves the debate over level of taxes and use of revenues.

Shifting to road user charges would mean lower-income households would pay less than they would under a gas tax.

Another concern is whether the correct jurisdiction gets the revenues. In fact, the current system is highly problematic in this regard. Residents who live and do most of their traveling in a high gas-tax jurisdiction have considerable incentive to fill up in lower-tax, nearby jurisdictions. An RUC system assigns costs to wherever they are imposed, not where the gas is bought. And it can do that quite accurately. As one study found, "Of the more than 23 million VMTs that were measured during the study, 99.4% were assigned to the correct jurisdiction. The results showed that from a technological standpoint, a nationwide VMT fee is completely feasible."[29] Moreover, the current system to allocate truck taxes based on miles driven in each state results in significant false reporting of miles in higher-tax states. A road user charge system would correct this problem.

Impact on the Environment

Some object to an RUC system tax because they believe taxing electric EVs for the miles they drive will limit their adoption and thus be bad for the environment.[30] To be sure, an RUC system would mean higher costs for EVs, but it is important to remember that buyers of new electric vehicles benefit from a sizeable tax credit of between $2,500 and $7,500. Moreover, the idea that EVs would be exempt from paying anything to use the nation's roads and bridges strikes most transportation experts as both unfair and unsustainable. Moreover, an RUC system could be designed to have higher-polluting vehicles pay more, which would make EVs more price competitive. Finally, a number of states are increasing annual vehicle registration fees for EVs to generate some funding for roads.

Finally, there have been a number of studies that suggest that an RUC system would lead to reduced driving, in part because of the behavior-economics effect of consumers realizing they are paying by the mile, but also because congestion pricing would lead to mode switching (e.g., taking transit or carpooling).[31] This is why the environmental organization Resources for the Future estimated that implementing an RUC system in the Washington, D.C., region would lead to a reduction in vehicle miles traveled of 15 percent.[32] Another study found that implementation of a road user charge reduces the amount of miles traveled relative to the existing conditions from between 2.2 and 4.3 percent.[33]

Diversion

Some have argued that road pricing can lead to diversion, with vehicles, including heavy trucks, traveling on unpriced roads. Diversion can indeed be issue with toll roads, where travelers can avoid tolls by driving on secondary roads, including roads not designed for heavy trucks. An RUC system, however, would have the exact opposite effect. Diversion makes no sense when vehicles are paying by the mile driven, regardless of whether it is on a freeway or secondary road.

In fact, a smart RUC system that includes heavy trucks and charges them not only by the mile, but axle weight and type of road they are on, would lead trucks to drive a larger share of miles on roads designed to handle heavy trucks. A wide range of studies clearly demonstrate that heavy trucks cause significant damage to the nation's roads, which they do not adequately pay for.[34] According to a 1979 GAO study, it would take 9,600 cars to cause the same pavement damage as one five-axle trailer hauling 80,000 pounds.[35]

To be sure, trucks pay significantly more than passenger cars in federal taxes (e.g., diesel fuel, truck sales, and tire taxes), in part to account for the damage they cause. But these taxes are lower than the overall costs trucks impose on the system, including pavement damage. Moreover, the taxes are not directly related to pavement damage. The existing heavy-vehicle use tax (HVUT) tries to get at this problem, but it is a blunt instrument that does not adjust for the actual weight of the truck (including freight) or the type of road the truck is driving on. An RUC system would have huge advantages over the current taxing system. First, charges would be more carefully related to true infrastructure costs. Trucks that do more damage to roadways would pay more.

This, in turn, would increase transportation efficiency by reducing pavement damage; encourage truckers to drive fewer trips with fuller loads on roads designed to take the pounding from heavy trucks; and perhaps lead to a shift to other modes, including rail and inland waterway shipping.

Cost and Implementation

The costs of collecting motor fuel taxes are extremely low—about 1.0 percent of gross revenues.[36] This is largely due to the efficiency of the fuel tax payment process, which collects taxes at the gross distribution level and only involves about 1,400 payees. To be sure, an RUC system would have higher collection costs. But the additional costs of pricing must be weighed against the poor long-term sustainability of the motor fuel tax as our nation's primary source of surface transportation funding and the potential for greater efficiency and other ancillary benefits associated with pricing.

An RUC system will have three major cost components. First, capital investment costs will enable the implementing agency (e.g., U.S. Treasury) to administer RUC charges, including costs for items such as hardware, system development, and start-up. Second, there are the costs associated with installing technology (e.g., GPS receivers/RUC calculators) in the fleet of new vehicles. Given that most new vehicles come equipped with sophisticated information technology systems, such additions are not likely to be all that costly. Indeed, if the necessary hardware were part of a broader vehicle technology platform installed in vehicles on a large scale as original equipment, the incremental costs to enable RUC pricing, on an individual vehicle basis, could be small. In addition, such technology would provide other ancillary benefits to travelers, such as GPS-assisted navigation. Moreover, payment companies are working with automakers on advanced technology to enable vehicles to connect to payment systems. For example, Visa is working on a system whereby an individual's credit card account could be integrated into in their vehicle's connectivity technologies in order to streamline payments.[37] An automated RUC payment would be just one more type of payment a car could make.

