MINNESOTA HIGHWAYS: REVENUE SINK OR REVENUE SOURCE

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ABSTRACT

This paper looks at VMT (vehicle miles traveled) fees along public finance principles, and considers the policy implications and potential revenue that could be generated if we took advantage of one of our most valuable resources: the highways. Instead of seeing highways and all roadways as a revenue sink, this thesis envisions them as a significant revenue source. Demand models for VMT both at the national and state level are estimated, and used to estimating the potential revenue that could be raised through VMT fees. This thesis explores the possibilities, both at the federal level and for the state of Minnesota, of using VMT fees to not only provide funds for the highways and other transportation purposes, but to also provide a significant revenue source for general funds. It is shown, that for relatively low and economically harmless VMT fee levels, great amounts of revenue could be raised. These revenues could not only fund the transportation system, but could save the state of Minnesota from harmful program cuts or tax increases, and could potentially help avert a fiscal crisis that could derail the United States' economic rebound.

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CHAPTER 1. INTRODUCTION

1.1 A Move to Charging by the Mile?

The federal Highway Trust Fund, which funds highway and other surface transportation infrastructure in the U.S., required an eight-billion dollar transfer from the general fund in 2007 and another seven-billion transfer in 2009 to stay solvent. These transfers, have led many transportation professionals and analysts to question the Fund's primary funding mechanism, motor fuel taxes', ability to provide adequate funding for transportation projects. Furthermore, while fuel taxes were initially meant to serve as a highway user fee with the inception of the Highway Trust Fund in 1956, several transportation professionals believe that fuel taxes' power as user fees has been significantly eroded. As vehicles have become more fuel efficient, and increases in fuel tax rates have not kept pace with inflation, the user fee principle has been eroded as many users do not pay the full costs they impose on the highway system. Furthermore, the user fee principle is further eroded as differing fuel economies and the introduction of hybrid and electric vehicles causes drivers to pay radically different amounts in fuel taxes per-mile of highway use.

These problems in highway funding and fuel taxes, have led many transportation analysts to suggest a move away from fuel taxes, towards road pricing and mileage-based user fees. Simply put, a mileage-based user fee or vehicle miles traveled (VMT) fee, is a road user fee based on miles traveled. A move towards charging drivers by the mile would be a move away from the current system of funding the roads through taxes based on gallons of motor fuel consumed.

A strong economic and policy rationale for moving from a system of fuel taxes to a VMT fee system is found in the following statistic: while an average driver pays approximately three cents per-mile in highway user fees at all levels of government (the bulk of which are state and federal fuel taxes), driving on a congested road imposes 10 to 29 cents per mile in total costs on the highway system when taking into account the external costs associated with congestion (National Surface Transportation Infrastructure Financing Commission 2008). Since fuel taxes do not have the flexibility to charge higher rates for congested conditions, the price signals sent to drivers encourage driving beyond the efficient level. If the user fee charged to vehicles was allowed to rise with the congestion costs that a vehicle imposed, roadways would likely be used more efficiently. Furthermore, there may be less of a need to expand highway capacity, if congestion charges dissuaded drivers from driving at peak hours or in congested zones. A well crafted VMT fee would be able to charge road users fees commensurate with the total costs they impose on the system as well as force drivers to internalize the external costs their driving imposed on society through congestion and pollution.

Furthermore, various VMT fee trials and systems in place from the state of Oregon to Germany have demonstrated that a move to charging by the mile is technologically feasible. The trials and VMT fee systems in place have utilized a variety of different technology options. Technology options for charging by the mile range from very simple systems that entail odometer checks to more sophisticated systems that use GPS or cellular communications technology.

Problems with the gas tax, the economic rationale behind VMT fees, and the available technologies have all led two recent congressional commissions to take notice of VMT fees. In fact, both the National Surface Transportation Infrastructure Financing Commission (2009) and the National Surface Transportation Policy and Revenue Study Commission (2007), suggested that policy makers consider road pricing as a long-term transportation funding mechanism.

1.2 Shortfalls in the HTF and Increasing Fuel Economies

As mentioned before, the Highway Trust Fund, which provides for surface transportation projects in the United States and is primarily funded through fuel taxes, required an eight-billion dollar bailout from the general fund in 2008, and another seven-billion in 2009. These dramatic bailouts, while necessary to plug a current funding gap, will not fix the long term problem, and it is likely that more and more revenue for transportation improvements will come from the general fund.

Several analysts and reports have made estimates regarding the long-run health of the Highway Trust Fund. The National Surface Transportation Infrastructure Financing Commission (2009), which was directed by Congress to investigate the state of our transportation system, stated, "At the federal level, the investment gap is of a similar magnitude, with long-term annual average Highway Trust (HTF) revenues estimated to be only $32 billion compared with required investments of nearly $100 billion per year" (p. 3).

These projected imbalances at the federal level are indicative of our transportation system at all levels of government. The NSTIFC noted, "Without changes to current policy, it is estimated that revenues raised by all levels of government for capital investment will total only about one-third of the roughly $200 billion necessary each year to maintain and improve the nation's highways and transit systems" (2009, p. 3).

So why exactly is our current system of transportation funding missing the mark, and likely to only get worse in future years? The simple answer is the inadequacy of our current system of funding surface transportation infrastructure through fuel taxes. One major reason for the inadequacy of the current system of fuel taxes to cover transportation investment needs is the fact that fuel taxes have not been raised to keep pace with inflation. Current federal fuel tax rates that stand at 18.4 cents per gallon on gasoline and 24.4 cents per gallon on diesel fuel have not been raised since 1993. The NSTIFC (2009) notes that since 1993 the federal gas tax has experienced a 33 percent loss in purchasing power. To shed some light on how low our fuel taxes are, it is useful to compare our rates to those of other countries. While Americans currently pay on average 49 cents per gallon in federal, state, and local fuel taxes, our neighbors to the north in Canada pay approximately $1.26, while the Dutch pay $5.57 (Marsh 2008). It should be noted that the high fuel taxes of other countries go well beyond just covering the costs of needed transportation projects, but also provide funding for non-transportation projects, and work to correct negative externalities such as carbon emissions.

Fuel taxes' low rates are not an inherent problem with fuel taxes themselves, but rather a problem of the political will and a political climate that makes it difficult to raise taxes. But the problem with the current system of fuel taxes goes well beyond just their low rates. Increasing vehicle fuel efficiencies and the inflexibility of fuel taxes to price for different road and traffic conditions are two significant factors that hamper fuel taxes going forward.

The most recent trend of increasing fuel economies, which began in 2005, is likely to continue and accelerate. The average fuel economy of new light-duty vehicles is likely to increase to 36 to 39 miles per gallon by 2030 (Energy Information Administration 2009). While this trend is a positive sign for motorists and environmentalist alike, it significantly hampers the fuel tax from collecting adequate revenue as drivers consume less fuel and pay less in fuel taxes.

1.3 State and Federal Fiscal Crisis

All of these issues with the gas tax and possibilities with VMT fees come against the backdrop of one of the worst recessions the United States has seen in modern history. The federal government, as well as many state governments, are facing historic budget deficits as a result. The federal budget deficits for 2009 and 2010 were the largest as a share of GDP since 1945 (CBO 2011). The Congressional Budget Office (CBO) (2011) estimates the 2011 federal budget deficit to be 9.8 percent of GDP. This would put 2011 on par with 2009 and 2010 as one of the largest federal budget deficits since World War II (CBO 2011).

Several states, including the state of Minnesota, are also facing significant budget deficits. Minnesota Management and Budget (MMB) (2011) estimates that the state of Minnesota is looking at a 2012-2013 biennium budget deficit of 5 billion dollars. While maybe not as dramatic a figure as the budget deficits facing the federal government, fixing Minnesota's budget deficit will undoubtedly come with painful cuts or economically harmful tax increases.

This thesis will later show how VMT fees could be used at the federal level to not only pay for the highways, but also significantly work towards deficit reduction. At the state level, this thesis will explore how, through a Minnesota VMT fee, the state budget deficit could be closed without cutting a single program or raising incomes taxes.

1.4 VMT Fee Revenue: How much and what to do with it?

The large amount of transportation funding that will likely have to come from general funds in the coming years and the problems with the gas tax beg several questions. What rationale is there for trying to uphold a user fee system that dedicates revenue solely for transportation purposes? Could transportation fees and taxes be used for other purposes? How much revenue could be generated through pricing the nation's roadways? Could we collect enough revenue from pricing to replace or lessen other taxes?

This paper looks at VMT fees along public finance principles, but also considers the policy implications and potential revenue that could be generated if we took advantage of one of our most valuable resources: the highways. Instead of seeing highways and all roadways as a revenue sink, this thesis envisions them as a significant revenue source. This thesis explores the possibilities, both at the federal level and for the state of Minnesota, of using VMT fees to not only provide funds for the highways and other transportation purposes, but to also provide a significant revenue source for general funds. It will later be shown, that for relatively low and economically harmless VMT fee levels, great amounts of revenue could be raised. These revenues could not only fund the transportation system, but could save the state of Minnesota from harmful program cuts or tax increases, and could potentially help avert a fiscal crisis that could derail the United States' economic rebound.

This paper proceeds as follows: Chapter two further explores the fiscal context both at the national level and in Minnesota. Chapter three explores the literature with a focus on what has been written about VMT fees, as well as the literature that sets up the empirical section of this paper. Chapter four presents the model, data, results, and technical issues for an empirical demand model for VMT. Chapter five uses the model developed in the previous chapter to help forecast the revenue that would result from different VMT fee levels at either the federal or state of Minnesota level. Chapter six presents the rationales for using VMT fee revenue to replace fuel taxes, reduce income taxes, or reduce deficits. Finally, chapter seven provides conclusions, final discussions, and the road ahead for VMT fee implementation.

CHAPTER 2. FISCAL CONTEXT

This paper imagines road pricing as something that is not simply used to plug the revenue gap in transportation, but as a tool to bring greater general revenue to federal and state budgets. Given this potential purpose, it is useful to examine the general health of both the federal budget and state budget for Minnesota. While transportation user fees are generally earmarked for transportation projects, it would not be unprecedented to use what is generally seen as a transportation fee for general purposes.

Fuel taxes in Europe, which are generally significantly higher than fuel taxes in the U.S., are frequently used for a host of non-transportation related purposes (petrolprices.com 2011). The U.S. has also used fuel taxes in the past for non-transportation purposes. When the gasoline tax was first implemented with the Revenue Act of 1932, revenues were not solely dedicated to transportation projects (Federal Highway Administration 2008). More recently, a portion of federal fuel tax revenues were used for budget-deficit reduction from 1990 to 1997. Given the current fiscal situation, it may be time to revisit the idea of using revenues generated from what Americans typically think of as transportation user fees for deficit reduction purposes.

The following two sections describe the budget deficits facing the federal government and the state of Minnesota.

2.1 Federal Situation

The federal budget shortfall as a percent of GDP for 2010 was the second highest in the last 65 years, beaten only by last year's shortfall (CBO 2011). The CBO (2011) reports the 2010 federal deficit at $1.3 trillion, which represented 8.9% of GDP for the year.

While the federal budget situation of the last two years is in part due to the current economic downturn and the large increases in government spending in the last two years intended to thwart an even greater downturn, relatively large deficits, primarily due to growth in entitlement spending, are expected to persist going forward. The CBO estimates that while the deficit will decrease as a percent of GDP in coming years, it will still be 7.0 percent of GDP by 2012 (CBO 2011). This estimate is based on current tax and spending policies.

Looking past the next few years, the deficit is projected to range from 2.9 to 3.4 percent of GDP from 2015 to 2021 (CBO 2011). The CBO (2011) projects that this will bring our federal debt to 77 percent of GDP by 2021. Once again, this is only a baseline projection based on current law. In December of 2010, the Obama administration's National Commission on Fiscal Responsibility and Reform released a plan entitled "The Moment of Truth" (also known as the Simpson-Bowles Plan for the two co-chairs of the commission Erskine Bowles and Alan Simpson) to help reduce our long term projected deficits. The political viability of this plan is still up for debate, however the plan is projected to achieve "nearly $4 trillion in deficit reduction through 2020" (The National Commission on Fiscal Responsibility and Reform 2010). Among the plan's objectives are to cut government spending in several areas, eliminate tax breaks, and to substantially increase the federal gas tax. While a 15 cent increase in the gas tax would be significant, given the discussion in the introduction regarding the problems inherent to the gas tax, this revenue source will be weakened going forward, especially if we continue to pursue policies aimed at making vehicles more fuel efficient and consuming less gasoline.

2.2 Minnesota Situation

At the state level, Minnesota is also facing sobering forecasts. In late 2010, state economist Tom Stinson painted a grim fiscal picture for Minnesota. For 2012-2013, the state is facing a $5 billion budget deficit (MMB 2011). Stinson has said that the projected deficit was a result of political decisions that favored payment delays and one-time fixes over structural reform (Helgeson et al. 2010).

Going forward conditions do not improve much. With no changes to programs, forecasters believe the state will face another $4.4 billion structural budget deficit for 2014-2015 (MMB 2011). In talking about the state's budgetary troubles, Stinson has stated that state leaders need to commit to structural changes or "it will take us several more bi-enniums to get out of it" (Helgeson et al. 2010).

State political leaders do not appear to have come to any consensus on what to do regarding the budget. Republican House Speaker Kurt Zellers has said, "The forecast shows what voters told us on Election Day: Government is spending too much money and they want it restrained," while DFL representative Ryan Winkler sees the problem differently stating, "That's the legacy of the Republican addiction to 'No New Taxes':

No new jobs, chronic deficits and a state undermining its children's future." (Helgeson et al. 2010.)

CHAPTER 3. LITERATURE REVIEW

The literature review has three sections: VMT Fees, Foreign Toll Systems in Place and Use of Revenues, and Model. The VMT fees section breaks down the literature further into five subsections: hypothecation, efficiency, equity and incidence, revenue adequacy and sustainability, and feasibility and costs. The foreign tolls systems in place and use of revenues section is more of a synopsis of current mileage-based fee systems in place. Finally, the model section explores the literature that is relevant to the model and techniques used in this thesis.

3.1 VMT Fees

This section begins with a review of the literature surrounding VMT fees and hypothecation. Hypothecation is simply the practice of earmarking or dedicating funds for a specific purpose or program. The hypothecation subsection relies heavily on a literature review by Robin Lindsey entitled, "Do Economists Reach a Conclusion on Road Pricing? The Intellectual History of an Idea" (2006). The hypothecation section is followed by four sections looking at the efficiency, equity and incidence, revenue adequacy and sustainability, and feasibility and costs of VMT fees. Except for a few noted changes, these four sections are pulled directly from sections of the third chapter of a paper entitled, "From Fuel Taxes to Mileage-Based User Fees: Rationale, Technology, and Transitional Issues" by Coyle et al. (2011b)[1, 2]. The Coyle et al. (2011b) paper is currently in the process of being published by the Center for Transportation Studies at the University of Minnesota.

3.1.1 Hypothecation

Hypothecation or 'earmarking' has been a long established practice in the U.S. when it comes to transportation funding. By the 1950s several states were dedicating their gas tax revenues to highway purposes (Patashnik 2000). As alluded to earlier, with the inception of the Highway Trust Fund in 1956, the federal gas tax also began to be earmarked for transportation, specifically building the interstate highway system. While transportation user fees at the federal level no longer collect enough money to cover transportation expenditures, the revenue collected through user fees is still, for the most part, specifically earmarked for transportation related spending.

