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MOTOR VEHICLE WEALTH TAXES AND FLEET AGE:
AIR QUALITY IMPLICATIONS

A Dissertation
Presented for the
Doctor of Philosophy
Degree
The University of Tennessee, Knoxville

Karie Anne Barbour
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Dedication

This dissertation is dedicated to my family in recognition of the endless love and encouragement they have given me over the years.

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Abstract

The objective of this dissertation is to determine whether motor vehicle wealth taxes have unintended consequences for fleet turnover, emissions and air quality. Twenty-eight U.S. states have an annual motor vehicle wealth tax that is based on either the age or value of the vehicle, which results in tax liabilities that decrease with age. Given this structure, households have an incentive to make adjustments to their vehicle stocks in favor of older vehicles. These adjustments may be harmful to the environment as older vehicles have higher emissions.

To achieve this objective I have divided this dissertation into three separate empirical analyses. In the first analysis, I use data from the 2001 National Household Travel Survey to identify the effects of motor vehicle wealth taxes on households' vehicle purchase and age decisions. I estimate a binary choice model to examine the effects of various measures of the motor vehicle wealth tax on households' decisions to purchase a vehicle in a given year while controlling for household demographics, the availability of public transportation and transaction taxes. I then estimate an ordinary least squares regression model to examine the effects of wealth taxes on the vehicle age decision for those households that purchased at least one vehicle in 2001. The results indicate that motor vehicle wealth taxes have a statistically significant negative but rather modest effect on the probability that a household purchases a vehicle in a given year. However, once a household has decided to make a purchase, the presence of a wealth tax does not affect its vehicle age decision.

In the second analysis, I use state vehicle registration data from R.L. Polk and Company to estimate vehicle age distributions in individual states. To isolate the effects of motor vehicle wealth taxes on the proportion of vehicles in each of twenty-five age categories, I estimate a multinomial logit model. I then conduct simulations using the results from this model to construct vehicle age distributions under each state's current wealth tax regime and the age distributions that would result given a change in the wealth tax regime. A comparison of these distributions identifies the magnitude of the effects of wealth taxes on fleet age by state. The results suggest that motor vehicle wealth taxes do indeed have a statistically significant effect on vehicle age distributions; however, the magnitude of the effect is quite modest. Specifically, motor vehicle wealth taxes slightly increase the fraction of vehicles between the ages of ten and sixteen and decrease the fraction of vehicles in the oldest age categories, all else constant.

In the final analysis, I employ the MOBILE6 emissions model created by the Environmental Protection Agency to explore the effects of motor vehicle wealth taxes on emissions and air quality. I use vehicle age distributions associated with different motor vehicle wealth tax regimes in the emissions model to generate emission factors for three major mobile source pollutants. The emission factors associated with these different scenarios suggest that the slight differences that exist between vehicle age distributions by wealth tax status have virtually no effect on emissions.

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Chapter 1

Introduction

Overview of the Analysis

As of 2001 wealth taxes on motor vehicles were utilized in twenty-eight U.S. states in the form of ad valorem personal property taxes, privilege taxes or age-based fees. Regardless of their form, motor vehicle wealth taxes tend to be based on either the age or value of the vehicle which results in a tax liability that decreases with age. The age distribution of vehicles in states with a wealth tax is expected to be skewed towards older vehicles as consumers have the incentive to delay the purchase of a new vehicle or to enter the used vehicle market to avoid paying higher tax liabilities. Older vehicles are more likely to emit larger amounts of harmful pollutants. Therefore, to the extent that motor vehicle wealth taxes have delayed fleet turnover, they may have resulted in additional unintended consequences, namely a decrease in air quality resulting from increases in emissions from motor vehicles. The objective of my analysis is to determine whether motor vehicle wealth taxes affect household decisions of whether to purchase a vehicle and of how old of a vehicle to purchase, state vehicle age distributions and consequently emissions and air quality.

The analysis begins in the present chapter with an overview of the use and structure of motor vehicle wealth taxes used throughout the United States. This summary highlights the specific tax provisions that lead to tax liabilities that decrease with the age of the vehicle and identifies key differences in tax provisions across states. Various measures of the motor vehicle wealth tax that serve as the key variables of interest in the empirical models are then defined and summarized. This chapter concludes with a

discussion of the effects of vehicle age on emissions and a brief review of the relevant literature.

The objective of Chapter 2 is to identify the effects of motor vehicle wealth taxes on household vehicle purchase and age decisions using data from the 2001 National Household Travel Survey. The data collected for this survey contain a wealth of information on the demographics, travel patterns and vehicle stocks for roughly 26,000 households living throughout the U.S. and allow for the identification of households that purchased a vehicle in 2001 as well as the ages of purchased vehicles. I estimate a binary choice model to examine the effects of various measures of the motor vehicle wealth tax on households' decisions to purchase a vehicle in a given year while controlling for household demographics, the availability of public transportation and transaction taxes. I then estimate an ordinary least squares regression model to examine the effects of wealth taxes on the vehicle age decision for those households that purchased at least one vehicle in 2001.

The objective of Chapter 3 is to model the effects of motor vehicle wealth taxes on the state-level age distribution of all vehicles. I use state vehicle registration data obtained from R.L. Polk and company in multinomial logit models of vehicle age. Again, I estimate three separate models using alternative measures of the motor vehicle wealth tax. I then use the results of these models in simulations that construct national and state vehicle age distributions that would result under various motor vehicle wealth tax regimes. A comparison of these distributions identifies the magnitude of the effects of wealth taxes on fleet age.

In Chapter 4, I use the MOBILE6 emissions model created by the Environmental Protection Agency (EPA) to identify the effects of motor vehicle wealth taxes on emissions and air quality. To accomplish this objective, I use vehicle age distributions associated with different motor vehicle wealth tax regimes in the emissions model to generate emission factors for three major mobile source pollutants (carbon monoxide, hydrocarbons, and nitrogen oxide). I then compare emission factors associated with various wealth tax policies for eight different states that face significant pollution reduction challenges to determine whether a change in the use of motor vehicle wealth taxes is a viable option for reducing emissions. In the final chapter of the analysis, I offer some concluding remarks and directions for future research.

Motor Vehicle Wealth Taxes at a Glance

As of 2001, annual wealth taxes on motor vehicles were used in twenty-eight states in the United States in the form of either an ad valorem personal property tax, a tax in lieu of a property tax or an age-based fee. In recent years, politicians have sought to take advantage of the unpopularity of these taxes to win votes. In particular, gubernatorial candidates in Virginia and California have proposed the reduction or removal of motor vehicle wealth taxes as part of their political platforms. Such proposals have been very popular among the electorate as the issue applies to nearly everyone given high motor vehicle ownership across most segments of the population. In 1998 alone, proposals to reduce motor vehicle wealth tax liabilities were made in California, Missouri, South Carolina, and Virginia. In practice, however, these proposals have been

difficult to implement as these taxes represent an attractive source of revenues for state and local governments.¹

Motor vehicle wealth taxes represent a fairly stable source of revenues given the relatively high demand for motor vehicle services. Although new vehicle demand is procyclical, households continue to drive and pay taxes on their existing vehicle fleets during economic downturns.² There is also some empirical evidence that suggests that motor vehicle wealth taxes are more equitable than other forms of taxation. A recent study by Dill et al. (1999) found that motor vehicle wealth taxes are less regressive than sales and gasoline taxes frequently used by state and local governments. Motor vehicle wealth tax revenues represent a sizable portion of annual revenues collected by local governments. Thus if these taxes are removed or reduced, local governments must find alternative sources of revenue to fund local public expenditures. Given the characteristics of the motor vehicle wealth tax, these alternative revenue sources would likely decrease the stability and increase the regressivity of the tax base.

Despite these attractive qualities, the utilization of motor vehicle wealth taxes may result in unintended consequences. These taxes may be inefficient in a fiscal sense as they may distort decisions made by households regarding their vehicle fleets.

Regardless of their form, motor vehicle wealth taxes tend to be based on either the age or value of the vehicle which results in a tax liability that decreases with age. Given this structure, consumers have an incentive to make adjustments to their vehicle stocks in

¹ Since 1998, California has successfully reduced its tax rate on motor vehicles and Virginia has phased-out a large portion of the tax. However, both states have encountered fiscal budget constraints that have prevented the complete elimination of the tax. The proposals to reduce the tax in Missouri and South Carolina never passed their state legislatures.

² Greenspan and Cohen (1996) report a contemporaneous correlation of the quarterly growth rate of motor vehicles and real GDP of about 0.5 over the past four decades.

favor of older vehicles as they receive preferential tax treatment. Specifically, motor vehicle wealth taxes are expected to affect household vehicle purchase decisions in two ways. First, households that reside in a state with a wealth tax on vehicles are expected to delay the purchase of a new vehicle. A household can expect to have a higher motor vehicle wealth tax liability when it replaces an older less valuable vehicle with a newer more expensive vehicle or makes an addition to its vehicle stock. All else constant, the higher tax liability may discourage many households from purchasing a vehicle. Second, those households living in a wealth tax state that do purchase a vehicle are expected to purchase older vehicles on average, all else constant. Given that a household has decided to purchase a vehicle, the structure of motor vehicle wealth taxes provides an incentive to purchase older vehicles as their absolute tax liabilities, and in some cases their tax liabilities as a percentage of their value, are lower than those of newer vehicles. Given these incentives, the age distribution of vehicles in states with a wealth tax is expected to be skewed towards older vehicles as consumers have the incentive to delay the purchase of a new vehicle or to enter the used vehicle market.