The third cost component of comprehensive pricing will be the recurring cost to administer it. U.S. DOT research from over decade ago estimated that administrative costs for a national system of road pricing using GPS technology would be 1.7 percent of revenues (equivalent to the cost of processing credit card transactions).[38] Although this is more than the cost of administering current motor fuel taxes, it would still be a relatively inexpensive fee to administer.

An RUC system, however, would allow other system costs to be reduced. For example, it would reduce the cost of public and private toll road administration, which according to the National Academies of Science, amount to an average of $85 million per year per toll road agency.[39] It could also dramatically reduce the costs to local governments of parking meter management.

Finally, some disparage an RUC system as being overly bureaucratic. The former president of the American Trucking Association stated, "Imagine the bureaucracy needed to oversee and collect VMT fees from millions of highway users."[40] But in fact, the lion's share of "bureaucracy" would

be a computer and software, just as the "bureaucracy" of a credit card system is a mainframe computer and point-of-sale terminals.

Trucking Impacts

Many in the trucking industry oppose an RUC system. For instance, the American Trucking Association opposes an RUC system—even one that applies to all trucks and passenger vehicles.[41] Some, much like privacy, increased taxes, double taxation, and road diversion, are not unique to trucking and have been shown to not be substantive issues. Others are specific to the trucking industry, which argues there is no need to move to an RUC system because, for the foreseeable future, trucks will be powered by diesel, not batteries. But this assumes the principal purpose of an RUC system is to raise revenues, when in fact, for heavy vehicles, it is not to more effectively raise revenues but to charge fees that match the actual costs imposed on the system. Moreover, by first moving to a truck RUC system, it will be easier to transition to a passenger RUC system, which will take more time.

In addition, the industry is concerned with pricing flexibility, with the industry asserting it does not have the ability to absorb increased costs. Any system can be structured to be revenue neutral, should Congress decide to do this. Even if the overall revenues from trucking are the same, some segments of the industry or kinds of trucks could pay more, while others pay less. But some representatives of the freight industry argue that they cannot always pass on added costs. They may in fact not be able to, which might lead to products being shipped by alternatives, such as rail or water. Government should not be "picking winners" in freight by allowing trucking to not pay its full share of costs.

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While the industry may not be able to pass along all the costs of targeted tolls to customers in the short run, truckers should be able to do so in the moderate term and long term if the fees are stable or changed with sufficient advance notice. Indeed, a Transportation Research Board report argued that these costs could be passed on to customers.[42] In other words, stable, nondiscriminatory pricing, possibly supported by national information systems that let truckers and shippers know the expected costs of tolls for any particular route, should not adversely affect the trucking industry as a whole, and would certainly not adversely affect the national freight shipping industry. One reason is that a per-mile pricing would create incentives to combine shipments in ways that minimize trip mileage. For example, the German heavy-vehicle comprehensive road pricing system has led to a 10 percent drop in empty trucks on long-distance trips, a 7 percent increase in containers moved by train, and a 6 percent increase in the purchases of truck tractors that emit less pollution (in part because their fee was higher for trucks with low mileage per gallon).[43]

HOW TO MOVE FORWARD

As the administration and Congress consider an RUC system, there are several key questions to consider, including whether this will be a federal-state system or a federation of state systems, whether and when heavy trucks should be included, and what the next steps for implementation should be.

Congress Should Charge DOT With Establishing a National RUC System

While congressional legislation has enabled several RUC pilot programs, the majority of efforts on VMT have come from the states. These "laboratories of democracy" are playing an important role in testing technologies, identifying and solving challenges, and working to increase public acceptance. But to be fully effective, an RUC system has to be mandated at the federal level. States should be able to choose to opt in to the federal system to have it collect and remit taxes for travel within their state. There are three main reasons for a strong federal role: The first is to eliminate the risk that different state systems would not be interoperable—as was the case when toll-transponder standards were first adopted. The second is to ensure a national standard to drive down the costs through economies of scale. And third, if the federal Highway Trust Fund is to remain solvent in decades to come, the federal government will need a replacement for the gas tax.

Start With, or At Least, Include Trucks

Congress should mandate that trucks be included in the system, and ideally that trucks be outfitted first. The advantages of starting a national RUC program with trucks are two-fold. First, the scope of the program would be smaller (there are many fewer trucks than cars), making it easier to implement. In addition, the cost of an RUC system for a truck is a much smaller component of overall vehicle costs than for less-expensive passenger vehicles, and any system could be designed around the technology already installed in the trucks. Second, the benefits from a truck RUC system are higher than for cars, in part because the variation of costs imposed by trucks on the system (including pavement damage) is much higher than for passenger vehicles.