Exceptions to earmarking gas tax revenues for highway purposes include: a small portion of federal fuel tax revenues to fund mass transit projects since 1983, an even smaller portion to fund the Leaking Underground Storage Tank Trust Fund since 1987, and a portion going to federal budget deficit reduction from 1990 to 1997. Some analysts have also noted that Highway Trust Fund revenues have also gone towards such things as graffiti elimination in New York and films about state roads in Alaska (Williams 2007). Others have estimated that at times nearly 40 percent of federal fuel tax revenues are spent on non-general road projects (Utt 2003).

Many transportation and public finance experts label this process of earmarking of user fees as the "user-pays-and-benefits principle." While this principle, barring the exceptions mentioned above, has long been supported when it comes to transportation, the support for it amongst economists is actually mixed. In 2006 article entitled "Do Economists Reach a Conclusion on Road Pricing? The Intellectual History of an Idea," Robin Lindsey explores the different attitudes of economists with regard to road pricing, and gives considerable attention to the debate over allocation of road-usage revenues and earmarking. Lindsey identifies four different camps that economists fall into when it comes to earmarking road-usage revenues: those against earmarking, those in favor of revenue neutrality (i.e. offsetting new road-user charge revenues with reductions in other charges), those in favor of earmarking generally, and those in favor of particular earmarked allocations.

In the against earmarking camp, Lindsey identifies Mohring (1991), Gómez-Ibáñez (1992), and *The Economist* (1989). In noting Mohring's perspective, Lindsey states, "Plowing congestion tolls back into road improvements is not necessarily efficient. Presume zero population and travel growth, infinitely durable roads, and an optimally designed road network. Marginal-cost tolls would then function as a normal return on the resources that society has invested in its road network. Efficiency would dictate using road-user tolls just as any other source of government revenues. Efficiency would not dictate spending these revenues on road improvements. (Mohring 1991)" (p. 336-337). Gómez-Ibáñez (1992) notes that surpluses may be more of an accounting artifact than a price signal to expand capacity and thus earmarking road-usage fees for highway or transit improvements would be undesirable. Finally, *The Economist* (1989) states,

> "[I]t makes no more sense than any other scheme to hypothecate tax revenues for specific sorts of spending: if a programme is sufficiently worthy, it should be financed regardless of where the tax-money comes from; if not, the money should be spent elsewhere. A clever transport minister, in his speech proposing road pricing, will nevertheless want to make voters feel that as travelers they would benefit: 'A good transport system is the handmaiden of a healthy economy. It also allows people an essential personal freedom-to travel as they wish. The government wants to meet the

> demand for more travel, including car travel, not to suppress it. The money raised from city drivers will not be earmarked for particular transport projects, but you can be sure that it will make it easier for the nation to afford new road and rail links generally.' Expect such words to be intoned in many great cities before this century is out" (p. 12).

In favor of revenue neutrality, Lindsey highlights Beesley and Roth (1962-63), Newbery (1990), and Walters (2002). All three seem to take the view that congestion charge revenues should be used to reduce or completely eliminate fuel taxes and other road taxes.

In favor of earmarking generally, Lindsey highlights Verhoef, Nijkamp, and Rietveld (1997) and Hau (1998). Verhoef, et al., are concerned that allocating revenues outside of the transport sector will likely stimulate prejudices that drivers are the government's favorite "cash cows." Hau believes that earmarking would enable governments to satisfy the principles of the World Bank's general guidelines for improving transport efficiency.

Among those in favor of particular earmarking schemes, Lindsey identifies several researchers that support particular schemes that give at least some portion of revenues to public transit, in part, to make VMT fees more politically and publically acceptable. These researchers include Goodwin (1989, 1997), Small (1992), Ison (2004), and King et al. (2006). Goodwin (1989) purposes a "Rule of Three" in which revenues are allocated in equal parts to development and maintenance of new road infrastructure, public transport, and to either reducing the general tax burden or to increasing spending. Lindsey notes that Goodwin acknowledges that these proportions are arbitrary, but that a scheme of this sort is essential to road pricing receiving public support. Similar to the researchers in this camp, Munnich (2009) argues that to win popular support, a VMT fee system proposal that includes a congestion pricing component may need to include extra funding for transit along with the implementation of the system. Munnich observes that while successful implementations of congestion pricing schemes have included funding for transit, failures of congestion pricing proposals, such as the recent proposal for congestion pricing in New York City, may be linked to a lack of attention to transit.

In concluding his discussion on earmarking, Lindsey states, "In summary, economists have a range of opinions on how the revenues from road pricing should be used. A growing proportion (and perhaps now a majority) seems to favour earmarking revenues in some way. However, it may be that they support earmarking only reluctantly as a necessary concession for road pricing to move forward" (p. 341).

3.1.2 Efficiency[3]

In reviewing the literature with regard to economic efficiency, the Coyle et al. (2011b) study explored how efficiency would be affected if VMT fees were set to directly reflect use of the transportation system. The study looked at three specific areas pertaining to economic efficiency: use of the transportation system, transportation investment, and land use.

3.1.2.1 Use of transportation system

For a tax or fee to send price signals that encourage efficient use of the transportation capacity, users must be aware of the fee and the fee must cover the full societal costs imposed by the user. As described by Small et al. (1989),

> “The best way to economize…is to apply a user charge equal to the actual cost each user imposes on society through his effect on the road’s conditions and on the speed that other users can travel. Such a charge, known as the marginal-cost user charge, ensures that the independent decisions by users reflect the interests of all…If road users are required to incur this entire amount themselves, they will use the highway…only if the value to them of doing so exceeds the amount society must pay…” (p. 9).

In contrast to fuel taxes, VMT fees are able to serve as what Small et al. would call a marginal-cost user charge. If VMT fees are set high enough to cover the costs users impose on the road’s condition, and are variable so that they change with the type of road and time of day to capture congestion costs, then VMT fees act as marginal-cost user charges. Furthermore, if the method of payment makes users aware of what they pay in VMT fees for particular roads and times of travel, then users can better weigh their travel time decisions and their choice of mode.

Effect on roadway congestion

Roadway congestion in the United States is a serious and growing problem. A recent congressional commission noted, “Without a doubt, congestion is one of the greatest threats to the integrity of the Nation’s transportation system and the country’s overall vitality and quality of life” (National Surface Transportation Policy and Revenue Study Commission 2007, p. 3.13). In the nation’s 14 largest urban areas, annual delay per peak period traveler rose by approximately 30 hours from 1982 to 2007 (Texas Transportation Institute 2009). For 2007, the total cost imposed by urban area congestion in the U.S. has been estimated at approximately $87.2 billion (Texas Transportation Institute 2009). Table 3.1 below illustrates the congestion costs for the nation’s 14 largest urban areas in 2007. As one can see from the table, the costs in terms of travel delay and excess fuel consumed are substantial.

Table 3.1: Costs of Congestion for Largest Urban Areas 2007

Urban Area	Travel Delay (1000 Hours)	Rank	Excess Fuel Consumed (1000 Gallons)	Rank	Congestion Cost ($ million)	Rank
Very Large Average (14 areas)	166,900		115,654		3,549	
Los Angeles-Long Beach-Santa Ana CA	485,022	1	366,969	1	10,328	1
New York-Newark NY-NJ-CT	379,328	2	238,934	2	8,180	2
Chicago IL-IN	189,201	3	129,365	3	4,207	3
Atlanta GA	135,335	6	95,936	6	2,981	4
Miami FL	145,608	4	101,727	4	2,955	5
Dallas-Fort Worth-Arlington TX	140,744	5	96,477	5	2,849	6
Washington DC-VA-MD	133,862	7	90,801	8	2,762	7
San Francisco-Oakland CA	129,393	8	94,295	7	2,675	8
Houston TX	123,915	9	88,239	9	2,482	9
Detroit MI	116,981	10	76,425	10	2,472	10
Philadelphia PA-NJ-	112,074	11	71,262	11	2,316	11

DE-MD						
Boston MA-NH-RI	**91,052**	**12**	**60,986**	**13**	**1,996**	**12**
Phoenix AZ	**80,456**	**14**	**57,200**	**14**	**1,891**	**13**
Seattle WA	**73,636**	**15**	**50,541**	**15**	**1,591**	**15**

(Texas Transportation Institute 2009)

Fuel taxes, our current method of funding the transportation system, have little or no ability to reduce congestion. On the other hand, VMT fees offer great promise in this area. Because VMT fees can be made to vary with time and location of travel, using congested roadways can be priced at levels that more closely reflect the cost of congestion. As noted by a recent congressional commission, "VMT fees, especially if applied as congestion pricing fees or weight-distance taxes can send strong pricing signals to users" (National Surface Transportation and Revenue Study 2007, p. 5.45). Studies have shown that users do in fact respond to these price signals. Traffic declined by approximately 20 percent in the first few months after congestion pricing was implemented in London (Litman 2004) and similar results were experienced in Stockholm (Robinson 2006). A test of congestion tolling by the Puget Sound Regional Council, found that the toll could reduce vehicle use during peak periods by approximately 10% (Oh 2008 p. 18).

While VMT fees that price for congestion are likely to lead to a more efficient use of the system, there is the possibility for some adverse effects, as noted by Whitty et al. (2009),

> "Adding a congestion pricing system…will create some undesired effects for urban areas, depending upon the congestion pricing method employed…Given a choice between a *free* facility and a tolled facility, many drivers will choose the *free* facility, even if its qualitative characteristics are not as good as those of the tolled facility. Non-tolled routes parallel to a route with a new toll may become quite congested as a direct result of the toll" (p. 32).

However, if all roads are priced, VMT fees will be lower because of the broader-tax base, thus making toll rates more affordable. In turn, since all roads are priced, diversion to "parallel" facilities will cease to be an issue. And even if only major roads are priced, the traffic management effect will be to accommodate greater volumes per hour than under congestion, thus reducing the pressure to divert[4].

3.1.2.2 Investment in transportation

Marginal-cost user charges, in addition to leading to efficient use of the transportation system, can also lead to more efficient investment in transportation. As noted by Small et al. (2009), "[T]he resulting revenues provide a tangible signal to public officials as to whether additional investments to provide more or better services are likely to be worthwhile" (Small 1989, p. 9). Thus, a VMT fee that prices for actual costs imposed will convey price signals to public officials and investors as to where true demand for service improvements are occurring.

Implementing a VMT fee system has the possibility of leading to additional investment in some areas and less in others. If VMT fees generate more revenue for a particular area than does the current system of fuel taxes, then worthwhile projects that previously did not have sufficient funds may be undertaken. This is more likely to happen in rural areas, where it is perceived that toll revenues would not be sufficient to cover system costs. For congested areas, VMT fees may actually decrease the need for additional improvements. As stated by Sorensen et al. (2009), "[VMT fees] could also enable our existing roads to carry far more vehicles per lane per hour during peak periods (see, for example, Obenberger 2004), effectively shortening the length of rush hour traffic periods and reducing the perceived need for roadway expansion" (p. 41). Making highways less congested, as opposed to just adding to capacity to relieve congestion, can lead to increased productivity for a region. An article by Boarnet (1997) found strong evidence that reducing congestion can increase county output, but weaker evidence that increasing the street and highway capital stock increases productivity.

3.1.2.3 Land use

VMT fees have the potential to lead to more efficient land use than fuel taxes do. Langer et al. (2008) note that the nation's fuel tax system, which undercharges vehicles for commuting, has contributed to urban sprawl. Simply defined, urban sprawl is the spreading of development away from a city's center, which requires the addition of costly infrastructure. Thus, if VMT fees can more accurately price the cost of commuting, then development pressures and decisions about where to live will be based on true costs, including transportation, and not be distorted by an artificially low cost of commuting. It should be noted, however, that development that spreads away from the city center is not necessarily an inefficient use of land. If roads are correctly priced, the spread that results may in fact be efficient.

Since VMT fees have not yet been implemented in the United States, there is much that is unknown about how they will affect land use. A general concern has been that the congestion pricing component of a VMT fee will cause businesses in the affected area to lose out to businesses located in areas that do not have congestion pricing. This, in turn, can alter land use if the shift in sales causes businesses in the priced area to shrink and development in the unaffected area to expand. This concern is not supported by evidence from areas that have implemented congestion pricing: Implementation of the Orchard Electronic Road Pricing in Singapore in October 2005, affected total traffic period, but not destination traffic. Data on retail sales from 2004-2008 in the Orchard commercial area shows that they have continued to experience healthy growth (Halim 2010). In London's charge system, daily vehicular traffic reduction was about 27 percent after pricing, but transit ridership increased by 26 percent and bicycles increased 98 percent. Analysis conducted after the pricing scheme was implemented indicated that the effect on overall retail business sales was largely neutral (Robinson 2006). In Trondheim, Norway, cordon pricing was introduced in 1991 and was phased out in 2005. (By law, pricing projects in Norway have a 15-year duration limit.) Analysis conducted prior to pricing, while pricing was in effect, and after the cordon was phased out, indicates that the effect on businesses in the cordon area was negligible. This effect applied to conditions before and after cordon pricing was introduced in 1991, and before and after it was taken out in 2005, Meland et al. (2010). Ultimately, how VMT pricing affects land use is likely to be dependent on how it is implemented and structured.

3.1.3 Equity and incidence[4]

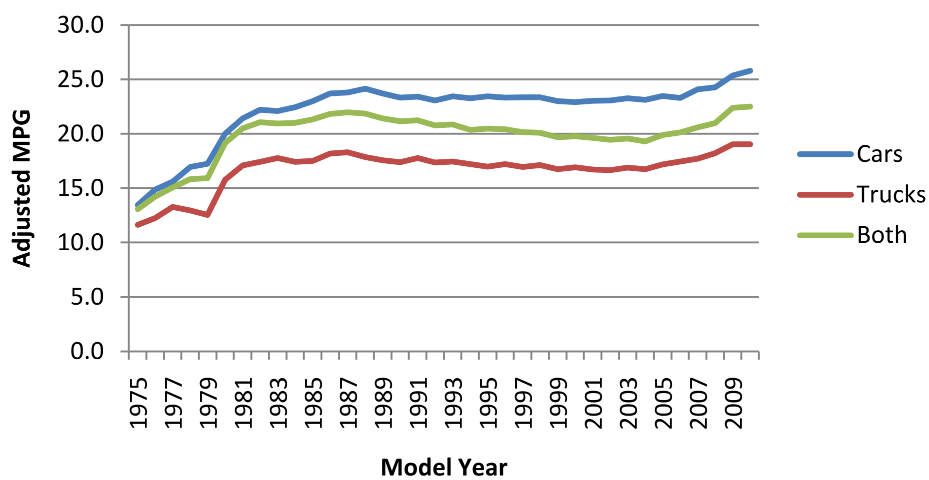
Under the equity criterion the Coyle et al. (2011b) study reviewed the literature on VMT fees for two different types of equity: (1) the benefit-received (or user-pays-and-benefits) principle, and (2) the ability-to-pay principle. Coyle et al. (2011b) focused primarily on the user-pays-and-benefits principle since this principle pertains to how equitable VMT fees are as user fees, and historically transportation finance in the U.S. has been based on user fees. While Coyle et al. (2011b) did give some attention to the ability-to-pay principle, additional literature not cited in the Coyle et al. (2011b) is presented when discussing the ability-to-pay principle.