To the extent that motor vehicle wealth taxes have delayed fleet turnover, they may have resulted in additional unintended consequences, namely a decrease in air quality resulting from increases in emissions from motor vehicles. Older vehicles are likely to emit larger amounts of harmful pollutants due to their less sophisticated emission control systems and the deterioration of these systems over time. Therefore, to the extent that motor vehicle wealth taxes affect vehicle age distributions, changes to these taxes may be a viable option for governments charged with the task of decreasing

mobile source emissions. The objective of this analysis is to quantify the economic distortions of motor vehicle wealth taxes that affect vehicle age distributions, emissions and air quality so that policy makers might make more informed decisions regarding the future use and structure of motor vehicle wealth taxes.

Overview of Motor Vehicle Wealth Taxes in 2001

Annual motor vehicle wealth taxes are used in some form or another in a majority of states across the U.S. Figure 1.1 (all figures appear in Appendix A) highlights the 28 states with motor vehicle wealth taxes as of 2001.³ The taxing methodologies used in these states generally fell into one of three categories: an ad valorem personal property tax, a state or local tax in lieu of a personal property tax or an aged-based fee. Thirteen states shown in the light gray color, located primarily in the southeast, tax motor vehicles as personal property. In these states, local jurisdictions administer the tax and have the authority to set their own mill levies and collect their own revenues. Thus, the effective tax rates as of 2001 varied across counties in a given state and may have even varied within a county if cities, municipalities or school districts had their own taxing authority. The twelve states shown in the dark gray color, located primarily in the West and Midwest, levy “privilege” taxes that are based on vehicle value but are levied “in lieu” of property taxes to eliminate situs and tax disparity problems. In a majority of these states the state legislature sets a statewide tax rate and the state collects tax liabilities as part of the annual vehicle registration process and later distributes these revenues to local

³ This figure reflects the changes that have occurred in motor vehicle wealth tax usage in recent years. See Mackey and Rafool (1998) for an overview of motor vehicle wealth tax usage and structure as of January 1, 1998. Motor vehicle wealth tax provisions from 2001 are used in this analysis to complement the 2001 National Household Travel Survey and the state vehicle registration data used by the empirical models.

governments. The remaining three states with motor vehicle wealth taxes (Montana, Utah and Oklahoma) simplified their tax structures in the years just prior to 2001 by replacing existing privilege taxes with annual age-based fees. The fee schedules are established such that residents with newer vehicles pay higher fees. The remaining states as well as the District of Columbia did not impose a wealth tax on motor vehicles as of 2001.⁴ However, many of these states did impose flat registration fees or taxes based upon the weight of the vehicle.

Wealth taxes in these 28 states differ by more than just their classification. Additional details collected through surveys, personal interviews and searches of state tax codes reveal that there are several significant differences in the taxing methodologies implemented in these states. Table 1.1 (all tables appear in Appendix B) provides a brief summary of motor vehicle wealth tax provisions by state as of 2001. As indicated in this table, different states use different methods for determining the value of a vehicle. Three of the most common valuation methods include the National Automobile Dealers Association “Blue Book” value method, the Manufacturers Suggested Retail Price (MSRP) base method and the purchase price base method. In most cases, state law specifies the valuation method that is used by all taxing jurisdictions within a state. States with wealth taxes classified as personal property taxes primarily use the “blue book” valuation method. This method allows tax assessors to set values for vehicles based upon their “trade-in” value which in most all cases decreases with the age of the

⁴ Taxing jurisdictions in Texas had the option to impose wealth taxes on motor vehicles in 2001. However only approximately 1 in 20 counties contained at least one jurisdiction that imposed the tax. Therefore, for the purposes of this analysis Texas is treated as a no-tax state.

vehicle. States with privilege taxes or age-based fees primarily use either the MSRP or purchase price base methods and establish their own depreciation rates so that the assessed value of the vehicle decreases with age.

As expected, the tax rate and assessment ratios on motor vehicles differed across states in 2001. However, in some instances they also differed within the same state based on the age of the vehicle. In 2001, the tax rates ranged from 0.65 percent in California to 4 percent in Nevada. The average mill rate in property tax states ranged from 10.5 mills in North Carolina to 87 mills in Kansas.⁵ Tax rates also varied significantly between local jurisdictions in states that used personal property taxes. For example, in Kansas mill levies ranged from roughly 37 to 131 mills. Most states had a uniform tax rate with respect to vehicle age; however, in a few states such as Colorado and New Hampshire the rate varied with vehicle age. Assessment ratios on motor vehicles ranged from 100 percent of a vehicle's value in several states such as Kentucky and North Carolina to a low of 10.5 percent in South Carolina. In several states the assessment ratio was a function of the age of the vehicle. For example, in Minnesota a tax rate of 1.25 percent was applied to 100 percent of a vehicle's value in years one and two, 90 percent of a vehicle's value in years three and four, 75 percent of a vehicle's value in years five and six and so forth until year ten when only 10 percent of a vehicle's value was subject to taxation.

Minimum tax liabilities were a common feature of motor vehicle wealth tax provisions in 2001. By law, tax liabilities in several states reached their minimums at

⁵ A mill rate indicates the tax liability per \$1,000 of assessed value. For example the tax liability of a vehicle with an assessed value of \$5,000 would be equal to \$52.50 in North Carolina in 2001.

some threshold value or vehicle age. For example, in Maine the motor vehicle tax statute set a minimum tax payment of \$5. In Wyoming, the tax liability on motor vehicles remained frozen at 3% of 15% of the MSRP after year six. The consideration of a minimum tax provision is very important to this analysis since it implies that after some threshold age there would no longer be any marginal tax advantages of holding older vehicles.

To model the effects of motor vehicle wealth taxes on household vehicle purchase decisions and vehicle age distributions, a practical empirical measure of the wealth tax is needed. Given the disparities in the taxing methodologies used by states including differences in valuation methods, tax rates, assessment ratios and minimum tax thresholds it is virtually impossible to adequately represent motor vehicle wealth taxes with a simple measure such as a tax rate. Such a measure fails to capture the dynamic structure of the tax that results in a decline in tax liabilities with vehicle age. Therefore, my analysis relies on more creative measures of the motor vehicle wealth tax to model households' vehicle purchase decisions and the age distribution of state fleets.

In theory, the vehicle purchase decisions of households are expected to be more responsive in situations where the tax liabilities of vehicles of various ages differ more dramatically. Therefore, I used the tax provisions outlined in Table 1.1 to create two measures of motor vehicle wealth taxes that compare the tax liabilities of a brand-new vehicle to the tax liabilities of a used vehicle. The representative vehicle used in this process was the Honda Accord as it has been one of the best selling sedans in the U.S. over the past several years. The process also required the creation of a depreciation

schedule for the Honda Accord in order to generate tax liabilities in states that use the blue book valuation method. I used the manufacturer's suggested retail price and resale value data for various model years of Accords to create a depreciation schedule. Specifically this process required the collection of MSRP and resale value data at various ages for 13 different model years of Accords. The first step in the calculation was to create a measure that represented the total percentage change in value for vehicles of each age. The second, and final, step was to create annual depreciation rates over a thirteen-year period by comparing the total percentage change in value for vehicles of consecutive ages.⁶

Figure 1.2 depicts the depreciation schedule derived from this method. Notice that the figure does not show a smooth downward trend that is normally expected. There are several explanations for the visible spikes. Recall that the calculations used to derive this schedule actually used price data for several model years of Accords. These different models tend to have different features; therefore, it is probably realistic to expect their values to depreciate at different rates. Also, the spikes at years five and eleven may reflect higher maintenance cost as vehicles generally reach mileage milestones near these ages and thus require more maintenance. So while this method may be less than perfect, using observed data on prices to create a depreciation schedule most likely leads to fewer errors than would using a schedule that had just been assumed.

The present value of a ten-year stream of tax liabilities for both a new 2001 Accord and a used 1998 Accord were created for each state using the MSRP values of the

⁶ For example, I created the depreciation rate for year three by subtracting the total percentage change in value of two-year-old Accords from the total percentage change in value for three-year-old Accords.

two vehicles, the depreciation schedule shown in Figure 1.2 and the tax laws for each respective state.⁷ Table 1.2 provides a list of the resulting tax liabilities by state for states with a wealth tax. The average present value of a ten-year stream of tax liabilities for a new 2001 Accord across states with wealth taxes was \$1,417 in 2001. Households living in South Carolina faced the highest tax liability, \$3,372, if they purchased a brand-new Honda Accord in 2001 and keep it for at least ten years. Households living in Michigan faced the lowest tax liability for the 2001 Accord, \$627. The second column of this table presents the present value of a ten-year stream of tax liabilities for the used 1998 Accord. Notice that in all states the tax liability for the used vehicle is lower than the tax liability for the new vehicle. Given the higher MSRP value for the 1998 Accord, this result is due entirely from the relatively favorable tax treatment received by older vehicles. Again, residents in South Carolina face the highest tax liability for the used Accord, \$2,443; however, the lowest tax liabilities are borne by residents of Indiana, \$444.

Two measures of the wealth tax are created using the respective tax liabilities for the new 2001 Accord and the used 1998 Accord in each state. The first of these variables is the absolute difference, which is the 2001 Accord tax liability minus the 1998 Accord tax liability. Column three of Table 1.2 shows the results of this calculation by state. The average difference between these tax liabilities across states is \$551. Mississippi has the largest difference (\$1,273), while Oklahoma has the smallest (\$85). The second measure of the wealth tax is the relative difference in the tax liabilities of a new versus

⁷ I chose the three-year-old 1998 Honda Accord as my representative used vehicle because it is old enough that its associated wealth tax liability is lower than that of a brand new vehicle, yet it is young enough to be driven for ten additional years. The 2001 and 1998 Honda Accord had MSRP values (in real dollars) of \$22,800 and \$23,801 respectively. The differences in these MSRP values are most likely due to differences in the features of the two vehicles.

used car, which is the ratio of the 2001 Accord tax liability to the 1998 Accord tax liability, thus the larger the ratio the more favorable the tax treatment for older vehicles relative to newer vehicles. The average wealth tax ratio across states is 1.72, indicating that on average the present value of a ten-year stream of tax liabilities for a brand new vehicle is 72 percent larger than the present value of a ten-year stream of tax liabilities for a three-year-old vehicle. Once again, Mississippi and Oklahoma define the range for this measure of the wealth tax with ratios of 3.00 and 1.15 respectively.