Several nations, including Germany, Switzerland, the Czech Republic, and New Zealand have adopted a truck VMT system. For example, in 2005, Germany began charging all heavy vehicles (i.e., trucks over 12 tons) for all miles driven on intercity motorways throughout the country. Tolls are charged per kilometer based on GPS for most vehicles, and vary by axle number (trucks with more axles pay a higher toll because they presumably do more damage to the roads)[44] and vehicle emission class (trucks that pollute more pay a higher toll). New Zealand has had a road user charges (RUC) system of distance/weight tax for trucks since 1977. Trucks must prepurchase a distance-weight authorization for a specific class of vehicle, with distance measured via a mechanical hub odometer or odometer for light vehicles. Generally, the heavier the truck, the higher the per mile charge.[45] An eRUC system to purchase these RUC permits electronically is

now available and used extensively by larger trucks. The law applies to any vehicle that does not use gasoline, and states that electric vehicles will start paying the RUCs in 2021, or when electric vehicles make up 2 percent of the fleet—whichever comes first.

There are a number of advantages to an RUC system over the current way trucks pay federal taxes. First, taxes would be more carefully related to costs imposed. Trucks that do more damage to roadways, add to congestion, and pollute more would pay more. This in turn would increase efficiency by reducing pavement damage and encouraging trucks to drive with fuller loads and pollute less. In addition, a truck RUC system would make it easier to implement truck-only toll lanes/roads, as the payment system would already be in existence. In addition, data on truck travel would help identify when and where truck bottlenecks exist, thereby helping to guide improvements to the transportation system.[46]

Finally, an RUC system would lead to more compliance with existing tax regimes. As one study found, "Truckers underreport the miles driven in each state, and hence pay less than they are legally required to."[47] Another study, of New York State, estimated that truckers pay about $90 million less than they are legally obligated to. This is because:

> Interstate truckers are required to report mileage each quarter to IFTA (International Fuel Tax Association). IFTA balances payments among the states based on miles driven in each state. Motor carriers, however, have an incentive to underreport mileage in high tax states (such as New York) and to over report miles in nearby relatively low tax states.[48]

In addition, the study found that there are number of ways to avoid diesel fees, and these losses are between $1 billion and $3 billion per year.[49] A VMT system would help address these challenges. As one study reported, a truck RUC system can "reduce inaccuracies and underreporting, and should streamline business practices."[50]

Without an RUC system, passenger vehicles will gradually pay less as fuel economy increases and they eventually become electrified, and transportation funding will decline.

Finally, there is another reason the trucking industry should support an RUC system: Without an RUC system, passenger vehicles will gradually pay less as fuel economy increases and they eventually become electrified, and transportation funding will decline. Because of battery-technology limits, trucks will continue to be powered by liquid (and taxable) fuels for a long time.[51] This will either mean less investment in road infrastructure or higher fuel taxes, of which trucks pay an increasing share.

Mandate That OEMs Install a GPS-Enabled OBU in All New Vehicles

Most new vehicles are essentially "smartphones on wheels." In other words, new vehicles are increasingly connected and digital.[52] As such, it is a relatively straightforward process to have vehicles come with GPS and an onboard computer system for recording trip data. Having built-in on-board units will be cheaper and more secure than using port plugins. As such, Congress should mandate that the vehicle industry (autos and trucks) work with the Department of Transportation to develop a technology standard for onboard units. Once the standard has been agreed upon and a period of implementation established, all new vehicles should be required to come equipped with a GPS-enabled OBU. The federal government should then require all new vehicles to pay into the federal RUC system, on which states could choose to piggyback.

CONCLUSION

Road user charges are the most viable and sustainable long-term "user pay" option for the federal government to both raise adequate and appropriate revenues and provide the federal share of funding for the nation's surface transportation system. Both real-world examples and academic research demonstrate that an RUC system has the capacity not only to raise needed revenues but also to provide additional benefits, including more efficient use of transportation infrastructure, reduced environmental and social externalities, and ancillary benefits to users in the form of information for drivers. Moreover, unlike other funding methods, an RUC system is the only option that, in addition to raising revenues, could actually reduce the amount of necessary additional capacity by improving the efficiency of current capacity use.

A transition from federal motor fuel taxes to a federal RUC system will present numerous political, technical, and technological challenges that will require broad stakeholder input throughout. In particular, outreach and education will be critical for moving forward on an RUC system. The federally funded state pilot programs have made some progress in this area, but more needs to be done to rebut the myths of road user charging. These challenges, however, should not deter policymakers from committing to a paradigm shift and an aggressive course of action to implement an RUC system.

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