3.1.3.1 VMT fees as user fees[6]

User fees, as opposed to taxes collected from the public in general, are paid by users of a particular service and vary, ideally, in proportion to degree of use of the service. As documented previously (see Patashnik 2000 and Small 1989), with the inception of the Highway Trust Fund, the highway network was financed with user fees that adhered to the user-pays-and-benefits principle. Because of several factors including increasing fuel efficiencies, the inability to keep pace with inflation, and the inability to vary with time or location of travel, the current fuel tax system has moved away from the user-pays-and-benefits principle. VMT fees, if implemented, have the potential to once again align the user fee system with the user-pays-and-benefits principle. As stated by Forkenbrock et al. (2002), variable road user charges could, "improve fairness, such that those who impose greater costs on the road system, on other users, or on society in general pay higher user charges" (Forkenbrock 2002, p. 22).

Improvements in fuel efficiency and use of alternative fuel vehicles

Increases in fuel efficiency and the introduction of alternative fuel vehicles are major reasons why today's system of fuel taxes has moved away from the user-pays-and-benefits principle. For model year 1975, the adjusted fuel economy was 13.1 miles per gallon (5.6 km/L), whereas for model year 2010 the adjusted fuel economy was 22.5 miles per gallon (9.6 km/L) (EPA 2010). Furthermore, for the overall model year 2008 fleet, hybrids represented about 2.5 percent of the fleet, which was their highest level ever (EPA 2008). Figure 3.1 below documents the dramatic increase in fuel efficiencies from the 1970s to today. Although the chart depicts a gradual decline from 1987 until 2004, the overall trend, and the most recent trend beginning in 2005, is increasing fuel economies.



(EPA 2010)

Figure 3.1: Adjusted MPG by Model Year

These trends in fuel economies are likely to continue in coming years. The Energy Information Administration (2009) predicts that average fuel economy of new light-duty vehicles will grow to between 36 and 39 miles per gallon (15 and 17 km/L) by 2030. Under a fuel tax system, these trends allow users with more fuel efficient vehicles to pay substantially less per-mile traveled. If VMT fees are implemented, however, increasing fuel efficiencies and the use of alternative fuel vehicles will not cause equity issues since fees are based on miles traveled and not fuel consumed.

Will all users pay VMT fees?[7]

Several researchers have expressed concern over the possibility of increased evasion under a VMT system. As noted by Sorensen et al. (2009), “Additionally, moving the point of collection from a relatively small number of entities (fuel wholesalers) to a much larger number (either retail fuel stations or individual motorists) would make it more difficult to prevent tax evasion” (p. xxii). VMT fees may be collected monthly (like utility fees), unlike fuel taxes that are collected each time fuel is purchased. Whitty et al. (2009) note that frequency of collection is an important factor when considering evasion rates stating, “Infrequent payment will likely result in greater defaults, more evasion and less public acceptance…” (p. 23). Thus, it will be important for policymakers to consider evasion when thinking through different payment schemes. The technology involved with VMT fees is also an important consideration for policymakers when addressing evasion. In considering the possibility of using GPS technology, the National Surface Transportation Policy and Revenue Study Commission (2007) notes,

> “Furthermore, there are several ways a VMT fee potentially could be avoided…For instance, devices are available that can block global positioning system (GPS) signals, making that technology vulnerable to evasion unless

> alternative methods for calculating mileage are available when GPS signals are not being received" (National Surface Transportation Policy and Revenue Study Commission 2007, p. 5.35).

To avoid this problem, a secondary method for estimating and verifying miles traveled (e.g., electronic odometer) may be required.

Full cost recovery of direct costs

For a user fee to adhere to the user-pays principle, it should work towards full cost recovery of direct costs such as road construction and maintenance. When considering direct costs, it is important to note that it is weight per axle and not total weight that matters when assessing road damage. As Small et al. (1989) state, "A 50,000-pound two-axle dump truck causes more road wear than a huge twin-trailer rig spreading 100,000 pounds over seven axles" (Small 1989, p. 11). Furthermore, in general, freeways are designed to withstand heavier loads than surface streets (Sorensen et al. 2009, p. 40). Thus, a proper user fee must be able to price for the design of the road as well as weight per axle to equitably recover direct costs. Successful implementations of similar pricing schemes have occurred, such as Oregon's weight distance tax, which accounts for weight, number of axles, and distance traveled (Whitty et al. 2009). It is anticipated that when implementing VMT fees, rates will vary, at a minimum, by vehicle weight and by miles driven.

Full cost recovery of external costs

In addition to recovering direct costs, a user fee must also work towards cost recovery of external costs such as those associated with congestion and greenhouse gas emissions. As noted in the efficiency section, roadway congestion in the United States is a serious and growing problem which imposes significant costs on society. Our current system of fuel taxes does little to account for congestion costs. While a typical user only pays three cents per mile in highway user fees, using a congested roadway imposes costs ranging from 10 to 29 cents per mile (6.2 to 18 cents per km) (Atkinson 2009). Thus, for a VMT system to be effective at recovering the costs from congestion it must price congested roads in this range of costs. In discussing the strengths of VMT fees, the National Surface Transportation Policy and Revenue Study Commission (2007) notes their ability to incorporate congestion pricing. Regarding the inclusion of congestion pricing in a VMT fee scheme, Sorensen et al. (2009) note, "The intent of this policy goal would be to raise the per-mile cost of peak hour travel in crowded corridors to capture the cost of delays imposed on others. By creating a financial incentive for drivers to shift their travel patterns where possible, this could significantly reduce traffic congestion" (p. 41). In addition to recovering the costs associated with congestion, VMT fees could be structured to recover environmental costs as well. Several studies have noted the possibility of charging different rates based on fuel efficiency[8].

3.1.3.2 Ability-to-pay considerations[9]

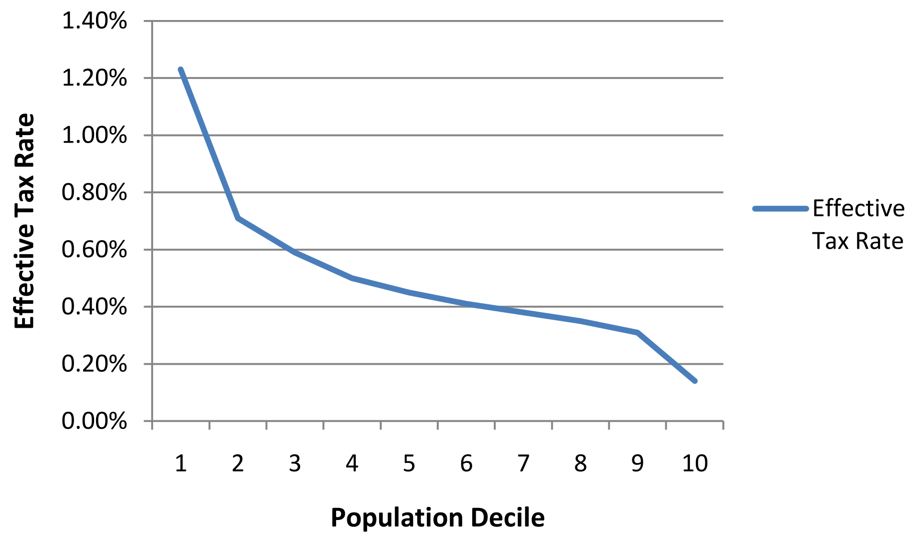
Vertical equity[10]

Vertical equity entails how tax burdens are distributed among different income groups. As a national VMT fee system has not yet been enacted in the U.S., it is unclear how a VMT fee system would affect different income groups. Whitty et al. (2009) note, "Whether the shift to a distance-based charge will positively or negatively affect the poorer element of society depends on the rate structure adopted and the type of vehicle operated" (p. 69). Fees like sales taxes tend to be regressive for those who pay them. In other words, the poor pay a greater percentage of their income in tax than the rich. However, Whitty et al. (2009) go on to note a study by Oregon State University which reports that "a large portion of the lowest income group tends not to be affected by road taxes and fees because they do not operate motor vehicles" (p. 69-70).

There are several factors that could lessen the regressivity of a VMT fee. First, how revenues generated by VMT fees are spent may affect vertical equity. If revenues are spent on public transit in poorer areas, this may work to lessen the regressivity of the system. To the extent that a VMT fee may include congestion pricing, providing funding to public transit may be essential. Munnich (2009) found that all successful congestion pricing implementations have been accompanied by a significant transit investment component. Second, Oh (2008) notes the possibility of introducing discounts and exemptions for lower income groups. Third, the visibility of a VMT fee may cause price-sensitive individuals, such as those from lower income groups, to drive less (National Surface Transportation Infrastructure Financing Commissions 2009). Finally, after citing that low-income groups are more likely to drive less fuel efficient vehicles, Whitty et al. (2009) note, "The poorer motorist would generally pay more per mile under the fuel tax than they would under a comparable flat rate mileage charge. The gas tax therefore would be more regressive to poorer motorists than a flat rate mileage charge. Graduated, stacked, multiplied or other non-flat mileage charge rate structures will yield different outcomes" (p. 70). *The remainder of the equity section below does not come from Coyle et al. (2011b)*

Nonetheless, like most consumption taxes, road pricing or a tax on vehicle-miles traveled would likely be regressive. While not exactly the same, the regressivity of road pricing would be similar to the regressivity of the gas tax. Williams (2007) reported that, "Americans earning less than $10,000 annually paid an estimated 2.5 percent of their income in gas taxes whereas Americans earning an annual salary of $150,000 and above pay only about 0.2 percent of their incomes in gas taxes" (p. 17).

Looking specifically at the state of Minnesota, the 2009 Minnesota Tax Incidence Study conducted by the Tax Research Division of the Minnesota Department of Revenue (2009) found the Suits index to be lower for the state motor fuels excise taxes (-0.308) than for the individual income tax (0.195) and even for total sales taxes (-0.195). The Suits index is a measure of collective progressivity with a value of 1 being a completely progressive tax while a value of -1 being a completely regressive tax. Figure 3.2 below demonstrates the regressivity of Minnesota's fuels excise taxes as reported by the 2009 Minnesota Tax Incidence Study.



Source: Minnesota Department of Revenue

Figure 3.2: Effective Tax Rate for Minnesota Motor Fuels Excise Taxes

The 2009 Minnesota Tax Incidence Study also sheds some light on the tax shifting and overall incidence of a VMT fee. While the statutory burden to pay a VMT fee would be on the individual households, some tax shifting may occur. Consumers of products whose firms rely on VMT for production may see higher prices, and labor and capital at those firms might have lower returns. Furthermore, although a VMT fee would be on travel and not gasoline, because gasoline consumption and VMT are closely related, the gasoline industry would also likely bear some of the economic incidence which it could in turn pass along to consumers, labor, and capital. The car insurance industry, car industry, and several other related industries would also likely be affected to some degree. The 2009 Minnesota Tax Incidence Study found that with the state motor fuels excise taxes Minnesota households directly bear 74% of the tax incidence, while business shifts 26% percent of the incidence on to consumers. 0% is shifted to labor or capital. A VMT fee would likely see similar incidence shifting.

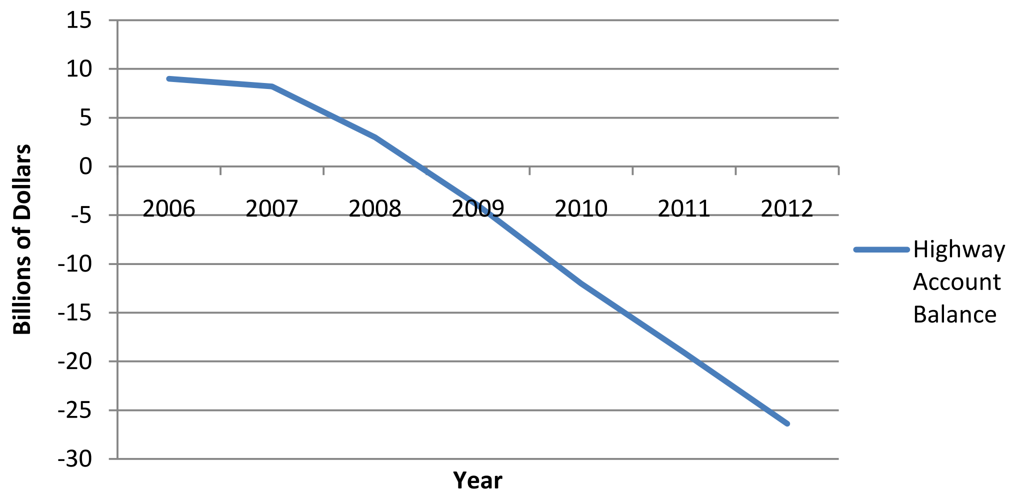
While road pricing is likely to follow a similar path as fuel taxes with regard to incidence shifting between consumers, labor, and capital, if road pricing were to completely eliminate the gas tax and be implemented at a revenue neutral level with current gas tax revenue levels, a tax on miles traveled would likely be less regressive than current fuel taxes. This is due to the fact that the poor on average own less fuel efficient vehicles than richer drivers. Rich drivers with more fuel efficient vehicles are able to pay less in fuel taxes as they consume less fuel per mile. However, under a VMT fee system (that does not have a variable rate by fuel economy) high income drivers would no longer be able to benefit from their fuel efficient vehicles when it came to paying their highway user fee.

3.1.4 Revenue adequacy and sustainability

Under the revenue adequacy and sustainability criterion, Coyle et al. (2011b) examine both the tax rate and base from which a VMT fee would be collected, and how well VMT fees would remain a stable revenue source in the face of external changes.

3.1.4.1 Revenue adequacy

It has been heavily documented that in 2008 the Highway Trust Fund, which is primarily funded through fuel taxes, needed an eight-billion dollar transfer from the general fund to stay solvent. In 2009, the Highway Trust Fund received an additional seven-billion dollar transfer. Without significant changes in how the system is financed, the solvency of the Highway Trust Fund will continue to be an issue. Figure 3.2 below documents the projected negative balances in the Highway Account of the Highway Trust Fund assuming no changes in revenues or program levels.



Source: U.S. Department of the Treasury projections
(National Surface Transportation Policy and Revenue Study Commission 2007)

Figure 3.3: Projected Highway Account Balances

Oh et al. (2008) assert, “Given that the objective of the VMT fees is to bridge the revenue…gap of current fuel taxes, the fee rates based on the revenue needed and the vehicle-miles driven could be higher than the current fuel taxes” (p. 26). Thus, given the inadequacy of fuel taxes at current rates, for a VMT system to cover the funding shortfalls rates will most likely have to be increased. However, rates will not have to be raised as high as they would under the current fuel tax system, as a VMT fee system broadens the base on which revenue is collected. While fuel taxes collect low levels of revenue per-mile of travel from highly fuel efficient vehicles and no revenue from non-petrol propelled vehicles, VMT fees have the potential to broaden the base and collecting significant revenues from both of these groups of motorists. Considering that in 2007 there were approximately 205 million licensed drivers in the U.S. (Federal Highway Administration 2009c), VMT fees have a potentially very large base from which to draw revenue.