Each of these wealth tax measures reflects the degree to which older vehicles receive favorable tax treatment relative to new vehicles under the motor vehicle wealth tax provisions in each state as of 2001. Larger values of both measures suggest that older vehicles receive more favorable tax treatment. However, the values of these measures reported in Table 1.2 seem rather modest considering that they represent a comparison of tax liabilities over a ten-year period. The maximum difference of \$1,273 would likely have larger implications on household vehicle purchase and age decisions if the entire amount were due at the time of purchase. Instead, households must pay the difference in tax liabilities over a ten-year time period. However, these values do represent the present value of tax liabilities; therefore, \$1,273 today would actually add up to more dollars over ten years. Of course, these calculations would generate larger differences if tax liabilities of vehicles older than the age of three were used in the comparison.

To some extent, the values reported in Table 1.2 may understate the relative differences in tax liabilities for average new and used vehicles. Although the Honda Accord is representative to the extent that it is a popular vehicle year after year, its

depreciation schedule may not be representative of the average vehicle. As evidenced by the depreciation schedule in Figure 1.2, the Accord tends to retain a large portion of its value over several years. The average vehicle's depreciation schedule likely exhibits larger depreciation rates for relatively newer vehicles. Thus the models estimated in this analysis use an alternative vehicle, the Ford Taurus, as a robustness check. Figure 1.3 depicts the depreciation schedule derived for the Ford Taurus using the same methods used for the Honda Accord. The value of the Taurus depreciates at a more rapid rate than the Accord, and its depreciation schedule is much smoother. Table 1.3 provides a list of tax liabilities by state for the Ford Taurus. Notice that although the value of the tax liabilities are lower compared to those of the Honda Accord, the absolute and relative difference measures are generally larger for the Taurus due to its more rapid depreciation rate.

It remains to be seen whether the relative and absolute differences reported in Table 1.2 and Table 1.3 are sufficiently large to affect household vehicle purchase and age decisions. The maximum difference between the present value of a ten-year stream of tax liabilities in Table 1.2 (\$1,273) represents roughly 5.6 percent of the MSRP of the 2001 Honda Accord, while the minimum difference (\$85) represents only 0.37 percent of the Accord's suggested price. Wheeler (1998) claims that motor vehicle wealth tax liabilities are such a small percentage of a vehicle's value that most individuals do not take this tax into consideration when purchasing a motor vehicle; however, her analysis offers no empirical evidence to support this claim. In fact, there appears to be no existing literature that directly tests the hypothesis of this analysis.

The Effects of Vehicle Age on Emissions

To the extent that motor vehicle wealth taxes have delayed fleet turnover, they may have resulted in additional unintended consequences, namely a decrease in air quality resulting from increases in emissions from older motor vehicles. In 1999, motor vehicle emissions represented 51 percent of carbon monoxide emissions, 34 percent of nitrogen oxide emissions and 29 percent of hydrocarbon emissions in the United States (Environmental Protection Agency, 1999). Although all motor vehicles contribute to pollution problems, older vehicles contribute disproportionately to the overall emissions from motor vehicles. Older vehicles are likely to emit larger amounts of harmful pollutants including hydrocarbons, carbon monoxide and nitrogen oxides. Zachariadis et al. (2001) outlines the various interdependencies between vehicle age, technological parameters and vehicle emissions. Their analysis identifies less sophisticated emissions control systems and the deterioration of emission control systems with age as the primary reasons why older vehicles have higher emissions.

Older vehicles tend to have less sophisticated emissions control systems than their newer counterparts, which must meet increasingly strict standards established by the Environmental Protection Agency under provisions of the Clean Air Act. Figure 1.4 depicts federal emission standards in grams per mile traveled between the years of 1966 and 2005 for three major pollutants. The EPA has dramatically increased the standards (i.e. lowered the allowable grams of emissions per mile traveled) for all three pollutants since the Clean Air Act was passed in 1969. Since 1966, emissions standards for carbon monoxide, hydrocarbons, and nitrogen oxides have increased by 96, 90 and 98 percent

respectively. As a result, newer vehicles have more sophisticated emission control technologies designed to meet these stricter standards and thus have lower emissions, all else constant. The change most relevant for this analysis given the data used occurred in 1994 when the EPA lowered the tailpipe standards for hydrocarbon and nitrogen oxide emissions. Even with this change the federal emission standards have remained fairly constant over the past twenty years. Most vehicles in today's fleet have emission control systems that were designed to meet roughly the same emission control standards. Therefore, of larger environmental consequence is the fact that emission control systems tend to deteriorate with age.

Fleet turnover is important in reducing overall vehicle emissions because vehicles pollute more as they age. For example, the MOBILE5 model used by the EPA to quantify mobile source emissions includes adjustments in emissions rates that account for deterioration in emission control systems with age. The model estimates that carbon monoxide emissions for a representative vehicle are ten times higher after four years or 50,000 miles, volatile organic compounds are four times higher, and nitrogen oxide emissions are about twice as high as when the car was new (U.S. Congress, Office of Technology Assessment, 1992). Results of emission tests reported in Johnstone et al. (2001) provide further evidence that the deterioration of emission control systems occurs quite rapidly. The results of these tests indicate that the average emission rates for model year 1990 vehicles increase dramatically in the first seven years of a vehicle's life as carbon monoxide emissions increase by 500 percent, hydrocarbons by 300 percent and nitrogen oxide by more than 200 percent. Thus, there is sufficient evidence that emission

rates are strongly correlated with vehicle age. Therefore, if motor vehicle wealth taxes result in older fleets, the unintended environmental consequences could be rather large.

The potential environmental consequences associated with motor vehicle wealth taxes may be more severe in states with extreme pollution problems. Motor vehicles are major contributors to the ground-level ozone as it is formed by reactions involving hydrocarbons and nitrogen oxides in the presence of sunlight, and carbon monoxide is a direct by-product of the combustion process of a motor vehicle. As of September 2002, nearly 25 states contained areas that were classified as either an ozone or carbon monoxide nonattainment area. The Environmental Protection Agency classifies an area as a nonattainment area when air pollution levels persistently exceed the national ambient air quality standards it has established. Nearly 57 percent of states with an ozone nonattainment area and 75 percent of states with a carbon monoxide nonattainment area as of 2002 were wealth tax states.⁸

State and local governments in nonattainment areas are charged with the task of developing air pollution reduction measures that are designed to achieve attainment of ambient standards. To the extent that motor vehicle wealth taxes affect vehicle age distributions, state and local governments in these states may be able to remove, reduce or change the structure of the wealth tax to reduce emissions and improve area quality. Simulations using the EPA's most recent emissions model (MOBILE6) reveal that a 20 percent age shift to older vehicles yields a 50 percent increase in hydrocarbon and carbon monoxide emissions and a 40 percent increase in nitrogen oxide emissions

⁸ For additional details on the specific areas that are currently designated as nonattainment or the technical details underlying these classifications see the *Green Book* published by the Environmental Protection Agency (2004).

(Environmental Protection Agency, 2002).⁹ Therefore, if changes to motor vehicle wealth taxes sufficiently increase the fraction of vehicles in younger age categories, emissions of these criteria pollutants could decrease dramatically.

Relevant Literature

This analysis is not the first to propose a relationship between tax structures and vehicle age. Johnstone et al. (2001) conducted a study in Costa Rica where a rapid depreciation schedule and extremely high consumption taxes have traditionally favored the importation of used vehicles. The results of their analysis indicated that a 10 percent increase in the relative price of used cars would result in a 5.6 percent fall in their share of total vehicle sales. Simulation results revealed considerable environmental benefits in terms of emission levels. A 10 percent increase in the price of used cars relative to that of new cars would after 5 years decrease nitrogen oxide emissions by 17 percent, decrease carbon monoxide emissions by 10 percent, and hydrocarbons emissions by 4 percent. Thus, changing the tax structure so that it does not favor used cars would have the potential to yield significant environmental gains. However, Johnstone et al. may have underestimated the magnitude of these emissions reductions. The simulations in their analysis are not based on the most recent mobile source emissions model developed by the EPA, but are instead based upon a vehicle certification database developed by the EPA's National Vehicle and Fuels Emissions Laboratory in Ann Arbor, Michigan. This data set was developed based on tests of vehicles that were not in use; therefore, it ignores the effects of the deterioration of the emission control systems on emissions rates.

⁹ This simulation adjusted vehicle age distributions by increasing the fraction of vehicles with ages greater than 13 years old and subtracting the same fraction from vehicles that were younger than 13 years old. Each vehicle age had an equal fraction added to or subtracted from it.

Thus, if consumers are as responsive to wealth taxes as they are to the transaction taxes examined in this analysis, reducing or removing the wealth tax on motor vehicles may lead to even larger environmental gains than those reported by Johnstone et al. Under these circumstances, removing the wealth tax on motor vehicles may be a viable option for governments charged with the task of decreasing mobile source emissions.

The hypothesis that annual motor vehicle wealth taxes may affect vehicle age distributions is certainly not original to this analysis. In fact, the government of Singapore has recognized that higher registration taxes on newer vehicles may discourage car owners from replacing their vehicles or encourage them to buy old cars and has placed an annual tax on vehicles that is in part based on age. Each vehicle registered faces an annual road tax and a surcharge of 10 percent for each additional year is imposed on vehicles more than 10 years old. For example, a 12-year-old vehicle faces a surcharge of 20 percent. The objective of the surcharge is to discourage households from holding older vehicles that pollute more. Chia and Phang (2001) analyze the use of this tax as well as other motor vehicles taxes as environmental management tools. Although their analysis concludes that motor vehicle wealth taxes offer a double dividend (i.e. tax revenues and emission reductions), they also note that it is difficult to isolate the direct impacts of these taxes on air quality. These taxes are generally applied simultaneously with other instruments such as fuel taxes, congestion tolls, and vehicle quota systems designed to reduce annual vehicle miles traveled and vehicle ownership rates that also impact air quality. Therefore, while the current analysis does not offer new economic theory, it is perhaps still the first to attempt to quantify the effects of annual motor

vehicle ownership taxes on vehicle age distributions and emissions using the variation in tax structures across states.

An extensive body of literature has developed over the past several decades on individual and household vehicle purchase and consumption decisions. Hensher (1985) provides an excellent review of the empirical studies of vehicle choice and usage models. The focus of much of this literature has been on household-based sub-choice models of fleet size, vehicle type and usage. Efforts to integrate at least two of these decisions in either a holdings or transaction framework include Hensher and LePlastrier (1985), Manski and Sherman (1980) and Hensher and Mansfield (1982). Train and Lohrer (1983) and Mannering and Winston (1983) represent the first attempts to incorporate all three decisions into one model. Many of these studies include various financial characteristics such as vehicle purchase price, operating costs, transaction-search costs, service and repair cost and sales taxes in multivariate choice models. Hensher and LePlastrier (1985) include motor vehicle registration cost in a nested logit model of vehicle choice. Hayashi et al. (2001) use measures of motor vehicle purchase and annual ownership taxes in multivariate models of household vehicle purchase, ownership and usage. The results of their analysis indicate that increases in purchase and ownership taxes reduce fleet turnover. Their analysis also concludes that a significant increase in ownership taxes results in an increase in the fraction of the vehicle fleet that is made up of smaller vehicles. Although a general specification of ownership taxes would include motor vehicle wealth taxes, the models estimated by Hayashi et al. use data from Japan

and thus could not possibly include a measure that is representative of the vehicle wealth taxes used in the United States.

Johnson (1978) is perhaps the first analysis that uses a multinomial logit probability model to explain a family's choice of vehicle age. The model includes only three independent variables (income, family size, and age of the head of the family) and six vehicle age outcome categories where the final category includes all vehicles that are six years of age or older. Given the capabilities of the latest software technology, this model could easily be extended to include a larger number of vehicle age categories and independent variables. The multinomial logit model has also been used extensively to model ownership and vehicle type decisions by Lave and Train (1979) and Manski and Sherman (1980). More recent research including that by Mannering and Winston (1983) and Hensher and Le Plastrier (1985) has focused on the use of the nested logit model to analyze joint fleet size and vehicle type decisions. While an extensive body of literature exists on vehicle consumption decisions such as ownership levels, vehicle type and usage, no paper exists that specifically analyzes the effects of wealth taxes on households' vehicle purchase and age decisions, state vehicle age distributions and emissions.

Chapter 2

Effects of Motor Vehicle Wealth Taxes on Household Vehicle Purchase and Age Decisions

Introduction to the Analysis of Household Vehicle Purchase and Age Decisions

The first objective of my analysis is to determine whether motor vehicle wealth taxes affect the vehicle purchase and age decisions of households. The main hypothesis is that motor vehicle wealth taxes discourage households from purchasing a vehicle in a given year and increase the age of vehicles that are purchased. Households living in a state with a motor vehicle wealth tax can expect their annual motor vehicle ownership costs to increase if they add a vehicle to their fleet or replace a vehicle with a newer, more valuable one as a result of the tax. Therefore, households living in motor vehicle wealth tax states are expected to be less likely to purchase a vehicle in a given year, all else constant. Those households that do decide to purchase a vehicle are expected to select older vehicles to avoid paying the higher tax liabilities associated with newer vehicles.

This chapter begins with a discussion of the data and methods used in this portion of the analysis. I then present descriptive statistics of households and their vehicle purchase decisions to motivate the multivariate analyses. I then analyze the results of binary choice models of household vehicle purchase decisions and the results of multivariate regression analyses of the vehicle age decision. The chapter concludes with a brief summary of the main findings of these models and motivation for the next step in the analysis.

Data and Methods Used to Model Household Vehicle Purchase and Age Decisions

In my analysis, I use data from the 2001 National Household Travel Survey (NHTS) conducted by the U.S. Department of Transportation between March of 2001 and May of 2002 to model the effects of motor vehicle wealth taxes on household vehicle purchase and age decisions.¹⁰ The data contain a wealth of information on demographics, travel patterns and vehicle stocks for a sample of 26,000 households living across the U.S. However, the state of residence is unidentified for those households living in states with small populations to protect the confidentiality of survey participants.¹¹ This lack of information reduces the viable sample to approximately 24,000 observations as the corresponding state motor vehicle wealth tax data cannot be matched with household data for those living in states that cannot be identified. I also merged state and local sales tax rates collected from the (2001) U.S. Master Sales and Use Tax Guide with the NHTS data.

The first column of data in Table 2.1 provides a distribution of households included in the NHTS data across various household demographics and other variables that may affect households' vehicle purchase decisions. These other variables include the availability of public transportation, household travel patterns, characteristics of the household's vehicle stock and taxes on automobile transactions in the household's state

¹⁰ For additional details on the sampling process, survey procedure and information included in the NHTS data file see the 2001 NHTS User's Guide available at <http://nhts.ornl.gov/2001/usersguide/index.shtml>.

¹¹ The state of residence cannot be identified for 2,024 households in the data set. To protect confidentiality, MSAs with a population of less than 1 million, states with a population of less than 2 million, and states that have a non-MSA population that is less than one half million can not be specifically identified in the data set. The states omitted include Alaska, Delaware, Hawaii, Idaho, Maine, Nebraska, Nevada, New Hampshire, New Mexico, North Dakota, Rhode Island, South Dakota, Vermont and Wyoming.

of residence. Households in the sample are more likely to have two or fewer members, an annual income below \$50,000 and a home of their own. Households are also more likely to reside in an MSA, drive less than 10 miles to work, and most likely do not use public transportation. Nearly all households live in a state that imposes a tax on the transaction of automobiles and roughly 50 percent live in a state where local jurisdictions have the option of taxing automobile transactions. Finally, household survey respondents are more likely to be white, without a college degree, and younger than the age of 56.

Also included in the data is information on the year, make, model, estimated annual miles driven and length of current ownership for over 45,500 vehicles that are owned by households in the survey. The survey data provide all the information necessary to identify the households that purchased a vehicle in 2001 and the age of each vehicle at the time of purchase. Specifically, the survey date and the length of time the household reports owning each of its vehicles is used to identify households that purchased a vehicle in 2001. For example, households that were surveyed in July of 2001 must report owning at least one vehicle for six months or less to be identified as a household that purchased a vehicle in 2001. However, certain vehicles are excluded from the sample of possible purchases for one reason or another. Vehicles not owned by the household, such as leased or company vehicles, are excluded from the analysis as it is not obvious whether the household is responsible for paying the wealth tax. Recreational vehicles, motorcycles and vehicles classified as something other than an automobile, van, SUV or truck are excluded because they are usually employed in leisure activities which

would represent a different choice decision facing households. A vehicle's age at the time of purchase is derived using information on the model year of the vehicle, survey data and length of ownership. Vehicles over the age of 39 are excluded as they were lumped into the same model year in the original data file and thus their actual age can not be determined. Finally, vehicles for which age cannot be determined for some other reason are excluded from the sample.

To model the effects of motor vehicle wealth taxes on household vehicle purchase decisions, I merged the motor vehicle wealth tax data described above with the survey data. Roughly half of the households in the data set resided in a state that had a wealth tax on motor vehicles in 2001. Table 2.2 presents the summary statistics of the three motor vehicle wealth tax measures for the households used in this analysis. The average ratio of the 2001 Accord tax liability to the 1998 Accord tax liability was 1.29 for these households and the average difference in these tax liabilities was \$208.

From the final sample of 23,278 households, 25 percent purchased at least one vehicle in 2001. Households living in states with a motor vehicle wealth tax were just as likely to purchase a vehicle in 2001 as households living in states without a motor vehicle wealth tax. Specifically, 24.95 percent of households living in states with a wealth tax purchased at least one vehicle, while 24.75 percent of households living in states without a wealth tax purchased at least one vehicle. However this simple comparison fails to control for the effects other variables may have on the vehicle purchase decision. Other variables such as household demographics, household composition, travel patterns,

access and use of public transportation and transaction tax rates most likely affect a household's decision to purchase a vehicle.

Columns two and three of Table 2.1 show the distribution of households across various characteristics by vehicle purchase status. Households that purchase a vehicle in 2001 are more likely to be larger in size, have higher annual incomes, and have more drivers and workers. Households that purchase a vehicle are also more likely to drive further distances to work and drive more miles in a year. Of course, to isolate the effect wealth taxes have on vehicle purchase decisions from the effects of these other variables a multivariate strategy is required.