It should be noted, that while the overall effect is a broadened base, some aspects of VMT fees may cause base reductions in some areas and at some times. If a VMT fee system includes a congestion pricing component, this could lead to a base reduction as motorists shift to other modes to avoid paying the congestion charge. Singapore saw public transport's mode share grow from 40% to 67% in the 30 years after congestion pricing was implemented. London and Stockholm experienced similar affects after implementation (Munnich 2009).

3.1.4.2 Revenue sustainability

In addition to generating adequate revenue from a large base, VMT fees are expected to generate revenue streams that remain stable and predictable despite external changes. While the effects of inflation may hamper the ability of VMT fees to be a sustainable revenue source, changes in fuel prices and fuel efficiencies and the introduction of alternative fuels should not dramatically affect the stability of VMT fees as a revenue source. In its findings and conclusions, the National Surface Transportation Infrastructure Financing Commission (2009) first noted that the current system of fuel taxes is "not sustainable in the long term" before recommending VMT fees as the consensus choice for the future. The Commission noted the drive for more fuel efficient and alternative fuel vehicles as a significant factor for why fuel taxes are not sustainable going forward.

Inflation erodes the value of revenue collected

Aside from increases in fuel efficiencies, a big part of why fuel taxes are currently inadequate and unsustainable is that they are not indexed to inflation. It has been noted that since 1993 the federal gas tax rate has fallen by 40 percent when it is compared to the Producer Price Index for Highway and Street Construction (National Surface Transportation Policy and Revenue Study Commission 2007). If implemented, a VMT fee system may face a similar challenge. As noted by Sorensen et al. (2009), "VMT fees would neutralize the issue of improved fuel economy…but it would still be appropriate in principle to index, or periodically increase, VMT fees to prevent the erosion of real revenue due to inflation. There is no indication that such increases would be easier to make, politically, than raising current fuel taxes" (p. 6).

Changes in fuel prices

Changes in fuel prices may have some affect on the revenue streams generated by VMT fees. Small et al. (1989) note that, since 1973, receipts from fuel taxes have fluctuated with changes in fuel prices and economic conditions. Patashnik (2000) notes that the energy crisis of the 1970s was a significant factor in dwindling fuel tax revenues during this time. If fuel price rises are dramatic enough to reduce vehicle-miles traveled, then a VMT fee system, like fuel taxes, will experience lower revenues.

While changes in fuel prices may affect driving behavior, sustained elevated prices can also lead to a drive for more fuel efficient or alternative fuel vehicles. As noted by a Transportation Research Board study (2006), "After 2025, large market shares for hybrid electric and fuel cell–powered vehicles, and consequently greater reductions in gasoline consumption, are possible, if driven by government intervention or high fuel prices" (p. 180). Elaborated on below[11], this drive for more fuel efficient and alternative fuel vehicles, which is in part induced by higher fuel prices, will have little effect on the revenue sustainability of a VMT fee system.

Fuel efficiency changes

As noted earlier by Sorensen et al. (2009), a VMT fee system would "neutralize the issue of improved fuel economy" as the tax is on vehicle-miles traveled and not on fuel consumed. This is an important attribute of VMT fees as fuel efficiencies are likely to continue their recent upward trend. As documented earlier in the Equity section, the Energy Information Administration (2009) suggests that the average fuel economies for new light-duty vehicles are predicted to grow to 36 to 39 miles per gallon (15.3 to 16.6 km/L) by 2030. Just as VMT fees improve equity, they also improve revenue sustainability since increasing fuel efficiencies leave VMT fee revenue largely unaffected.

Introduction of alternative fuels

When considering revenue sustainability, it is important to consider the introduction of alternative fuel vehicles. Once again, as noted in the Equity section, alternative fuel vehicles are gaining market share. For model year 2008, hybrids represented their highest market share to date, coming in at 2.5 percent of the fleet (EPA 2008). In 2003, Wachs (2003) noted that some believe that hydrogen may become the basis of automotive power. With the emergence of the Leaf and Volt, electric vehicles and plug-in hybrids now seem more poised than hydrogen to take an early lead in the alternative fuel vehicle market. Moving to a VMT fee system would inoculate transportation funding from these changes, since adequate revenue would still be collected from those drivers using alternative fuels.

3.1.5 Feasibility and costs

Under the feasibility criterion, Coyle et al. (2011b) explored the literature on the political feasibility and administrative feasibility of a VMT fee system.

3.1.5.1 Political feasibility

Before the literature is reviewed on the political feasibility of VMT fees[12], it is important to remember that most taxes and fees are not particularly popular. Nonetheless, not all taxes are viewed the same by taxpayers. A recent poll found that when compared to cigarette, beer and wine taxes, corporate income taxes, social security payroll taxes, estate taxes, and federal income taxes, the gas tax was the second least popular tax, with only the estate tax seen as less fair (Harris Interactive Inc./Tax Foundation 2009).

Although fuel taxes are currently not very popular, there is little indication that VMT fees would enjoy any higher rates of popularity. A recent study looking at shifting to VMT fees noted the following:

> "In considering the public acceptability of VMT fees, the experts consulted in this project offered two salient observations. First, there is little public understanding of the current challenges in transportation finance, and in turn the motivations for a transition to VMT fees. Second, the privacy concerns associated with GPS remain a potent obstacle to the acceptance of sophisticated in-vehicle metering equipment. To bolster the prospects of transitioning to a VMT-fee system, concerted public education and outreach would likely be imperative" (Sorensen et al. 2009, p. xxiv).

Nonetheless, taxpayers' response may be different if given the opportunity to experience a VMT fee system in operation. A recent report analyzing the Oregon VMT fee pilot project noted that 91% of participants of participants would continue paying highway user fees through VMT fees if given the option (O'Leary 2009).

The structure of any VMT fee system, and how revenues will be raised, will be significant factors in determining the level of public and political support. If a VMT fee system includes a congestion pricing component, it may be critical to also include extra funding for transit along with the implementation of the system to win popular support. In a recent paper, Munnich (2009) argues that successful implementations of congestion pricing schemes have included a significant investment in transit, and that the failure of congestion pricing proposals, as such as the one in New York City, may be linked to a lack of attention to transit.

Under the political feasibility principle three specific criteria are examined[13]: visibility to taxpayers, tax exportation, and drivers' privacy and system security.

Visibility to taxpayers

Tax visibility can be broadly defined as the degree to which taxpayers are aware of a tax or fee. This should not be confused with tax transparency, which relates to the degree to which taxpayers know the actual costs they incur from a tax. As taxes become more visible, their popularity tends to decrease. Also, governments may more easily raise taxes when they are less visible. The degree of visibility of a VMT fee system is dependent on how the system is implemented and designed. Whitty et al. (2009) presents a discussion of the visibility issues policymakers will need to think through:

> "Many user fees are embedded within transactions and therefore hidden. Policymakers must decide whether mileage charges should be transparent to the payer or embedded within each fuel purchase like the current gas tax. If hidden, the motorist may never know the mileage charge amount. If transparent, the motorist will know the mileage charge amount either at the time of payment or while the charge tallies during travel, depending upon the technology employed within the vehicle" (p. 23).

Thus, since there are several options for the design of a VMT fee system, the visibility of the system and how this level of visibility will affect political support and public opinion is largely unknown at this time. On the other hand, as discussed previously, the visibility of VMT fees is one of its key attributes since it helps drivers to be more aware of the true cost of their travel.

Tax exportation

Tax exportation enhances the popularity of a tax as it generates revenues for an area without any direct costs to area residents. A federal VMT fee would benefit little or not at all from tax exportation. Depending on the set up of the system, foreign tourists and truckers may pay some in VMT fees; however, this would be a minimal amount when considering total national miles traveled and fees paid. Tax exportation may be a relevant issue when considering state VMT fees. Whitty et al. (2009) notes, "Legally, out-of-state motorists must not drive free of charge when local residents pay the charge. Policymakers must decide whether out-of-state motorists should pay under the same system as resident motorists or whether a different system could be deployed for them" (p. 23).

Driver's privacy and system security[14]

As mentioned before, privacy concerns are a significant hurdle to public acceptance of VMT fees. A recent congressional report noted, "Privacy is perhaps the biggest concern with a VMT fee. Many motorists fear that information on when and where they drive would be transmitted to government authorities" (National Surface Transportation Policy and Revenue Study Commission 2007, p. 5.35). Oh (2008) notes that while in initial stages, pricing project users are reluctant to reveal their travel pattern information, users show less reluctance as they become more accustomed to the new technologies that are gathering their information. Oh goes on to note two studies that illustrate how the privacy concern has lessened for users after implementation. In particular, Oh cites a study that reported that with the SR-91 Express Lanes in Orange County, California, and the Highway 407 Toll Road in Toronto, Canada, approximately 99% of users used a transponder system that kept travel records.

Nonetheless, despite the fact that privacy concerns have lessened for users after implementation, privacy concerns remain an important issue. Sorensen et al. (2009) note, "[T]he perception that GPS will be used to track and monitor travel remains a potent public concern despite the fact that technical approaches to the protection of privacy have already been developed and demonstrated" (p. xvi). One such privacy protection was demonstrated in the Oregon VMT project, in which intermediate travel data was purged from memory after being used for fee calculation and bill submission (Whitty 2003).

In addition to developing and demonstrating technologies that ensure drivers' privacy, additional strategies could be utilized to help VMT fees overcome privacy concerns and gain public support. Sorensen et al. (2009) note, that in addition to public outreach and education, two factors that may assist VMT fees in overcoming privacy concerns are the ability to save money through the use of the GPS technology such as pay-as-you-drive insurance, and additional user features brought about by the technology such as navigation features. Another possible solution that has been suggested is to have a private operator as opposed to a government entity run the system (Sorensen et al. 2009, p. 37)

To gain public acceptance and political support, it will also be important for the VMT fee system to ensure system security. This entails employing features that protect the system from unauthorized access and illegal use. Sorensen et al. (2009) note that, through the use of firewalls and data encryption, it would be able to attain an acceptable level of security for different VMT fee system designs.

3.1.5.2 Administrative feasibility

Administrative feasibility deals with the degree of difficulty and costs involved with implementation, operation, and enforcement as well as compliance costs.

Implementation, operation, and enforcement costs

A VMT fee system is likely to experience significant implementation, operation, and enforcement costs, especially when compared to the current system of fuel taxes. Sorensen et al. (2009) note that the three most promising options for implementation of a VMT fee system all have high administrative costs:

> "Though promising, the three mechanisms suggested for further consideration share several important obstacles related to cost, administrative complexity, and political acceptability…current evidence suggests that any of the three options would be more expensive - potentially much more expensive – than collecting fuel taxes…it may be necessary to develop or secure new tax collection channels; a new national agency or expanded state powers; cooperation from entities not currently involved with fuel tax collection, such as cellular providers and retail fuel stations; support from the Internal Revenue Service (IRS)…" (p. xxii-xxiii).

Moving the point of collection from a relatively small number of wholesalers to the driving public at large will also most likely come with additional enforcement costs. A recent congressional report notes evasion as a concern with VMT fees and explains the need for a back-up system for monitoring miles traveled since devices are available to block GPS signals (National Surface Transportation Policy and Revenue Study Commission 2007). *The remainder of the *implementation, operation, and enforcement costs* section below does not come from Coyle et al. (2011b)*

At the 2010 Symposium on Mileage-Based User Fees (2010), the Chief Economist at the U.S. Department of Transportation, Jack Wells, gave a presentation regarding the administrative costs of VMT pricing. Wells explained that administrative costs vary with different VMT pricing systems and mechanisms as well as with what revenue is being generated. Wells discussed a U.S. Department of Transportation sponsored study that found the following with regard to administrative costs (Coyle et al. 2010, p. 33):

> "Fuel tax costs…are generally about 1 percent of revenues…Thick OBUs [on board units] run about $650…Thin OBUs cost less, about $195 per unit, but have more privacy concerns and higher data transmission costs. However, they are easier to update in terms of mapping software…Transaction costs are very low with GPS, running about 0.07% of revenues. Capital costs would be about 1-4% of revenues. Total costs of the system, if including the costs of OBUs,

would be 7.9% of revenues for a thin OBU configuration and 33.2% of revenues for a thick OBU."

Wells concluded that GPS is the only feasible technology for a nation-wide VMT pricing system and that, "administrative costs are feasible if a thin OBU configuration is used" (Coyle et al. 2010, p. 33). Wells went on to note that the costs from a GPS, thin OBU configuration are still higher than the cost to administer fuel taxes, and thus collection costs from a VMT fee "could only be justified if significant benefits other than just collecting revenue…are realized" (Coyle et al. 2010, p. 33). Thus, based on Chief Economist Wells' remarks, it would appear that the best path forward in regard to costs is some form of a GPS, thin OBU approach. While this may be the best approach now, as technology changes and costs are thereby altered, another approach may prove to be superior.

Compliance cost

Compliance costs are costs that are in addition to the direct tax or fee that taxpayers incur by complying with the tax policy. To get a better idea of the compliance cost issues involved with a VMT fee, it is useful to look at the compliance costs associated with the current fuel tax system. Fuel taxes have very low compliance costs as the statutory burden is on a relatively small number of wholesalers as opposed to the general driving public.

Depending on design and fee collection method, compliance cost for VMT fees may be somewhat higher than the current system of fuel taxes. If a pay-at-the-pump method is utilized the compliance costs will be no greater than the current system of fuel taxes However, if a central billing model is used, compliance costs will be somewhat higher since motorists would have to take the time to pay their periodic VMT bills. Whitty et al. (2009) highlights an additional compliance burden for some with the central billing method stating, "For members of the cash paying economy without access to a bank account or easy access to the Internet, regular payment of a mailed mileage charge billing adds a significant burden. While cash payers now easily pay the gas tax at the fueling station…a monthly billing requires traveling to the collection center…" (p. 42).

3.2 Toll Systems in Place and VMT Trials

The following section is taken directly from the first section of the fourth chapter of the Coyle et al. (2011b) study, and provides a brief overview of some of the mileage-based fee systems already in place in Europe and one VMT fee trial at the state level in the United States.

Germany: Robinson (2008) provides a thorough description of the German Heavy Goods Vehicle (HGV) tolling system. This system, introduced in 2005, uses a GPS-based system to charge heavy commercial vehicles based on distance traveled, number of axles and emission class. The rationale for implementing the German system was: significant infrastructure costs were being imposed by heavy trucks; a significant amount of truck-kilometers on German roads were being driven by foreign-registered vehicles that were not directly paying fuel and road taxes; many foreign trucks had a competitive advantage as they were not complying with EU emission standards; and taxes on gasoline and diesel fuels had been raised several times since 1991, and further increases were no longer a good option (Robinson 2008).

The Euro-Vignette: This is a sticker-based system that charges vehicle users based, typically, on emission level, time of travel, number of axles, and specific traffic regulations (Robinson 2008). This system was initially introduced in 1995, and is currently used in five countries: Sweden, Denmark, Belgium, The Netherlands, and Luxemburg (Eurovignette 2011). Since October 1, 2008, users have been able to register their vehicle online, thus removing the need to carry paper documentation of their enrollment in the program (Eurovignette 2011). Robinson (2008) notes the advantages of this system: ease of implementation, low risk of manipulation, need for storing only limited data, low enforcement costs, and the ability to expand to cover additional vehicles.