The vehicle purchase decision represents a binary choice; either the household chooses to purchase a vehicle or it chooses not to purchase a vehicle. Therefore, a binary response model such as the probit model is an appropriate multivariate strategy. Such a model assumes that a household's vehicle purchase decision is a function of a vector of explanatory variables represented by $\mathbf{x}_i$. The dependent variable in the model, y_i , takes a value of one for households that purchase a vehicle and a value of zero for households that do not purchase a vehicle. The probability that a household purchases a vehicle is expressed as $\Pr(y_i = 1 | \mathbf{x}_i)$, while the probability that the household does not purchase a vehicle is expressed as $1 - \Pr(y_i = 1 | \mathbf{x}_i)$. The likelihood equation estimated by any binary response model is:

$$L(\beta | y, X) = \prod_{y=1} \Pr(y_i = 1 | x_i) \prod_{y=0} [1 - \Pr(y_i = 1 | x_i)] \quad 2.1$$

When a latent variable $y^* = \mathbf{x}_i\beta + \varepsilon_i$ is used to derive the model, this equation can be expressed as:

$$L(B | y, X) = \prod_{y=1} F(x_i \beta) \prod_{y=0} [1 - F(x_i \beta)] \quad 2.2$$

where $F(x_i \beta) = \Pr(y_i = 1 | \mathbf{x}_i)$ and is simply the cumulative density function of the error distribution evaluated at $\mathbf{x}\beta$. The probit model specifically assumes that the error terms have a normal distribution with $E(\varepsilon|\mathbf{x}) = 0$ and $\text{Var}(\varepsilon|\mathbf{x}) = 1$. Maximum likelihood estimates of the parameters associated with each explanatory variable are obtained by applying the Newton-Raphson method to the log of equation 2.2.

To determine the effects of individual continuous variables on the household vehicle purchase decision, the parameters estimated by the probit model are used to calculate the partial change in the probability that a vehicle is purchased for a given change in each explanatory variable. This change is often referred to as the marginal effect and is calculated as:

$$\frac{\partial \Pr(y = 1 | \bar{\mathbf{x}})}{\partial x_k} = \phi(\bar{\mathbf{x}}\beta) \beta_k \quad 2.3$$

where $\phi(\bar{\mathbf{x}}\beta)$ is the normal probability density function evaluated at the mean values of the independent variables and the parameters estimated by the model.

The marginal effects of dummy variables are calculated as:

$$\Pr(y = 1 | \bar{\mathbf{x}}, \text{dummy variable} = 1) - \Pr(y = 1 | \bar{\mathbf{x}}, \text{dummy variable} = 0) \quad 2.4$$

To summarize the estimation procedure, the dependent variable of the probit model of the vehicle age decision used in this analysis takes a value of one for households that purchased at least one vehicle in 2001. A variety of independent

¹² This is the change in the probability that a vehicle is purchased as the dummy variable goes from 0 to 1, holding all other variables at their means.

variables that measure household demographics, composition, travel patterns, vehicle fleets and transaction tax rates are used in the model as controls. See Table 2.3 for a list of definitions for the variables used in the model. I estimate three separate models of the purchase decision that include different specification of the motor vehicle wealth tax measure. The effects of motor vehicle wealth taxes as well as the effects of explanatory variables are expressed as marginal effects. The marginal effect on the wealth tax dummy variable is expected to be negative indicating that the presence of a wealth tax decreases the probability that the average household purchases a vehicle. The marginal effects of the ratio and difference measures of the wealth tax are also expected to be negative as larger differences between the tax liabilities of new and used vehicles likely encourage households to keep their current vehicles.

The next step in this portion of the analysis is to model households' vehicle age decisions. The final column of Table 2.1 presents the average age of vehicles purchased by households in 2001 across various characteristics. For those households that were interviewed in 2001, vehicle age is determined by subtracting the vehicle model year from 2002; however, model year 2002 vehicles are assigned an age of one year. Vehicle age for those households interviewed in 2002 is derived by subtracting the model year from 2003. Figure 2.1 shows the distribution of vehicle age by the wealth tax status in the household's state of residence. There are only minor differences in these distributions. In fact, as noted above, the mean vehicle age for households in states with a wealth tax is 5.42 years, and the mean age is 5.24 years for households in states without a wealth tax. According to standard t-test, these values are not statistically different.

Notice that the largest difference between these distributions occurs for new cars (where age = 1). A Kolmogorov-Smirnov test applied to these distributions generates a corrected p-value of 0.128.¹³ This result suggests that these distributions are not statistically different at the ten-percent level of significance.

These results certainly suggest that motor vehicle wealth taxes do not significantly influence the age of vehicles purchased. However, simply comparing the vehicle age distribution by wealth tax status fails to control for the effects other variables may have on a household's vehicle age decisions. As reported in Table 2.1, a household with a survey respondent that is white, older and has more education tends to purchase newer vehicles. Households that live in a metropolitan statistical area, have higher annual incomes, drive further distances to work and plan to put more miles on the vehicle purchased also tend to purchase newer vehicles. To isolate the effects of motor vehicle wealth taxes from the effects of these other variables a multivariate strategy is required. Therefore, in this portion of the analysis I use an ordinary least squares regression model to model vehicle age for those 5,500 plus households that purchased a vehicle in 2001. As reported in Table 2.1, over 86 percent of these households purchased only one vehicle. However, the dependent variable in the regression is set equal to the average age of vehicles purchased in 2001 since nearly 15 percent of these households did purchase more than one vehicle. Again, the wealth tax measures of interest include a wealth tax dummy variable and the wealth tax ratio and difference measures. Each of these alternative specifications of the wealth tax is used in a separate linear regression model.

¹³ The Kolmogorov-Smirnov test is a test of the equality of two distributions. The test is a statistical procedure that uses the maximum vertical distance between two functions as a measure of how well the functions resemble each other (Conover, 1998).

For the most part, the other independent variables used in the baseline specification include those variables that are used in the purchase decision model. In addition to these variables, the vehicle age model includes two vehicle-specific attributes. The first is a dummy variable indicating whether any of the vehicles purchased by the household are classified as something other than an automobile.¹⁴ The second is the household's estimate of the average number of miles it expects to drive the newly purchased vehicle (or vehicles) in the first year of ownership.

The motor vehicle wealth tax is expected to have a positive effect on vehicle purchase age in the multivariate regression analysis, all else constant. Households that live in states with a wealth tax are expected to purchase older vehicles in order to avoid paying higher taxes. Both the ratio of the new versus used vehicle tax liabilities and the difference between these tax liabilities are also expected to have a positive effect on vehicle age as larger values of these variables reflect higher relative tax payments for newer vehicles. Table 2.4 presents the summary statistics of the wealth tax variables for households that purchased at least one vehicle in 2001. The mean ratio of tax liabilities faced by these households is 1.28, while the mean tax difference is roughly \$208.

Analysis of the Household Vehicle Purchase Decisions

Table 2.5 presents the marginal effects for three different probit models of the 2001 vehicle purchase decision. Over 21,000 households whose state of residence could be identified in the NHTS and whose data for the included variables was non-missing are

¹⁴ This classification includes sports utility vehicles, mini-vans and trucks.

included in the sample used to estimate the model.¹⁵ The analysis includes separate models for three different measures of the motor vehicle wealth tax – a dummy variable indicating the presence of a wealth tax in the household’s state of residence, the ratio of tax liabilities and the absolute difference in tax liabilities. In each of the models the dependent variable takes a value of one for households that purchased at least one vehicle in 2001. The control variables in the models reflect household demographics, household composition, public transportation use and access and transaction tax rates.

The wealth tax variable has a negative and statistically significant effect on the probability that a household purchased a vehicle in two of the three models. However, in all cases the magnitude of the effect is rather modest. The results from model 1 indicate that if a household lives in a state with a wealth tax, its probability of purchasing a vehicle is 1.23 percentage points less than that of a household living in a state without a wealth tax, all else constant. The baseline proportion of households in this sample that actually purchased a vehicle is 26.61 percent; therefore, this change represents a 4.62 percent decrease in the likelihood that a vehicle is purchased. The marginal effect of the ratio of tax liabilities is highly statistically significant in model 2. However, the small marginal effect results in an elasticity of only -0.10 . Thus the model predicts that a one-percent increase in the ratio of tax liabilities would decrease the predicted probability that a vehicle is purchased by only 0.10 percent, all else constant. The marginal effect of the difference in tax liabilities fails to be statistically significantly different from zero in model 3.

¹⁵ Although the state of Virginia could be identified in the data, its 2001 wealth tax data are difficult to obtain due to recent changes in the tax structure. Therefore all households living in Virginia are excluded from this analysis.

A majority of the marginal effects on the additional explanatory variables used in these models are statistically significant and consistent across the various specifications of the wealth tax. In most cases, the marginal effects of these explanatory variables are of the expected signs or are consistent with the trends presented in Table 2.1. For example, increasing a household's income would increase the probability that it purchases a vehicle, all else constant. Households with a youngest child between the ages of 16 and 21 are more likely to purchase a vehicle than are households in other stages of the life cycle. Homeowners are less likely to purchase a vehicle in 2001, which is not surprising considering that mortgage payments tend to impose liquidity constraints on households. Households that reside in an MSA with a population of at least a million people and a heavy transit system are less likely to purchase a vehicle, perhaps due to a lack of need or the availability of other transportation options. However, the marginal effect of the public transportation variable that indicates whether a member of the household used some form of public transportation in the past two months is not statistically significant. Increasing the household size, worker count or average distance to work would increase the probability that a vehicle is purchased. Households with younger respondents and those with respondents without a college degree are less likely to purchase a vehicle. Intuition would suggest that transaction taxes such as sales, use or excise taxes on motor vehicles would discourage households from purchasing a vehicle as they increase the overall cost of the purchase. However, neither state nor local transaction tax rates in the household's state of residence significantly affect the purchase decision in these models.

Tables 2.6 and 2.7 present the results of various alternative specifications of the vehicle purchase decision that serve as robustness checks of the baseline model. The first set of results in Table 2.6 is from a model that includes additional control variables at the expense of nearly half of the observations. The most interesting of these variables are perhaps those that provide information on the households' current vehicle fleet. Variables that measure the average age of the household's fleet as well as the total annual miles the household drives are included in this model. The addition of explanatory variables and the reduction in the sample size lead to several changes in the results of the model. However, the overall results for the wealth tax variables are fairly consistent. The magnitude of the effects of the wealth tax dummy and wealth tax ratio increases slightly in absolute value. The presence of a wealth tax now decreases the predicted probability that a household purchased a vehicle by roughly 0.02 or nearly 8 percent, which is indeed a larger effect. Interestingly, the difference between the wealth tax liability of new versus used vehicles is now statistically significant in model 3; however, again the effect is very small. A \$100 increase in the tax difference between new and used vehicles would decrease the probability that households purchase a vehicle by only 0.34 percentage points or only 0.01 percent.

Of the additional explanatory variables, only two are statistically significant; however, there are considerable changes in the significance patterns of the original explanatory variables. However, most of the changes reflect a loss of statistical significance, which certainly suggests that the significant decrease in the sample size may be the primary force behind these changes. In fact, re-estimating the baseline model

using only those observations that are included in this alternative specification results in nearly all of the same changes.

The second set of results in Table 2.6 includes a dummy variable that indicates whether or not the household was interviewed in the fourth quarter of 2001. This dummy variable serves two purposes. First, it captures the effects of special promotions (such as zero percent down) that are frequently offered during this time of the year as auto-dealers prepare to make room for new model year vehicles. Secondly, the dummy variable serves as a control for the influence that the events of September 11, 2001 may have had on household vehicle purchase decisions. The results of the baseline model are somewhat sensitive to the inclusion of this additional variable. The marginal effect on the wealth tax dummy variable is no longer statistically significantly different from zero. However, the marginal effect on the wealth tax ratio variable remains statistically significant. These results suggest that after controlling for a fourth quarter interview households' vehicle purchase decisions are not affected by the mere presence of a motor vehicle wealth tax but are still responsive to the relative differences in tax liabilities for new versus used vehicles.

The first three columns of Table 2.7 present the marginal effects of a model that excludes households with one or no vehicles. For most households, the marginal utility from their first vehicle is likely larger than the marginal utility from any subsequent vehicle. As a result, households with more than one vehicle may be more sensitive to motor vehicle wealth taxes. The results in Table 2.7 suggest that this may indeed be the case. The marginal effects on all three motor vehicle wealth tax measures are statistically

significant at the ten-percent level or better in this specification. Although the marginal effect of the presence of a wealth tax declines in this specification, the magnitude of the marginal effect on the wealth tax ratio variable increases in terms of absolute value and the difference in wealth tax liabilities becomes statistically significant. These results suggest that households with more than one vehicle are less likely to purchase a vehicle when faced with greater relative and absolute differences in tax liabilities of new versus used vehicles. However, the marginal effect on the wealth tax difference variable is very small. A \$100 increase in the difference between the ten-year present value stream of tax liabilities for a new and used vehicle would decrease the probability these households purchase a vehicle by only 0.27 percentage points.

As mentioned above, the tax liabilities created using the Honda Accord may not be representative of the average vehicle since the Accord tends to retain its value over a longer period of time. Therefore, the final robustness check uses alternative continuous wealth tax measures created using the Ford Taurus as the representative vehicle. The results of these models suggest that the results of the baseline model are robust to the use of an alternative representative vehicle. Although the marginal effect for the Ford Taurus wealth tax difference measure is statistically significant, it has little economic significance as a \$300 increase in the difference in tax liabilities would be required to decrease the probability that the average household purchases a vehicle by even one percentage point.

Analysis of the Household Vehicle Age Decisions

The results of this analysis have thus far established that household vehicle purchase decisions are indeed affected by the presence and structure of motor vehicle wealth taxes. Therefore, the next objective of the analysis is to model the effects of motor vehicle wealth taxes on the age of vehicles purchased in 2001. The sample used to model vehicle age includes the 5,656 households that purchased at least one vehicle in 2001 and provided complete records of data for necessary variables. Table 2.8 presents the results of multivariate OLS regression models of vehicle age. In each model, the dependent variable is the average age of vehicles purchased by households in 2001; however, each model includes a different measure of the motor vehicle wealth tax. The control variables include household demographics and composition, public transportation and transaction tax rate variables. Overall the baseline models perform fairly well. Each model is capable of explaining over 17 percent of the variation in average vehicle age. The results of F tests strongly reject the hypothesis that the coefficients in each model are jointly equal to zero. In fact, a large majority of coefficients are statistically significantly different from zero in each of the models and the results tend to be consistent across the various specifications of the wealth tax. However, each of the motor vehicle wealth tax variables fail to be statistically significant, suggesting that wealth taxes do not have a significant effect on households' vehicle age decisions. This result is unsurprising given the vehicle age distributions in Figure 2.1.

The largest effects in each of these models appear on the life cycle and MSA dummy variables. For example, households that have reached the retirement phase of life

purchase vehicles that are roughly one and a half years younger than the vehicles purchased by households whose youngest child is of driving age. Households with no children or with a youngest child below the age of 16 also purchase vehicles that are younger than households with a youngest child between the ages of 16 and 21 do. Households not living in an MSA purchase vehicles that are approximately two years older than the vehicles purchased by households in the largest MSAs with a heavy transit system, all else constant. Households living in smaller MSAs also purchase older vehicles.

Households that own their own homes, have higher incomes, drive further distances to work, do not use public transportation and have fewer members tend to purchase newer vehicles on average. Households where the survey respondent is white, older and has a college education are more likely to purchase newer vehicles.

Tables 2.9 through 2.12 present the results of various models estimated to test the robustness of the baseline specification. The first set of results reported in Table 2.9 is from a model that adds additional explanatory variables to the baseline specification in a parallel fashion to Table 2.6 above. The addition of the estimated number of miles the household intends to drive the purchased vehicle(s), average vehicle age, and total annual miles traveled significantly improves explanatory power. Each of these models explains over 25 percent of the variation in the purchase age of vehicles; however, the inclusion of the additional variables results in a large reduction in the sample size as many observations are missing data for one or more of these variables. Although the wealth tax variables remain insignificant, the statistical significance of a few variables does in fact

change between model specifications. However, once again further investigation reveals that many of these changes are due to the drastic reduction in the sample size rather than to the addition of new variables.

Interestingly, in all three specifications both the state and local transaction tax rates are statistically significant. However, the economic significance of changes in transaction tax rates on vehicle age is rather small. Increasing the state transaction tax rate in the household's state of residence in the wealth tax dummy variable model by one percentage point would only increase vehicle age by approximately 0.24 years or roughly three months. Increasing the average local transaction tax rate in the household's state of residence by one percentage point would only increase vehicle age by 2.28 months. These small increases in vehicle age that would result from changes in transaction tax rates are unlikely to have significant effects on emissions levels. It is unlikely that the emissions of a vehicle that is one year and three months old would differ dramatically from the emissions of a vehicle that is only one year old.¹⁶

Unlike the results of the vehicle purchase model, the coefficients on the wealth tax measures in the vehicle age models are unaffected by the inclusion of a control for a fourth quarter purchase as reported in the final three columns of Table 2.9. The coefficients on the dummy variable that indicates whether the household purchased at least one vehicle in the fourth quarter of 2001 are negative and highly statistically significant. Households that purchase vehicles in the fall select vehicles that are roughly half a year younger than households that purchase a vehicle during the rest of the year, all

¹⁶ Although these vehicles are likely to be of different model years, CAFÉ and emission standards rarely change dramatically from year to year. In addition, three extra months of wear and tear on the emission control system is unlikely to have a significant affect on emissions.

else constant. However, the coefficients on all three specifications of the wealth tax remain statistically insignificant.

Intuitively, vehicle age decisions for households with more than one vehicle may be more sensitive to motor vehicle wealth taxes than those for households who own only one vehicle. Households with only one vehicle may rely solely on this vehicle for their transportation needs; therefore, they are probably more likely to purchase a more reliable, newer vehicle. Thus the status of motor vehicle wealth taxes in their state of residence may be less of a factor in their vehicle age decisions. However, wealth taxes may be a stronger factor in the decision process of households with two or more vehicles. As long as these households have at least one reliable vehicle, they may be more willing to purchase an older second vehicle to avoid paying higher motor vehicle wealth taxes. To test this hypothesis the model is estimated using only the households that report owning more than one vehicle. The first set of results in Table 2.10 reports the coefficients from these models. Once again the results are robust to those presented in Table 2.8; the coefficients on the wealth tax measures remain statistically significant.

The final columns of Table 2.10 report the results of vehicle age models that use wealth tax measures that I created using the Ford Taurus as the representative vehicle. The coefficients on the wealth tax measures remain statistically insignificant, which suggests that the conclusions of the baseline model are robust to the selection of the representative vehicle.

Table 2.11 presents the results of the final robustness checks of the vehicle age linear regression model. The first three columns of results are from models that use the

vehicle as the unit of analysis. To accomplish this, the data set is adjusted to allow each vehicle that was purchased in 2001 to be its own observation in the data. Thus the dependent variable in the model becomes the respective vehicle's age instead of the average age of vehicles purchased by its respective household. The estimation technique used for these models allows for possible heterogeneity across households.¹⁷ As with all other robustness checks the results of these models are consistent with the results in Table 2.8. In other words, using vehicles as the unit of observation did not change the fact that the wealth tax variables fail to significantly affect vehicle age.