The Netherlands have been attempting to implement road pricing since 1988, with the primary goal of congestion reduction. Preparations were underway for the roll-out of a pricing scheme in 2010. However, the collapse of the coalition government in February of 2010 has put the program in limbo (Coyle et al. 2010). The pricing system seeks to improve road accessibility and the quality of the environment by transitioning to a system that taxes car use as opposed to car ownership. The Dutch system considered would use in-vehicle "registration units" that have GPS capabilities. Taxes would be based per-kilometer travel and would also include a rush-hour surcharge (Dutch Road Pricing Act 2010).

The Oregon Pilot Project has demonstrated what a state-level road pricing scheme could look like. The motivation for the Oregon pilot was rooted in eight principles: users should pay, local government should have control over local revenue sources, the system should have revenue sufficiency, the system should be transparent to the public, there should not be substantial burdens for taxpayers or private sector entities, the system should be enforceable, should support the entire highway and road system, and should enjoy public acceptability (Whitty 2007). The system used in the Oregon trials was a coarse-resolution GPS-based system, with a pay-at-the-pump payment method. The Oregon pilot program revealed many key findings: the concept is viable, paying at the pump works, the mileage fee can be phased in, integration with the current system can be achieved, congestion and other pricing options are viable, privacy is protected, the system would place minimal burden on business, potential for evasion is minimal, and the cost of implementation and administration is low (Whitty 2007).

3.3 Model

The literature review pertaining to the models and techniques used in this thesis are divided into three subsections below. Section 3.3.2 discusses literature in which demand models for either VMT or gasoline consumption are developed using time series data. Section 3.3.2 surveys literature that has produced elasticity estimates for VMT. Finally, section 3.3.3 reviews the literature with respect to estimating the revenue potential of VMT fees.

3.3.1 Demand models with time series data

Schimek (1996) provides the foundation for the techniques and data used in this paper to estimate demand for VMT. Schimek (1996) develops a reduced-form model and components model for highway gasoline demand. In the components model, Schimek (1996) decomposes gasoline demand into three models, one of which is demand for distance traveled per vehicle. Schimek's (1996) primary analysis uses U.S. annual time series data from 1950 to 1994, with most of his data taken from the FHWA annual publication *Highway Statistics*. Schimek (1996) models highway gasoline use per capita as a function of the real gas price, real GDP per capita, a time trend, constant term, dummy variables for 1974 and 1979 and a lagged dependent variable which allows long-run elasticities to be obtained. Schimek (1996) found a long-run price elasticity of gasoline of -0.7 in his reduced-form model, and a long run price elasticity of -0.26 in his driving model.

More recently, Hughes et al. (2008) and Coyle et al. (2011a) have used aggregate U.S. time series data and log-log functional forms to obtain price and income elasticities for gasoline demand. Hughes et al. (2008) using monthly data found short-run price elasticties ranging from -0.03 to -0.34 depending on the model and techniques used, while Coyle et al. (2011a) using quarterly data found a short-run price elasticity of -0.06 with Ordinary Least Squares estimation and -0.09 with Three Stage Least Squares estimation.

3.3.2 Demand for VMT and elasticities

In addition to Schimek (1996), several studies have developed demand models and found price and income elasticities for VMT. Goodwin et al. (2004) conducted an exhaustive literature review of studies published since 1990 that estimate price and income elasticities of fuel consumption as well as road traffic. Their review contained a wide array of studies that differed in both estimation techniques (i.e. dynamic and static) as well types of datasets (i.e. cross-section, time series). A limitation of their review is that the studies surveyed for vehicle travel reported price elasticities with respect to the price of fuel as opposed to the actual cost of vehicle travel. Their review found short-term price elasticities of demand for total vehicle kilometers from dynamic estimation to range from -0.05 to -0.17, and from static estimation to range from -0.13 to -0.54. Short-term income elasticities for total vehicle kilometers from dynamic estimation ranged from 0.05 to 0.62, with static models ranging from 0.05 to 1.44.

Another review by Litman (2011) looked at studies that produced various transportation related elasticities. One section of Litman's (2011) review looked at price elasticities of road travel with respect to out of pocket expenses. These expenses are more encompassing than simply fuel prices as they include things like parking fees and road tolls in addition to fuel. Litman (2011) found price elasticities for road travel ranging from -0.02 to -3.2[15].

3.3.3Demand for VMT and Revenue estimation

The methodology employed in this study is similar to the methodology advanced in a Sorensen et al. (2009) study. The study described its methodology as follows:

> "The process of forecasting VMT-fee revenue can be broken down into two stages: forecasting VMT, then applying a VMT-fee rate (which may in turn influence VMT). The research team first considered several options for developing state VMT forecasts…and then applied VMT fees to forecast revenue…there are several methodologies that states could pursue to forecast VMT at the state level…" (p. 13).

The report goes on to explain several different options for forecasting VMT and VMT revenue at the state level. One option they discuss involves extrapolation from national Energy Information Administration (EIA) forecasts. The report explains that the EIA forecasts VMT based on several factors including fuel prices, the economy, and fleet-wide fuel economy. State level forecasts can then be extrapolated from the national forecast by multiplying the national forecast for all vehicle miles traveled in the U.S. by the percent of total national miles driven in the state of interest[16]. The percent of national miles driven in any given state can be found on the Federal Highway Administration's Highway Statistics Series (the same data source used to obtain miles for this thesis).

After VMT is obtained, the report goes on to explain how revenue is forecasted:

> "Once VMT forecasts have been generated, the next step is to predict future VMT-fee revenue. This must account for two factors: (a) how the VMT fee will be structured, and in turn how that will influence the cost of driving, and (b) how VMT will be affected by changes in the cost of driving. The latter can be determined by examining the elasticity of travel demand with respect to changes in the cost of driving…One useful measure is the elasticity of VMT with respect to changes in the price of fuel, which may be used to evaluate, for instance, the effect on VMT that would result from increasing or decreasing fuel taxes…In similar fashion, the effect of replacing fuel taxes with VMT fees could be approximated as a change in the price of fuel" (p. 14).

Based on a review of the research, the study used a long run price elasticity of demand for VMT of -0.29. The study first applied a flat VMT fee that was an initially revenue-neutral replacement of fuel taxes. By flat, the study meant that all miles would be charged equally (no increase for congestion) and all vehicles would be charged the same rate. The report found that this flat, revenue-neutral fee would have little effect on miles traveled and explained, "This is because changes in the price of fuel have only a modest effect on changes in VMT…and fuel taxes only account for a small share of the price of fuel" (p. 14). A limitation of the methodology described in Sorensen et al. (2009) is that in forecasting revenue "VMT fees could be approximated as a change in the price of fuel." (p. 14). To be precise, VMT fees should not simply approximated as a change in the price of fuel, but rather a change in the price per-mile of travel. This thesis will build on Sorensen et al. (2009) by having VMT fees affect the overall price of travel as opposed to being approximate as a change in fuel prices.

This thesis has given significant attention to the Sorensen et al. (2009) methodology for forecasting revenue from a VMT fee, since this thesis will employ similar methods. It should be noted however, Sorensen et al. (2009) is not the only study to advance a methodology for forecasting VMT fee revenue. Baker et al. (2010) advances a methodology for forecasting VMT fee revenue specifically for the state of Texas. The model advanced projects fuel consumption based on population growth. After obtaining estimated fuel consumption, total VMT can be calculated using average vehicle fuel efficiency. VMT fee revenue can then be calculated by applying a VMT fee rate to the estimated total VMT. Although this model has its merits, it was not utilized for this thesis since it is limited in that it does not yield price and income elasticities and thus VMT and VMT revenue is not allowed to fluctuate with changes in behavior brought on by different VMT fee levels.

CHAPTER 4. RESULTS

This section develops two demand models, one for the nation at large and one for the state of Minnesota, that yield estimates for the price and income elasticity of demand for highway VMT. The chapter proceeds by presenting the model in section 4.1, the data in 4.2, the estimation results in 4.3, and elaborating on technical issues in 4.4. The models are then used in chapter 5 to forecast both the revenue that would result from pricing miles traveled for the entire functional roadway system in the United States and for the state of Minnesota.

4.1 Econometric Model

The basic model estimates demand for VMT as follows:

$$(4.1)\ ln(Miles_t) = \beta_0 + \beta_1\, ln(P_t) + \beta_2\, ln(Y_t) + \beta_3 \mathrm{t_t} + u_t$$

Where $ln(Miles_t)$ is the natural log of demand for vehicle miles of travel in year t, β_0 is the intercept, $ln(P_t)$ is the natural log of the price to drive one mile in year t with β_1 as its coefficient, $ln(Y_t)$ is disposable income in year t with β_2 as its coefficient, $\mathrm{t_t}$ is the natural log of a time trend with β_3 as its coefficient, and u_t is the error term. This same equation will be used to estimate demand equations for VMT for both the U.S. and the state of Minnesota.

The model is in the log-log form which allows the coefficient estimates to be treated as elasticities. In other words, once estimated the coefficients on the price and income variables can be interpreted as the percent change in miles traveled in the U.S. or state of Minnesota given a one percent change in that variable.

The coefficient on the price variable is expected to have a negative sign. This would conform to results found in similar studies and make sense given basic economic principles. Simply put, as the price for vehicle travel increases, it is expected that miles traveled will decrease as consumers take fewer trips or find substitutes for their trips such as public transit or telecommuting (working from home). The coefficient on the income variable is expected to have a positive sign. Once again, this would conform to the literature and make economic sense. Travel can rightly be seen as a normal good, or a good for which demand increases as income increases. As consumers' incomes increase, they are more likely to commute via car as opposed to public transit as well as take more trips for leisure.

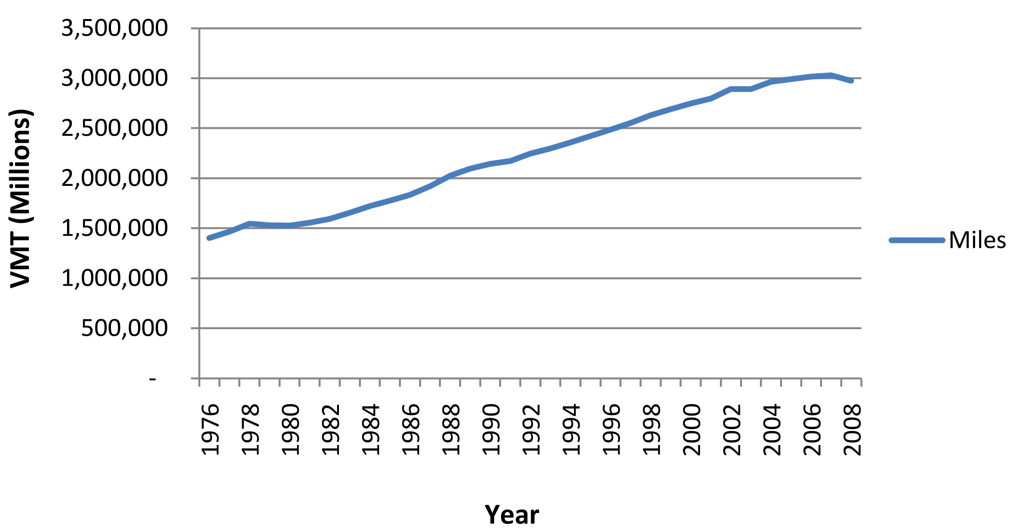
What will be interesting and novel is not whether the variables conform to their expected signs, but the magnitude of these price and income effects. These effects will later be used in chapter 5 to give forecasts for VMT and VMT fee revenue given different VMT fee rates.

4.2 Data

Two time series data sets were constructed; one at the federal level and one for the state of Minnesota. Both data sets consist of one observation for each year running from 1976 to 2008. In the federal level data set each observation consists of VMT for the entire functional roadway system in the U.S.[17], the average price per-mile of travel in the U.S., total personal disposable income for the U.S., and a time trend. In the state of Minnesota data set each observation consists of VMT in the state of Minnesota, the average price per-mile of travel in Minnesota, total personal disposable income for

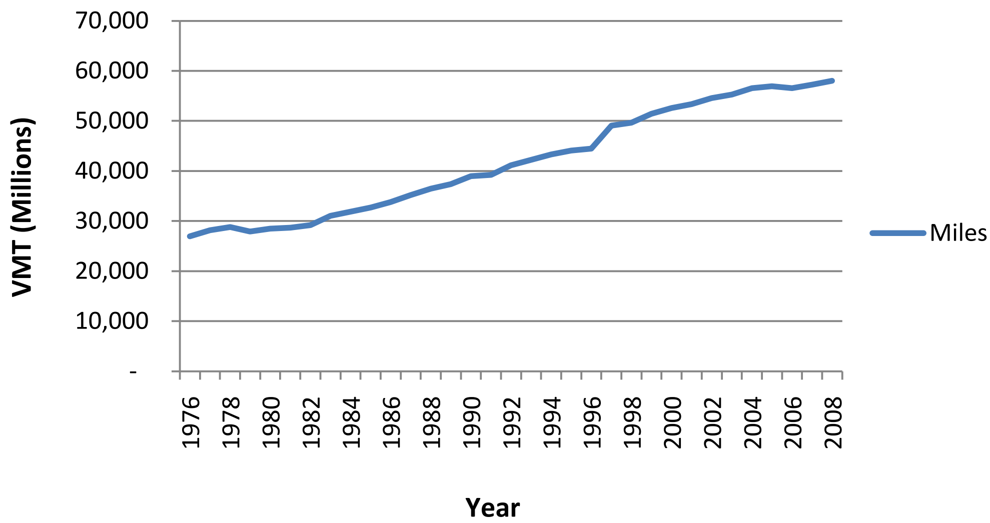
Minnesota, and a time trend. The paragraphs below explain where the data was obtained and how each variable was constructed.

Data for miles traveled in millions was obtained from the Federal Highway Administration's Highway Statistics 2008. The data aggregates annual VMT for the entire functional system. This includes travel on interstates, other principal arterials, minor arterials, major collectors, minor collectors, local roads, other freeways and expressways. The Federal Highway Administration bases its data on State highway agency's reported estimates. The federal level data set includes the 50 States and the District of Columbia, while the state of Minnesota data set includes VMT just in the state of Minnesota. Figures 4.1 and 4.2 below document the trend in millions of miles traveled.