The exclusion of households that failed to purchase a vehicle in 2001 in the vehicle age model may bias the coefficients of the ordinary least squares regression model. Households that failed to purchase a vehicle in 2001 may have been more likely to purchase vehicles in certain age groups. The final three columns of Table 2.11 report the results of a two-step Heckman selection model that controls for any selection bias that may occur. The specification of the model is such that the selection equation is the household's vehicle purchase decision and the regression equation models the vehicle age decision. The instrument used to identify the model is the count of drivers in the household. After controlling for the age of the drivers in the household, the actual number of drivers is unlikely to affect household vehicle age decisions. However this variable is expected to affect vehicle purchase decisions as a larger number of drivers leads to the need for more vehicles regardless of the age of the drivers. This variable proves to be a sufficient instrument as it is highly statistically significant in the probit

¹⁷ The model is estimated in Stata and employs the robust cluster option that specifies that the Huber/White/sandwich estimator of variance is to be used allowing observations (vehicles) to be dependent within groups (households).

model but fails to be significant in the regression model. Again the results are robust for the wealth tax measures. The coefficients on all three measures remain insignificant. In fact, the lack of statistical significance for the coefficient on the inverse mills ratio suggests that sample selection bias is not a concern in the vehicle age model.

Figure 2.1 reveals that the largest difference between the vehicle age distributions of vehicles purchased by NHTS households in 2001 by wealth tax status occurs for new vehicles. Households in non-wealth tax states are 1.05 times more like to purchase a new vehicle than households in wealth tax states; however, the remainder of the vehicle age distribution is very similar across wealth tax status. Thus the results of the linear regression model of vehicle age may fail to reveal the complete effects of motor vehicle wealth taxes on the decision to purchase a new vehicle. The first three columns of Table 2.12 present results from a probit model of the household's decision to purchase a new versus used vehicle. The dependent variable in the model takes a value of one for households that purchased at least one new vehicle in 2001. After controlling for the effects of the other explanatory variables, the motor vehicle wealth tax measures fail to affect the probability that a household chooses to purchase a new vehicle versus a used vehicle. The results of the Heckman probit model suggest that these results are again robust to controls for sample selection bias.

Conclusions Regarding the Effects of Motor Vehicle Wealth Taxes on Household Vehicle Purchase and Age Decisions

The results presented in this portion of the analysis indicate that motor vehicle wealth taxes have a statistically significant but rather modest effect on the probability that a household purchases a vehicle in a given year. Households' vehicle purchase decisions are responsive not only to the presence of a motor vehicle wealth tax but also to the relative tax treatments of new and used vehicles. The presence of a motor vehicle wealth tax decreases the probability that a household purchases a vehicle by nearly 4.6 percent, all else constant. The ratio of tax liabilities is highly statistically significant. These results are fairly robust to various specifications of the model and to the use of an alternative representative vehicle.

Contrary to the proposed hypothesis, motor vehicle wealth taxes appear to have no significant effects on vehicle age. All three wealth tax measures failed to be statistically significant in the baseline model as well as all alternative specifications of the model. However, this result alone does not provide conclusive evidence that motor vehicle wealth taxes have no effects on vehicle age distributions. Wealth taxes may have an indirect effect on vehicle age through their influence on households' vehicle purchase decisions. As households delay the purchase of a vehicle their current vehicles continue to age. If this process continues for several years in a row, the overall effect on vehicle age distributions could be quite dramatic when even a modest effect is aggregated across households in a state. Unfortunately, the NHTS data used in this analysis do not capture specific details of vehicle transactions such as information on whether the transaction represented a vehicle replacement or an overall addition to the household's stock of

vehicles. There is at least a possibility that the purchases recorded for households in wealth tax states represent trade-ins of newer, more valuable vehicles for older, less valuable vehicles. An analysis of vehicle age distributions by state is necessary to capture these potential indirect effects. Thus far, the analysis has focused on the effects of motor vehicle wealth taxes on recently purchased vehicles; however, an analysis of the entire vehicle age distribution is necessary to identify the complete effects of these taxes on vehicle age.

Chapter 3

Effects of Motor Vehicle Wealth Taxes on Vehicle Age Distributions

Introduction to the Analysis of Vehicle Age Distributions

Motor vehicle wealth taxes were found to have a statistically significant effect on households' vehicle purchase decisions in the analysis of the previous chapter. The objective of this portion of the analysis is to determine whether this effect significantly affects vehicle age distributions. State vehicle age distributions are modeled using vehicle registration data from R.L. Polk and Company that provide an aggregate count of vehicles by age for each state. The empirical analysis uses a multinomial logit model to estimate the effects of motor vehicle wealth taxes on the proportion of vehicles in each age group. Simulations are used to identify the effects of changes in motor vehicle wealth tax regimes at the national and state level.

The chapter begins with a description of the Polk data used in the analysis. I then present descriptive statistics used to motivate the multivariate empirical model. I then review the multinomial logit model before presenting the main results of the analysis. The chapter concludes with a discussion of results from alternative specifications of the model that use the ratio and difference measures of the motor vehicle wealth tax to test the robustness of the baseline model.

Data Used to Model Vehicle Age Distributions

The data I used to construct vehicle age distributions are from the 2001 National Vehicle Population Profile maintained by R.L. Polk & Company which represents a quarterly census of all registered cars and light duty trucks in the U.S. As of 2001, there were over 209 million vehicles registered throughout the lower continental United

States.¹⁸ However, I excluded light duty trucks from the analysis due to a lack of data on wealth tax provisions for commercial vehicles.¹⁹ This leaves 129,266,768 cars, or 61.71 percent of the national vehicle fleet for use in this analysis.

The original data file contained aggregate counts of vehicles by state in 30 different model year categories, ranging from brand new vehicles to vehicles that are 30 years of age or more. However, I condensed vehicle counts to 25 age categories to facilitate the construction of vehicle age distributions that meet the requirements of the mobile source emissions model to be described in the next chapter. After reconstruction, the brand new vehicle age category consisted of both 2002 and 2001 model year vehicles, while vehicles with model years of 1977 or earlier are lumped into a 25 plus age category. From these data, I constructed state vehicle age distributions by dividing the count of vehicles in each age category by the total number of vehicles.

The motor vehicle wealth tax data used in the analysis discussed above was also used to supplement the Polk data. Thus, there are three different motor vehicle wealth tax measures in the data. The first is a dummy variable that takes a value of one if the state had an annual tax on motor vehicles in 2001. The second is a ratio of the present value of a ten-year stream of tax liabilities for a new 2001 Honda Accord versus the present value of a ten-year stream of tax liabilities for a used 1998 Honda Accord. The third measure represents the absolute difference between these tax liabilities. Merging

¹⁸ Hawaii and Alaska are excluded from the analysis as the supply of both new and used vehicles may be affected by their isolated locations.

¹⁹ To be sure, passenger cars may also be registered as commercial vehicles, but the utility of light-duty trucks increases their probability of commercial registration. As it is impossible to distinguish between private and commercial registrations in the Polk file, the best course of action was to eliminate light-duty vehicles from the analysis. Recent strong sales of sports utility vehicles and the findings of Pickrell and Schimck (1998) suggest that the exclusion of light-duty vehicles may slightly bias vehicle age distributions towards older vehicles.

these variables with Polk's vehicle registration data provides several advantages over the analysis of the National Household Transportation Survey data. Vehicle registration data allow for the identification of the effects of motor vehicle wealth taxes on entire vehicle age distributions for the lower 48 continental states; whereas, the analysis of the NHTS data was restricted to only a subset of vehicle fleets in only 36 states. The analysis of the NHTS data was also limited to a set of vehicles recently purchased by a sample of households; whereas, the Polk data allow for an analysis of every single vehicle registered in the United States as of July of 2001.

To complete the analysis, I collected additional data from a variety of sources. I obtained state and local sales tax data from the 2001 U.S. Master Sales and Use Tax Guide. I collected economic indicators including gross state product, income per capita and average unemployment rates by state for 2001 from the Bureau of Economic Analysis and the Bureau of Labor Statistics. I obtained state demographic data from U.S. Census Bureau. Finally, I collected variables reflecting the demand and use of motor vehicles from a variety of sources. A complete list of variables used in this portion of the analysis as well as their sources appears in Table 3.1. I discuss the details regarding these additional variables, as well as their use in the model, in the text below.

Motivating Statistics

Table 3.2 provides a count and average age of vehicles in 2001 by state and wealth tax status. Approximately 50 percent of the nation's 129.3 million vehicles were registered in wealth tax states as of 2001. As expected, states with larger populations had larger vehicle counts. California's vehicle fleet represented 11.20 percent of the national

fleet, while Wyoming's fleet represented only 0.13 percent. The national average vehicle age was 9.58 years; however, vehicles in wealth tax states were slightly older than vehicles in non-wealth-tax states with a mean age of 9.71 versus 9.46. The variation in vehicle age was also slightly larger in wealth tax states. However, the range of average vehicle age was very similar for the two groups. Average fleet age in wealth tax states ranged from 8.76 to 11.69 while the range for non-wealth-tax states was 8.74 to 11.71.

Figure 3.1 shows the average distribution of vehicles across age categories by wealth tax status. Only modest differences exist for much of the vehicle age distribution. In fact, the differences between these distributions are only one-tenth of a percentage point or less for age categories 5 through 24. States without motor vehicle wealth taxes have on average a larger fraction of vehicles in each of the first four age categories. The largest discrepancy occurs for two-year old vehicles where the fraction of vehicles in non-wealth-tax states is 7.2 percent larger than the fraction of vehicles in this category for wealth tax states. The remaining differences over this range are at least a quarter of a percentage point higher in favor of non-wealth-tax states. At the opposite end of the distribution, vehicles in wealth tax states are more likely to be in the 25 and older age category. On average, the fraction of vehicles in this group is 18.42 percent larger in wealth tax states than the fraction for non-wealth-tax states. Thus, the difference in the mean vehicle age for wealth tax versus non-wealth-tax states is a result of deviations in the distributions that occur in the tails.