Source: Federal Highway Administration

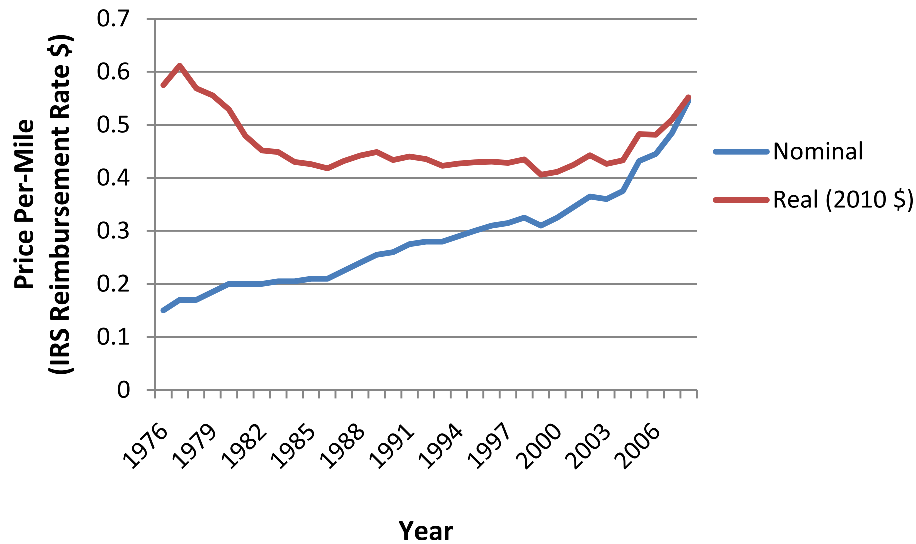
Figure 4.1: Annual VMT in the U.S. (Millions), 1976-2008



Source: Federal Highway Administration

Figure 4.2: Annual VMT in Minnesota (Millions), 1976-2008

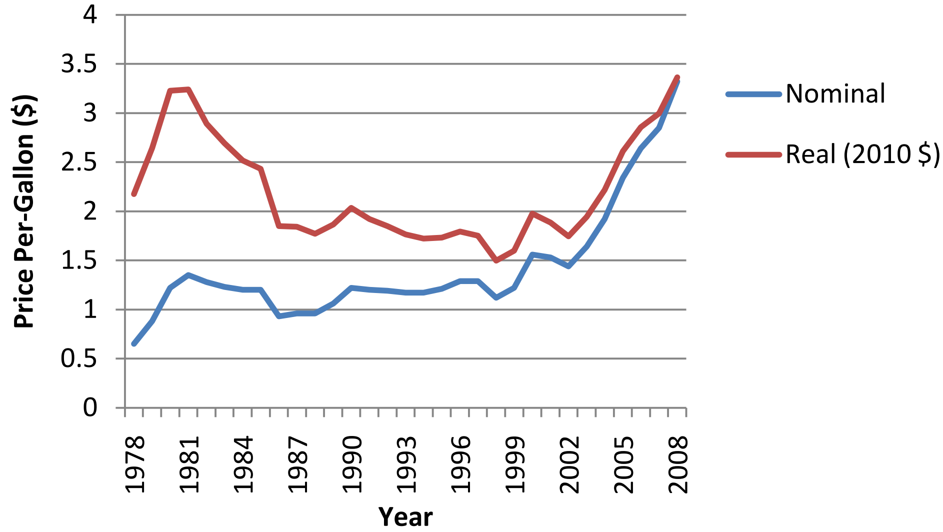
The federal mileage reimbursement rate, obtained from the Internal Revenue Service (IRS), was used as a proxy for the price per-mile both for the federal level data set and Minnesota data set. While not a perfect measure of price per-mile, the federal reimbursement rate is a decent proxy and "is based on an annual study of the fixed and variable costs of operating an automobile." (IRS 2010) While the IRS does not publish the methodology for calculating the reimbursement rate, sources have suggested that the costs that make up the rate include such things as gasoline and oil, depreciation, maintenance, accessories, parts, tires, insurance, and taxes (Windows on State Government 2004, Defense Travel Management Office 2011). The IRS reimbursement rate is published in nominal dollars for each year. To have the values in real dollars for the analysis needed in this thesis, the nominal values provided by the IRS were then converted to 2010 dollars using the CPI-U published by the Bureau of Labor Statistics (BLS). Figure 4.3 below documents both the nominal and real (2010 dollars) IRS reimbursement rate. As indicated by the figure, the IRS reimbursement rate in 2010 dollars has ranged between 60 cents and 40 cents for most of the time series.



Source: IRS and BLS

Figure 4.3: Price Per-Mile in Nominal and Real Terms (2010 $), 1976-2008

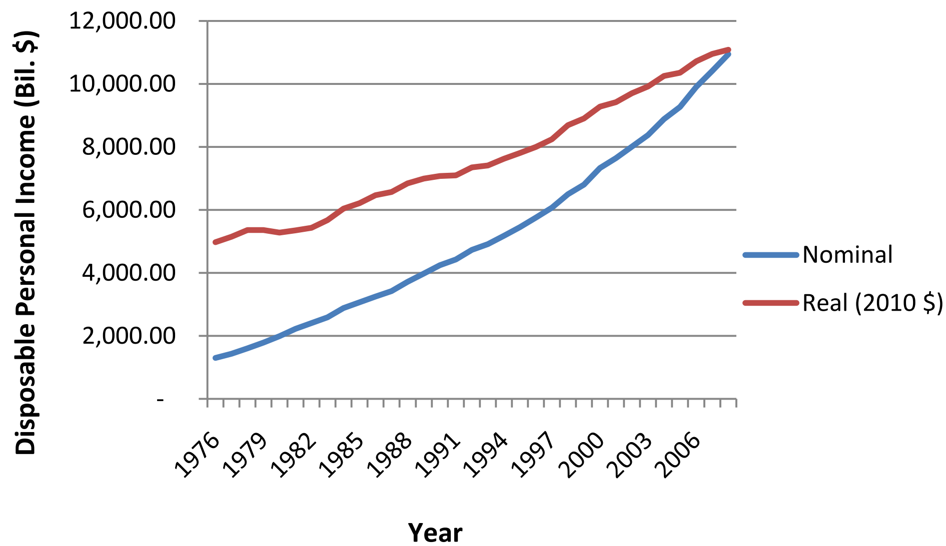
As mentioned above, one component to the IRS reimbursement rate is the cost of gasoline. Figure 4.4 below documents the nominal and real price of gasoline over the time series. As one can see, the IRS reimbursement rate and average U.S. price of gasoline move relatively in sync with one another. Due to data limitations, figure 4.4 begins in 1978.



Source: Energy Information Administration and BLS

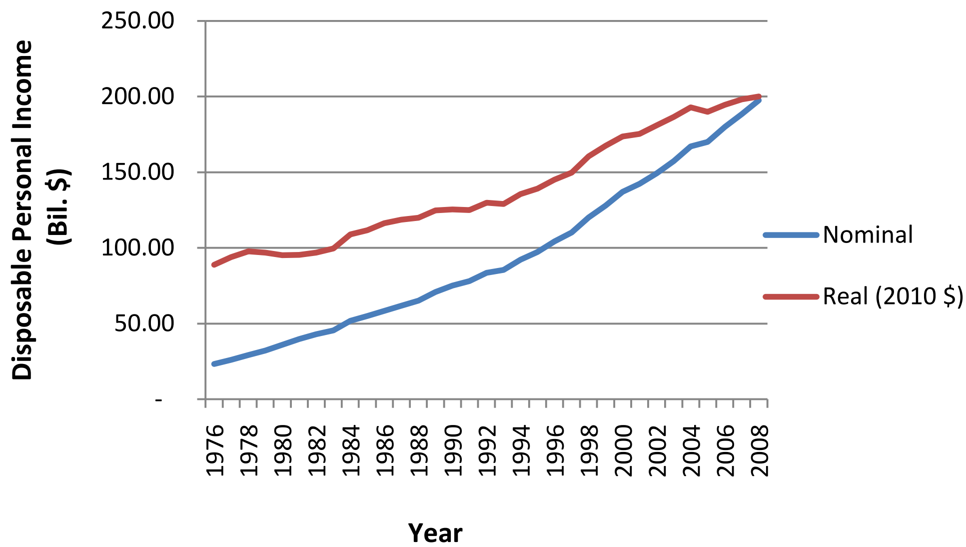
Figure 4.4: Price of Gasoline in Nominal and Real Terms (2010 $), 1978-2008

Data for total personal disposable income for the U.S. and state of Minnesota comes from the Bureau of Economic Analysis (BEA). Figures 4.5 and 4.6 below illustrate the growth in personal disposable income for the U.S. and Minnesota.



Source: BEA

Figure 4.5: Personal Disposable Income for the U.S. (Billions), 1976-2008



Source: BEA

Figure 4.6: Personal Disposable Income for the State of Minnesota (Billions), 1976-2008

Finally, a linear time trend starting at 1 for year 1976 and ending at 33 for year 2008 is included in both data sets.

4.3 Estimation Results

Equation 4.1 was estimated for both the federal level data set and the state of Minnesota using ordinary least squares (OLS). The results and a brief discussion are presented below in sections 4.3.1 and 4.3.2.

4.3.1 National

Results from estimating equation 4.1 for the entire U.S. are presented below in table 4.1

Table 4.1: National Results

$ln(Miles_t) = \beta_0 + \beta_1\, ln(P_t) + \beta_2\, ln(Y_t) + \beta_3 t_t + u_t$		
Independent Variables	**Parameter Estimates**	**Standard Errors**
ln(price per mile)	-0.211***	0.050
ln(disposable income)	0.633**	0.240
time	0.009	0.006
Intercept	-4.474	7.008
R-Squared	0.989	
N	33	

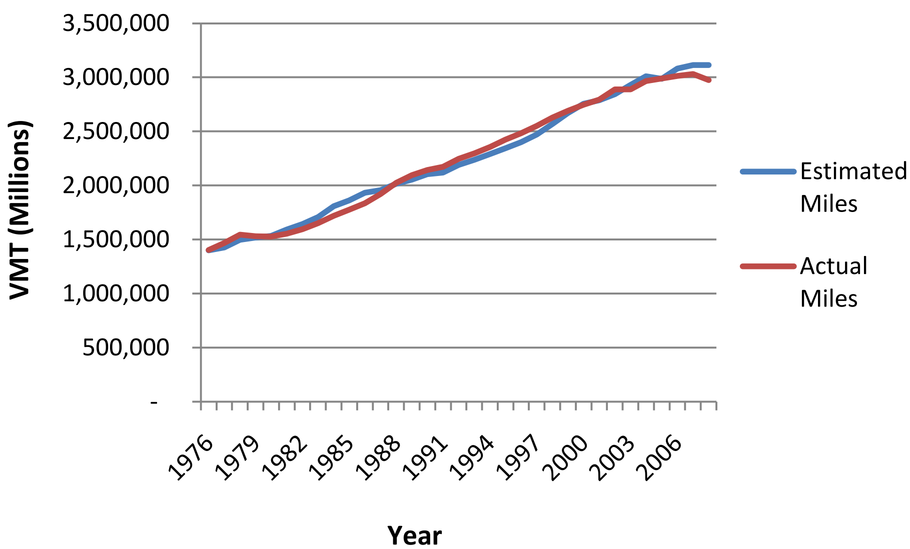
***=Significant at the 1% level, **=Significant at the 5% level, *=Significant at the 10% level

As mentioned before, the log-log form allows the parameter estimates to be interpreted as elasticities. Thus, the price elasticity of demand for this model is -0.211, and the income elasticity is 0.633. In other words, a 1% increase in the price per mile will lead to a 0.211% decrease in the number of miles traveled over a year, while a 1% increase in disposable income will lead to a .633% increase in the number of miles traveled over a year. The estimates are of the expected sign and both are inelastic, particularly the price effect.

The highly inelastic price effect should come as no surprise, particularly in the short-term. Commuters often have few suitable alternatives to driving unless they are commuting a short distance or live in an area with a highly developed transit system. While some drivers may have reliable substitutes in the face of higher prices per-mile, most drivers rely heavily on their cars to get to and from work, pickup their kids from school, and run other errands necessary for their survival and well being in a 21st century world.

The results are not only economically significant, but highly statistically significant as well. The coefficients on the variables of interest are both statistically significant at the 5% level, with the price variable's coefficient being significant at the 1% (the price variable in fact is even significant at the .1% level).

The results also show a very high R-squared, 0.989, suggesting that the data fits the model well and the variables used have high explanatory power. The strong fit of this model to the data and its predictive power is illustrated by figure 4.7. Figure 4.7 plots estimated VMT in the U.S. obtained from the model against the actual miles for each year. As shown by the graph, this parsimonious model performs relatively well in predicting annual VMT for the U.S. In fact, for the last 10 years of the model, 1999 to 2008, estimated miles are less than 2% off from actual miles in seven out of the 10 years.



Source: Federal Highway Administration and estimates from model

Figure 4.7: Estimated and Actual Annual U.S. VMT (Millions), 1976-2008

4.3.2 Minnesota

Results from estimating equation 4.1 for the state of Minnesota are presented below in table 4.2.

Table 4.2: Minnesota Results

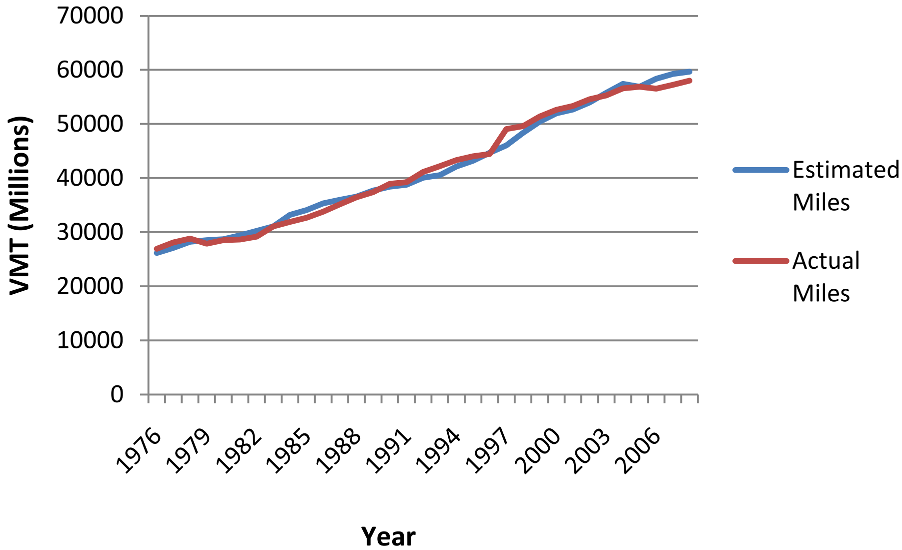
$ln(Miles_t) = \beta_0 + \beta_1\, ln(P_t) + \beta_2\, ln(Y_t) + \beta_3 t_t + u_t$		
Independent Variables	**Parameter Estimates**	**Standard Errors**
ln(price per mile)	-0.113**	0.052
ln(disposable income)	0.552***	0.157
Time	0.012**	0.004
Intercept	-3.810	3.946
R-Squared	0.989	
N	33	

***=Significant at the 1% level, **=Significant at the 5% level, *=Significant at the 10% level

Once again, the log-log form allows the parameter estimates to be interpreted as elasticities. Thus, the price elasticity of demand for this Minnesota model is -0.113 and the income elasticity is 0.552. In other words, a 1% increase in the price per mile will lead to a 0.113% decrease in the number of miles traveled over a year, while a 1% increase in disposable income will lead to a 0.552% increase in the number of miles traveled over a year. These estimates are of the expected sign and are statistically significant at meaningful levels (price at the 5% level and income at the 1% level).

It is not surprising that the price elasticity for the Minnesota model is lower than the national model. It is quite likely that Minnesotans are in fact more dependent on their cars than the nation at large and do not alter their behavior as much in the face of price changes. This is likely the result of two factors: a relatively undeveloped public transit system in the largest metropolitan area and cold weather. First, when compared to places like New York City and Washington, D.C., Minnesota's largest metropolitan area, Minneapolis/St. Paul, has a relatively underdeveloped public transit system. While residents of cities with extensive subway systems like New York City or Washington, D.C. can easily substitute subway/metro travel for car travel in the face of rising prices per-mile of travel, many Twin Cities residents will not see their public transportation options as suitable substitutes for their cars. Second, Minnesota has a very cold climate when compared to the rest of the United States. While residents of warmer climates may be more likely to walk or bike long distances to get to work, or wait outside for their bus or train to come, the idea of walking, biking, or waiting outside for public transit during a Minnesota winter with sub-zero temperatures is unthinkable to many Minnesotans.

Finally, when looking at the results we see that like the national model, the Minnesota model has a very high R-squared, 0.989, suggesting that the data fits the model well and the variables used have high explanatory power. The strong fit of this model to the data and its predictive power is illustrated by figure 4.8. Figure 4.8 plots estimated VMT in Minnesota obtained from the model with the actual miles for each year. Once again, this parsimonious model performs relatively well in predicting annual VMT. Like the U.S. model, for the last 10 years of the model, 1999 to 2008, estimated miles are less than 2% off from actual miles in seven out of the 10 years.



Source: Federal Highway Administration and estimates from model

Figure 4.8: Estimated and Actual Annual Minnesota VMT (Millions), 1976-2008

4.4 Serial Correlation and Other Technical Issues

While the models do a relatively decent job of predicting VMT, and the coefficients on the variables of interest are statistically significant, there are several technical issues to sort out. The following four subsections identify and address various problems or limitations of the models.

4.4.1 Test for serial correlation

Time series data often suffers from serial correlation or what is sometimes called autocorrelation. Simply put, this means the errors in different time periods are correlated with each other, which violates the fifth Gauss-Markov assumption for time series regression and leads to inconsistent standard errors. While the parameter estimates themselves are unaffected and remain unbiased, the standard errors left uncorrected harms the validity of the model. The data was checked for serial correlation using the Durbin-Watson test in the SAS statistical software package. In each test, the Durbin-Watson statistic was less than two and thus we fail to reject the null hypothesis that the data is serially correlated. The standard errors reported in section 4.3 are thus inconsistent.

4.4.2 Newey-West correction

As mentioned above, the standard errors reported in section 4.3 are not consistent due to the presence of serial correlation. However, this problem can be addressed using Newey-West standard errors. Newey-West standard errors correct for serial correlation and are thus consistent. The Newey-West standard errors correction was performed in the STATA statistical software package and the new standard errors and p-values are reported below in tables 4.3 and 4.4. The Newey-West correction was applied for zero and one lag. As the coefficient estimates do not change with the Newey-West correction, they are not reproduced below.

Table 4.3: National Results with Newey-West Correction

Independent Variables	Newey-West S.E. lag(0)	P-Value lag(0)	Newey-West S.E. lag(1)	P-Value lag(1)
ln(price per mile)	0.059	0.001	0.074	0.008
ln(disposable income)	0.258	0.021	0.319	0.057
time	0.007	0.216	0.009	0.314
Intercept	7.552	0.558	9.327	0.635

Although the Newey-West standard errors are larger than the originally reported standard errors, the coefficient estimates in the national model remain statistically significant at meaningful levels. The coefficient on the price variable is statistically significant at the 1% level both with lag(0) and lag(1). The coefficient on the income variable is statistically significant at the 3% level with lag(0) and at the 6% level with lag(1).

Table 4.4: Minnesota Results with Newey-West Correction

Independent Variables	Newey-West S.E. lag(0)	P-Value lag(0)	Newey-West S.E. lag(1)	P-Value lag(1)
ln(price per mile)	0.057	0.057	0.073	0.134
ln(disposable income)	0.154	0.001	0.191	0.007
time	0.004	0.013	0.005	0.041
Intercept	3.872	0.333	4.805	0.434

Similar to the national model, the Minnesota model Newey-West standard errors are larger than the originally reported standard errors (with the exception of the income variable for lag(0) and intercept for lag(0)), however the coefficient estimates remain statistically significant at meaningful levels. The coefficient on the price variable is statistically significant at the 6% level with lag(0) and at the 14% level with lag(1). The coefficient on the income variable is statistically significant at the 1% level with lag(0) and with with lag(1).

4.4.3 Constant elasticity assumption

Another issue with the model is its constant elasticity assumption. While the model provides one single elasticity, in reality the price and income elasticities would vary with different income or price levels. While this makes the model problematic for predicting what will happen to VMT if the price per mile is increased dramatically, for small changes in the price level the price elasticity is likely to stay relatively constant.

A literature search for studies that estimate price elasticities of demand for VMT at different points along the demand curve yielded no results. However, several studies have estimated price elasticities of demand for VMT for countries that have significantly greater fuel prices and thus greater costs per-mile to drive than the U.S. (see Goodwin et al. 2004, Litman 2011). While it should be noted that European countries will have different looking demand curves than the U.S., many European countries are consuming gasoline at a higher price point on their demand curves than the U.S. and thus elasticity estimates for VMT from these countries can shed some light on what elasticity estimates might look like for higher price points along the U.S.'s demand curve. These studies have found price elasticities similar to those in the U.S. (and those found in this study) despite the fact that consumers in these other countries (mostly Europe) face significantly higher prices. One study by Oum et al. (1996) found price elasticies of automobile travel in the Netherlands ranging from -0.02 to -0.28. The Dutch, who have the highest tax on fuel in the world, are currently facing 1.73 euros/liter at the pump or $9.33 per gallon (NU.ul 2011). Once again it should be noted that the Netherlands most likely has a significantly different looking demand function for gasoline and VMT than the U.S. Nonetheless, the low price elasticities of demand in the Netherlands, despite their nine dollar a gallon gasoline, imply that in the short-run price elasticities of demand for VMT in the U.S. likely stay quite low for significantly higher price levels.

In chapter 5 the model is used to predict the resulting VMT and VMT fee revenue given certain VMT fee levels. While the constant elasticity assumption may be problematic if trying to accurately predict how much revenue a dramatically high VMT fee rate would yield, as long as the model is used to predict revenues resulting from relatively low VMT fees (1 to 10 cents per mile) it should be relatively informative.

4.4.4 How to treat truck VMT?

One final issue is caused by the fact that the VMT data used includes heavy truck VMT. While the Federal Highway Administration provides data differentiated by vehicle type for the most recent years of the time series, data differentiated by vehicle type could not be found for the entire time series (1976 to 2008). Heavy truck VMT makes up generally 7% of the VMT in the nation each year. Ideally heavy truck VMT would have been excluded from the model as the trucking industry's demand function for VMT would look different and have different components than the model estimated in this study for general drivers (car and light truck users).

As alluded to in the *full cost recovery of direct costs* section of the literature review, heavy trucks should be treated different from general vehicle users when assigning a user fee for highway use. Nonetheless, for the purposes of this study chapter 5 envisions the revenue that would result if all VMT, including the roughly 7% from the trucking industry, were assigned a flat mileage fee. If VMT fees were one day implemented, policy makers would likely argue over whether to make the trucking industry exempt from the VMT fee or whether to make the VMT fee assigned to heavy trucks higher than the general fee to account for the extra wear and tear on the roads caused by heavy trucks.

CHAPTER 5. REVENUE SIMULATIONS

Chapter 4 developed a model and addressed its shortcomings. Using this model and a methodology similar to that utilized by the RAND study discussed in chapter 3, this chapter gives estimates for the resulting VMT fee revenue that different VMT fee levels would yield for the U.S. and state of Minnesota. These revenue projections are then used to explore how much of the state of Minnesota and federal fuel tax, income tax, and deficit could be reduced if VMT fees were implemented. It should be noted that since fuel taxes are already included in the model's price per-mile, the VMT fees used in this revenue estimation exercise should be seen as supplements to current fuel taxes rather than replacements. All estimates presented are in 2010 dollars. All federal estimates are one year estimates for the year 2010 and use the actual values of disposable income and the price per mile for that year, while due to data restrictions all Minnesota estimates are one year estimates for the year 2009 and use the actual values of disposable income and the price per mile for that year.

The revenue projections were calculated in a three step process:

1. A VMT fee rate was chosen and added to the 2010 IRS reimbursement rate (2009 reimbursement rate for the Minnesota model).
2. The new price per-mile (IRS reimbursement rate + chosen VMT fee level), disposable income for 2010 (2009 for Minnesota model), and the appropriate time trend value were then plugged into the model to obtain a VMT estimate. This allows the estimated price elasticity and the chosen VMT fee level to affect overall VMT.

3. The resulting VMT estimate was then multiplied by the VMT fee level to obtain the resulting estimated revenue.

5.1 Federal

Table 5.1 below provides the results of revenue simulations for federal VMT fees of one cent, two cents, five cents, and 10 cents. Relevant policy goals are attached to each per-mile fee and each goal is exclusive of the other ones. In other words, a two cents per mile fee will meet unmet federal need, but it will not also raise a federal fuel tax equivalent amount in addition to meeting the unmet need. Thus to accomplish all four policy goals below a VMT fee would have to be set above 18 cents per mile.

Table 5.1 also provides the percent reduction in VMT caused by the VMT fee and the estimated cost per-household.

Table 5.1: Federal Revenue Simulations

Policy Goal*	Per-Mile Fee	Projected Revenue	Reduction in VMT	Cost Per-Household**
Raise Federal Fuel Tax Equivalent	1 cent	$32.7 billion	.42%	$285
Unmet Federal Transportation Need	2 cents	$65.2 billion	.82%	$568
Reduce the Federal Deficit by 11%	5 cents	$161 billion	1.99%	$1403
Reduce Federal Income Taxes by 35%	10 cents	$316 billion	3.78%	$2754

*The federal fuel tax amount comes from the 2009 value given by the Federal Highway Administration, the unmet federal need is an annual estimate that comes from a 2009 report by the National Surface Transportation Infrastructure Financing Commission, the federal deficit comes from a Congressional Budget Office projection for the year 2011, and the federal income tax comes from a Congressional Budget Office estimate for the year 2010.
**Number of households comes from the U.S. census.

As illustrated by table 5.1, because of the price inelastic nature of demand for VMT, substantial amounts of revenue can be raised by relatively small VMT fee levels. Furthermore, these large amounts of revenue can be raised with a relatively small effect on behavior, as illustrated by the small reductions in VMT, and without overly burdensome costs per-household. This is important because if the effect on driving behavior was large it could have a depressive effect on the economy as some laborers begin to work fewer hours, some consumers make fewer shopping trips, and/or the trucking industry makes fewer shipments.

5.2 Minnesota

Table 5.2 below provides the results of revenue simulations for Minnesota VMT fees of 1.3 cents, 4.2 cents, and 10 cents.

Table 5.2: Minnesota Revenue Simulations

Policy Goal*	Per-Mile Fee	Projected Revenue	Reduction in VMT	Cost Per-Household**
Raise State Fuel Tax Equivalent	1.3 cents	$785 million	.26%	$366
Unmet State Transportation Need	4.2 cents	$2.52 billion	.81%	$1177
Wipeout the State Deficit***	4.2 cents	$2.52 billion	.81%	$1177
Reduce State Income Taxes by 75%	10 cents	$5.94 billion	1.84%	$2773

*The state fuel tax amount comes from the FHWA's Highway Statistics 2009, the unmet state need comes from a Mn/DOT Statewide 20 year Highway Investment Plan study from 2009 (the study suggests that for the entire 20 year period there is 2.5 billion in high priority unmet state need), the deficit figure is a biennium figure for fiscal year 2012-2013 from a 2011 MMB forecast, and the income tax amount also comes from a MMB forecast and is for fiscal year 2010.
**Number of households comes from the Minnesota State Demographic Center
***Over two years

Because demand for VMT in Minnesota is even more inelastic than overall U.S. demand, the same fee levels will cause even less of a reduction in state VMT for Minnesota than they would cause for the nation as a whole. As illustrated by the tables, while a five cents per-mile national VMT fee will reduce national VMT by nearly two percent, a Minnesota VMT fee of 4.2 cents will reduce Minnesota VMT by less than one percent.

So what does this added revenue amount to? Does it make a significant dent in state and federal budgets? The simple answers are a lot, and Yes. A 4.2 cents Minnesota VMT fee could raise enough revenue in just one year to meet the entire high priority unmet state transportation investment need for a 20 year period as laid out by Mn/DOT's Statewide 20 Year Highway Investment Plan Study (Minnesota Department of Transportation 2009). As mentioned in the beginning of this paper, the state of Minnesota is facing a $5 billion dollar budget deficit. Applying a 4.2 cent per-mile fee to travel in Minnesota over two years would completely erase the biennium deficit. This would allow the state to maintain spending on necessary and worthy programs without having to raise income or property taxes. At the federal level, a five cent per mile fee could reduce the federal deficit by 11%, or could close the funding gap in unmet federal transportation investment while also providing close to 100 billion to the general fund.

Furthermore, these are just baseline projections with a flat VMT fee applied to all VMT. A VMT fee system that wishes to include a congestion pricing component or a higher rate for dirtier vehicles could reduce negative externalities while raising even more revenue than the figures presented in this analysis. Finally, as mentioned in the previous chapter policy makers may want to consider higher VMT fee levels for heavy trucks. Once again, if heavy trucks were made to pay for their fair share of wear and tear on the highways with higher VMT fees, the revenue projections here would underestimate the total revenue potential of VMT fees.

CHAPTER 6. WHAT TO DO WITH THE REVENUE?

The revenue projections in the previous chapter beg three questions, "Should VMT fee revenue be used to replace fuel taxes? Reduce incomes taxes? Reduce deficits?" These three questions are addressed in sections 6.1-6.3. The case is made for policy makers to not just stop at replacing fuel taxes, but to also consider VMT fees for income tax or deficit reduction.

6.1 The Case for Replacing Fuel Taxes

Many of the arguments for replacing the fuel tax system with VMT fees can be seen throughout sections 3.1.2-3.1.5 of the literature review. The literature review noted that because VMT fees have the ability to more accurately price the use of the roads, they more closely resemble a marginal-cost user fee than the current fuel tax system. Furthermore, a VMT fee system that has a congestion pricing component can be even more precise in making users pay for the external costs they impose. As noted before, while drivers typically pay approximately three cents per-mile in highway user fees, most of which are from fuel taxes, costs of driving in congest conditions can range from 10 to 29 cents per-mile (National Surface Transportation Infrastructure Financing Commission 2008). A VMT fee system that has the flexibility to increase for those driving in congestion will lead to gains in the areas of efficiency and equity as it will lead to more efficient driving behavior and will more accurately and fairly charge users for the costs they impose. Finally, to the extent that the poor drive less fuel efficient vehicles, VMT fees may be less regressive than the current fuel tax system.

In addition to the areas of efficiency and equity, VMT fees also have a significant advantage over fuel taxes in the area of revenue sustainability. Increasing fuel economies mean that fuel taxes raise less and less revenue per-mile of VMT. As VMT fees are charged by the mile instead of by the gallon, they would be unaffected by increasing fuel economies. Given the Obama administration's recent pledge to reduce our imported oil consumption by a third by 2025, in part by making vehicles more fuel efficient and building more vehicles that run on alternative fuels, it is likely that vehicle fuel economies will only continue to rise. This makes fuel taxes less and less effective at raising revenue.

Finally, while VMT fees outscore fuel taxes in the areas of efficiency, equity, and revenue sustainability, they do face significant hurdles not faced by fuel taxes in the area of political and administrative feasibility. Under political feasibility, VMT fees may face their toughest hurdle in trying to convince the public that their privacy will be protected. To many, the idea of having the government place a device in their vehicle that records not just how many miles they travel but where they travel reeks of "Big Brother." VMT fees also face significant hurdles when it comes to administrative feasibility, as the costs to administer and enforce the system would be much greater than the current system of fuel taxes. Furthermore, switching the statutory burden from a relatively small number of wholesalers to all drivers will dramatically increase compliance costs.

Some Minnesota politicians have already begun to voice their opposition to a Mn/DOT study that tests mileage-based user fees. 18 GOP legislators have sponsored legislation to strip $5 million in funding already approved by an earlier legislature for the study (Doyle et al. 2011). A recent Minneapolis Star Tribune (Doyle et al. 2011) article noted comments shared by representatives Bob Barrett (R-Shafer, MN) and Steve Drazkowski (R-Mazeppa, MN) regarding mileage-based user fee technology. Rep. Barrett stated, “I don’t want the government understanding exactly home much we drive, through GPS or any other electronic means…It’s none of their business. It eliminates some freedoms we have in this country.” (Doyle et al. 2011). While Rep. Drazkowski remarked, “For government to assume this kind of way of tracking people would completely violate their sense of privacy and freedom…It’s just wrong.” (Doyle et al. 2011)

Despite these criticisms, given VMT fees advantages in the areas of efficiency, equity, and revenue sustainability, policymakers should give considerable thought to the idea of transitioning from a fuel tax based system to a VMT system. Further demonstrations and trials of VMT fees are likely to help VMT fees gain popular and political support as citizens and politicians see that privacy can be protected with a VMT fee system. Also, as technologies are further developed and tested administrative and enforcement costs are likely to come down. Tables 6.1 and 6.2 are taken from the Coyle et al. (2011b) study that looked at both fuel taxes and VMT fees along public finance principles. As indicated by the chart, VMT fees were seen as superior to fuel taxes in the areas of efficiency, equity, and revenue adequacy and sustainability with fuel taxes outranked VMT fees in the area of feasibility.

Table 6.1: Fuel Taxes Assessment Scorecard

Principles	Ability to Achieve Principles
Efficiency	Weak
Equity	Moderate
Revenue Adequacy and Sustainability	Moderate
Environmental Sustainability	Moderate
Feasibility	Strong

Source: Coyle et al. 2011b

Table 6.2: VMT Fees Assessment Scorecard

Principles	Ability to Achieve Principles
Efficiency	Strong
Equity	Strong
Revenue Adequacy and Sustainability	Strong
Environmental Sustainability	Moderate
Feasibility	Weak

Source: Coyle et al. 2011b

6.2 The Case for Reducing Income Taxes

As discussed in the hypothecation section of the literature review, economists are mixed on whether VMT fee revenue should be hypothecated for highway or transportation purposes. Assuming there is merit to the views of those economists who are against earmarking, this thesis now looks at whether there is a case to be made for using VMT fee revenue to reduce income taxes.

As noted before, a VMT fee can be seen as a pigouvian tax. Pigouvian taxes are named after the English economist, Arthur Pigou who developed the concept of correcting negative economic externalities through tax policy. Driving a vehicle leads to negative externalities in the form of congestion and environmental pollution. This is because drivers only take into account their private costs and not the social costs of their driving. VMT fees, especially those that have a congestion pricing component and are also variable based on emissions class of the vehicle, work to correct these negative externalities by raising the marginal private cost of driving closer to the marginal societal cost imposed by drivers.

VMT fees and other pigouvian taxes are said to have a double dividend, as they not only raise revenue but also correct a negative externality which improves efficiency, equity, and overall societal welfare. Compare this to the income tax. An income tax does raise substantial amounts of revenue, but it does so with harmful economic effects. Income taxes or other taxes on labor earnings distort the decision to work and lead to a less than optimal supply of labor. A 2001 study by Parry et al. (2001) found that if road pricing revenues were recycled back to tax payers through lower labor taxes, there would be a positive impact on labor supply and an overall welfare gain. The study found that while road pricing added to the cost of commuting and put a negative pressure on the labor supply, the reduction in congestion costs brought on by pricing as well as lower labor taxes outweighed the added cost of commuting and led to an increased labor supply.

While the Parry et al. study is very theoretical, given the fragility of our current economic recovery, there is good reason for policymakers to consider using VMT fee revenues to offset income taxes.

6.3 The Case for Reducing the Deficit

Finally, this thesis considers whether VMT fee revenues should be used for deficit reduction. As discussed before, the historic nature of the federal budget deficits in recent and coming years cannot be denied. The CBO projects that 2011 budget deficit to be close to $1.5 trillion dollars or 9.8 percent of GDP (CBO 2011). As a share of GDP this ranks second only to 2009 as the largest budget deficit since 1945. These recent, historic deficits have pushed federal debt held by the public to 62 percent of annual economic output (CBO 2011). The CBO projects that this figure will grow to 77 percent by 2021 (CBO 2011).

These massive federal deficits and debt will work to put an upward pressure on interest rates, crowding out private investment. While it can be argued that in the short-term the federal government should continue with stimulative measures that increase the federal debt, for our long term fiscal and economic health these deficits must be attacked. Several economist and pundits have expressed grave concern that the U.S. is at risk of a fiscal crisis if federal budget are not given proper attention. Maybe most notably, Peter Orszag, former budget director for the Obama administration, recently wrote a piece for the *Financial Times* in which he suggested that the U.S. is at risk of a home-grown fiscal crisis derailing our economic rebound and stated, “If policymakers won’t act before we have a fiscal crisis at the federal level, a fiscal crisis we will ultimately have” (Orszag 2011).

As previously noted in the literature review section, in discussing hypothecation of road pricing revenue *The Economist* states, “[I]t makes no more sense than any other scheme to hypothecate tax revenues for specific sorts of spending: if a programme is sufficiently worthy, it should be financed regardless of where the tax-money comes from; if not, the money should be spent elsewhere” (1989, p. 12). Given the urgency of the federal budget situation, *The Economist* would likely agree that reducing the federal deficit is a program that is more than just “sufficiently worthy” and thus should be funded regardless of where the revenue comes from.

As noted in chapter 6, a VMT fee of five cents per-mile could reduce 2011’s projected historic deficit by 11%. Just as discussed in the previous section, using a VMT fee to reduce the deficit would have a double dividend as it not only raises revenue for an important purpose, but works to correct negative externalities.

Finally, it should be noted that it would not be unprecedented to use a transportation user fee for deficit reduction. As noted before, from 1990 to 1997 a portion of fuel tax revenues went towards federal budget deficit reduction. It is worth mentioning again, however, that VMT fees would be regressive. Thus, if VMT fee revenues are used for deficit reduction we will be balancing the budget while proportionally inflicting greater harm on the poor. Policymakers should take heed of this and consider including tax reform that aids the poor or ensures the survival of vital programs for low income households when crafting a budget balancing proposal that includes the use of VMT fee revenue.

At the state level, the argument for using VMT fee revenue for budget deficit reduction is slightly different. Because of the mandate for balanced budgets at the state level, Minnesota faces two choices to deal with its deficit: cut spending or increase taxes. The political battle in Minnesota over the state deficit has seen many Republicans advocate for spending cuts while many Democrats fight for income tax increases. Given the deficit and fragile economic recovery, both sides are not without merit for criticizing the other. Both spending cuts and income tax increases would have an adverse effect on the economy. Using VMT fee revenue provides a path toward balancing the budget that neither raises the economically harmful income tax nor involves painful spending cuts.

A *Forbes.com* (Bartlett 2009) article from 2009 regarding the value-added tax noted, “Back in 1988, Harvard economist Larry Summers, now a key Obama advisor, explained that the reason the U.S. doesn’t have a VAT is because liberals think it’s regressive and conservatives think it’s a money machine. We’ll get a VAT, he said, when they reverse their positions.” The same could be said about a VMT fee. If presented to Republicans as an alternative to stiff income increases on the top bracket, and to Democrats as a savior for funding crucial programs in the short run and a sustainable revenue generating machine for the long run, there is potential for both sides to see VMT fees as a politically acceptable way to reduce or eliminate the state deficit. Furthermore, as noted in chapter 5, just a 4.2 cent per-mile fee over two years would completely wipe out the state’s biennium budget deficit. Once again, because of the regressive nature of VMT fees, proposals that include using VMT fees for deficit reduction should also include programs or tax breaks for low income drivers.

CHAPTER 7. CONCLUSION, DISCUSSION, AND ROAD AHEAD

> *"…the art of taxation consists in so plucking the goose as to obtain the largest possible amount of feathers with the smallest amount of hissing." Jean-Baptiste Colbert, Controller General of France 1665-1683* ()

This thesis has documented the revenue shortfalls of the Highway Trust Fund and current inadequacies of the fuel-tax-based surface transportation funding system, reviewed the literature on VMT fees, developed a national and state of Minnesota demand model for VMT, illuminated the revenue potential of VMT fees, and explored the cases for using VMT fee revenue to offset other taxes or state and federal deficits.

As transportation professionals continue to explore the possibility of VMT fee implementation more research will need to be done on various political and legal issues related to implementation and privacy issues with GPS-based VMT technology. Also, several institutional and implementation issues will need to be thought through: At what level (local, state, federal) should VMT fees be implemented? If implemented who will set the rates and collect the relevant data and revenue? Will all vehicles be taxed the same as explored in this thesis, or will heavy trucks and dirtier vehicles be charged more? Will VMT fees be phased in through a voluntary opt-in system or will they be mandated on all vehicles at once? How should revenue be allocated?

Much attention has been given in this thesis to the last question posed above. While more research needs to be done as to what revenue allocation schemes would be most beneficial to society while at the same time being able to achieve the necessary political support for implementation, based on the discussions outlined in chapter six as well as the need to do as little harm to the current recovery as possible while rescuing the state and federal budget's from their precarious positions, this thesis suggests that policymakers strongly consider a three pronged approach to VMT fee revenue allocation. This approach would be somewhat similar to the approach advocated by Goodwin (1989) who suggests allocating pricing revenue in equal parts to development and maintenance of new roads, public transport, and towards reducing the general tax burden or increased spending. This thesis' suggested revenue allocation scheme is outlined below and is applicable at either the state or federal level.

1. In the near-term, current fuel taxes remain in place while VMT fees are phased-in. A portion of VMT fee revenues are allocated to highway development and maintenance to cover projected gaps in highway funding and the Highway Trust Fund. In the long-term, after VMT fees have proved reliable, VMT fees are set at rates sufficient to replace fuel taxes as the primary funding mechanism for surface transportation.
2. A portion of VMT fee revenues are allocated to public transit. As Munnich and others have suggested, this may be crucial to winning public support.
3. Finally, until the state and federal government are on more sustainable budget paths, a portion of VMT fee revenue will be dedicated for deficit reduction.

While this three-pronged approach could be criticized on economic and public acceptance grounds, it aims to in the words of Jean-Baptiste Colbert, “obtain the largest possible amount of feathers with the smallest amount of hissing.” This three pronged approach provides better and less congested roads to the drivers who will be using the roads and directly paying the VMT fee, an increased public transportation option for those drivers who will find it economically burdensome to pay the VMT fee, and crucial budget deficit reduction dollars which will eliminate some of the need to increase income or other taxes or reduce spending. All of this could be accomplished with a 5 cent per-mile fee.

While a 5 cent fee, after allocating portions to surface transportation, would provide only minimal deficit reduction at the federal level, at the state level it would be quite significant. Based on the revenue simulations in this thesis, a 5 cent per-mile VMT fee over three years could fill the entire high priority, 20 year, transportation funding gap, and completely erase the state’s budget deficit. All of this could be done without raising income taxes or making a single dollar in spending cuts. While transportation professionals and concerned citizens continue to fret over the deteriorating condition of our nation’s surface transportation system, and politicians in St. Paul and Washington, D.C. remain locked in gridlock over looming budget deficits, VMT fees provide a possible path forward towards a better transportation system and a more fiscally sound nation.

NOTES

1. Unless noted here in the notes section or in the body of the thesis, sections 3.1.2 through 3.1.5 are pulled directly from the third chapter of Coyle et al. (2011b). The heading and sub-heading titles remain the same as the ones used in Coyle et al. (2011b), however the numbering and formatting of them are different to fit with the numbering and formatting of this thesis.

2. Chapter three of Coyle et al. (2011b) includes an introduction, conclusion, and section on environmental sustainability. All three of those sections have been omitted from this thesis. Furthermore, in Coyle et al. (2011b) each sub-section (Efficiency, Equity, Revenue Adequacy and Sustainability, and Feasibility) contains its own concluding summary. These summaries are also omitted from this thesis.

3. The introduction to the Efficiency section (3.1.2), as well as all other introductory sections (3.1.3, 3.1.4, and 3.1.5) have been written uniquely for this thesis and are not pulled directly from the Coyle et al. (2011b) paper.

4. Coyle et al. (2011b) contains another sub-section under the "Use of transportation" section entitled "Effect on mode shift." This sub-section has been omitted from this thesis.

5. The title of this sub-heading in the Coyle et al. (2011b) paper is simply "EQUITY."

6. The first sentence of this section from Coyle et al. (2011b) has been omitted from this thesis. It read, “We begin our analysis with how VMT fees, as user fees, perform under the user-pays-and-benefits principle.”

7. The first paragraph of this section from Coyle et al. (2011b) has been omitted from this thesis.

8. Coyle et al. (2011b) contains another sub-section under the “VMT fees as user fees” section entitled “Will VMT revenues be used for other purposes?” This sub-section has been omitted from this thesis.

9. Coyle et al. (2011b) contains another sub-section under the “Ability-to-pay considerations” section entitled “Horizontal equity.” This sub-section has been omitted from this thesis.

10. The first sentence of this section from Coyle et al. (2011b) has been omitted from this thesis. It read, “In concluding our discussion of the equity criterion, we examine VMT fees through their affect on vertical equity.”

11. The Coyle et al. (2011b) paper starts this sentence, “As we will discuss below”.

12. The Coyle et al. (2011b) paper starts this sentence, “Before we begin our analysis of the political feasibility of VMT fees”.

13. The Coyle et al. (2011b) paper starts this sentence, “Under the political feasibility principle we take a closer look at three specific criteria”.

14. The first sentence of this section from Coyle et al. (2011b) has been omitted from this thesis. It read, “Finally, we consider how privacy and system security issues involved with VMT fees would affect political feasibility.”

15. It should be noted, the -3.2 estimate is from a study that looks at price elasticities for various types of trips, and -3.2 is an estimate of the price elasticity for urban shopping trips.

16. This can be done for the aggregate of all vehicle miles traveled. This includes travel on all public roads from interstate highways to local roads in residential areas.

17. In both the federal and state dataset VMT data is for all vehicle travel that takes place within the applicable jurisdiction. This includes interstates and other “(1) arterial highways, which generally handle the long trips; (2) collector facilities, which collect and disperse traffic between the arterials and the lower level roads; and (3) local roads,

streets, and other public ways, which serve a land access function to homes, businesses, individual farms and ranches, and other uses." (Federal Highway Administration 2011)

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