Table 3.3 presents state summary statistics by wealth tax status for a large number of factors that may also affect vehicle age distributions. The tax portfolios of 58 percent

(or 28 states) of the states used in this analysis include some form of a motor vehicle wealth tax. The average ratio and difference of new versus used wealth tax liabilities for the Honda Accord in wealth tax states were 1.72 and \$558.31 respectively in 2001. Statistics reported in Table 3.3 reveal that on average wealth tax and non-wealth-tax states differed in several respects as of 2001. A smaller percentage of the population in wealth tax states lived in a metropolitan statistical area or in areas with motor vehicle inspection/maintenance programs. Wealth tax states also tend to have lower state and average local sales tax rates. The gross state product, personal income, and public transportation trips per capita are also lower in wealth tax states. Table 3.4 presents similar statistics using vehicles as the unit of observation. A more thorough analysis of the statistics in these tables is left to the reader.

The modest age differences that exist across state fleets by wealth tax status suggests that motor vehicle wealth taxes have few consequences on state vehicle age distributions. However, the statistics presented thus far fail to control for the effects other factors may have on vehicle age. Factors related to the economic well being, demographic composition, and automobile demand and use in a state such as those summarized in Table 3.3 may also have significant effects on the state's vehicle age distribution. If any of these factors are also correlated with the use of motor vehicle wealth taxes, the preliminary conclusion suggested by these basic statistics that wealth taxes do not have major effects on vehicle age could be biased. To be sure, a multivariate regression strategy is required to isolate the effects of motor vehicle wealth taxes on vehicle age distributions.

Overview of the Multinomial Logit Model

The multivariate regression strategy of choice for this analysis is the multinomial logit model (MNL). The multinomial logit model is the most frequently used model for nominal dependent variables. A variable is considered to be nominal if it consists of discrete outcomes whose categories cannot be ordered. Classic examples of nominal outcomes include occupation and mode of transportation decisions made by individuals. Examples of nominal outcomes in the vehicle choice literature include decisions regarding vehicle type and ownership levels (i.e. the number of vehicles a household chooses to own). For specific examples see Johnson (1978) and Manski and Sherman (1980).²⁰ Vehicle age may also be viewed as a nominal outcome as owners must choose a vehicle of either one age or another. Although age categories could certainly be ordered from youngest to oldest, not all owners would agree that newer vehicles are necessarily better in all respects.²¹

Given that the objective of this portion of the analysis is to model the effects of motor vehicle wealth taxes on the fraction of vehicles in each age group, it is convenient to derive the multinomial logit model as a probability model.²² The probability that a vehicle selected at random from a state's fleet is of a particular age is equal to the fraction

²⁰ For other applications of the multinomial logit model see Hensher (1986), Schmidt and Strauss (1975) and McFadden (1974).

²¹ Some researchers may argue that an ordered regression model should be used. However, estimated coefficients are biased when an ordered model is used on a nominal variable, while the consequence of the use of a nominal model on an ordered variable is a loss of efficiency. Long (1997, p.149) argues that when the nature of the variable is in doubt the MNL should be used to avoid biased coefficients.

²² The discrete choice model could also be used to derive the model. The discrete choice model assumes that an individual will choose an outcome that maximizes the utility gained from that choice. Therefore if the utility of holding a vehicle of a particular age is U_j , the probability of outcome m is equal to the $\Pr(U_m > U_j \text{ for all } j \text{ not equal to } m)$. The MNL is obtained if utility is then set equal to $\mathbf{x}_i\boldsymbol{\beta}_m + \boldsymbol{\varepsilon}_{im}$. McFadden (1973) proved that the MNL results if and only if the error terms are independent and have a type I extreme-value distribution.

of vehicles that are in that respective age category in the state. Therefore, let y denote vehicle age with 25 possible outcomes, where outcomes 1 through 24 correspond to vehicle age in years and outcome 25 represents vehicles that are 25 years of age or older. Let $\Pr(y = m | \mathbf{x})$ be the probability of observing a particular age outcome, m , given a vector of explanatory variables $\mathbf{x}$. A distinguishing feature of the MNLM is that it assumes that $\Pr(y = m | \mathbf{x})$ is a function of the linear combination $\mathbf{x}\boldsymbol{\beta}_m$, where the vector $\boldsymbol{\beta}_m$ includes an intercept and coefficients for each of the independent variables that are unique for each outcome m . For example the coefficient for the effect of a motor vehicle wealth tax on the probability that a vehicle is two years old is different from the coefficient for the effect it has on the probability that a vehicle is ten years old.

Several adjustments must be made to the probabilities before the model can be considered complete. First, the fraction of vehicles in each age category must be nonnegative; therefore, it is necessary to take the exponential of $\mathbf{x}\boldsymbol{\beta}_m$. To ensure that each vehicle falls into at least one of the twenty-five age categories, it is necessary to divide $\exp(\mathbf{x}\boldsymbol{\beta}_m)$ by the sum of $\exp(\mathbf{x}\boldsymbol{\beta}_j)$ across all age outcomes, which are indexed by j . Thus the probability that a vehicle is in a particular age category is equal to:

$$\Pr(y_i = m | x_i) = \frac{\exp(x_i \beta_m)}{\sum_{j=1}^J \exp(x_i \beta_j)} \quad 3.1$$

However this specification allows for more than one set of coefficients to generate the same probabilities of observed vehicle age outcomes. Therefore some sort of constraint must be imposed in order to identify the model. The most common constraint is to

assume that $\beta_1 = \mathbf{0}$, or in other words set the coefficient for the effect of each independent variable on the probability that a vehicle is brand new equal to zero. The probability that a vehicle is brand new then becomes:

$$\Pr(y_i = 1 | x_i) = \frac{1}{1 + \sum_{j=2}^J \exp(x_i \beta_j)} \quad 3.2$$

Estimation of the multinomial logit model is straightforward using maximum likelihood techniques. Assuming observations are independent, the likelihood equation is

$$L(\beta_2, \dots, \beta_J | y, X) = \prod_{i=1}^N p_i \quad 3.3$$

where p_i is the probability of observing the value of y that was actually observed for the i th observation. Substituting equation 3.1 for p_i gives:

$$L(\beta_2, \dots, \beta_J | y, X) = \prod_{m=1}^J \prod_{y_i=m} \frac{\exp(x_i \beta_m)}{\sum_{j=1}^J \exp(x_i \beta_j)} \quad 3.4$$

where $\prod_{y_i=m}$ is the product over all cases for which $y_i=m$. The Newton-Raphson method then estimates the coefficients using the log of the likelihood equation.

Unfortunately the coefficients estimated by the multinomial logit model provide little information regarding the effects of the independent variables on vehicle age outcomes. For example, given the identifying constraint that $\beta_1=0$, the coefficient β_{km} represents the effect of a unit change in x_k on the logit of outcome m relative to new vehicles holding all other variables constant. This definition lacks real usefulness, as it is

often difficult to convey the meaning of a change in the logit of two outcomes.

Therefore, this analysis must rely on other forms of interpretation.²³

Generating predicted probabilities is perhaps the simplest method of interpretation. Probabilities that each of the 25 age outcomes are observed can be calculated using equations 3.1 and 3.2, the respective coefficients for each age outcome generated by the model and the mean values of the independent variables. A graph of these probabilities provides an illustration of the vehicle age distribution estimated by the model. To identify the effects of an individual variable, this procedure is repeated after some desired discrete change has been made to this variable holding all else constant. Graphing both distributions would then reveal the effects of this variable on fleet age.

Measures of discrete change in probabilities are also an effective method for interpreting the results of a multinomial logit model.²⁴ A discrete change in probabilities is defined as the change in the predicted probability when x_k changes from a start value of x_s to an end value of x_e , or in other words:

$$\frac{\Delta \Pr(y = m \mid x)}{\Delta x_k} = \Pr(y = m \mid x, x_k = x_e) - \Pr(y = m \mid x, x_k = x_s) \quad 3.5$$

Changing the value of x_k from 0 to 1 identifies the effect of a dummy variable on the probability that a particular age outcome is observed. The effects of continuous variables

²³ The MNLM requires the independence of irrelevant alternatives (IIA) in order to estimate unbiased coefficients. This assumption requires that the relative probabilities for each pair of outcomes remain constant regardless of which outcomes are included in the choice set.

²⁴ Although marginal effects are often a popular method of interpreting empirical results, Long (1997, p166) discourages their use in conjunction with the multinomial logit model. Unlike the discrete changes in probabilities, the sum of the marginal effects across outcomes is not restricted to sum to one, which is counterintuitive given that an observation falls into only one category of the dependent variable. The value as well as the sign of a marginal effect may change with the value of x_k , further decreasing its attractiveness.

are calculated by allowing the variable to change by a single unit or by a standard deviation centered at the mean. A thorough analysis includes 25 discrete change measures (one for each age outcome) for each independent variable. Computing the average absolute discrete change summarizes these changes. This measure is derived as:

$$\bar{\Delta} = \frac{1}{J} \sum_{j=1}^J \left| \frac{\Delta \Pr(y = j | x)}{\Delta x_k} \right| \quad 3.6$$

where the absolute value is required since the sum of discrete changes in probabilities across all outcomes is necessarily zero.

Although the discrete change in probabilities is a convenient method for interpreting the effects of independent variables in the MNLM, it does have some limitations. Due to the nonlinearity of the model, the discrete change values are dependent upon the start value of x_k , the magnitude of the change and the values at which the other independent variables are held constant. Second, measures of discrete change fail to capture the dynamics among the dependent outcomes. For example, the discrete change method may indicate that the presence of a wealth tax increases the probability of both a new and two-year old vehicle when the more relevant question may be how the wealth tax increases the relative probability of new versus two-year-old vehicles.

A measure of the ratio of the relative risk of the two outcomes provides the answer to this question. The relative probability (i.e. the relative risk) that a vehicle is two years of age relative to being brand new is:

$$\frac{\Pr(y = 2)}{\Pr(y = 1)} = \exp(\mathbf{x}\beta_2) \quad 3.7$$

The ratio of the relative risk for a one-unit change in x_i is then:

$$\frac{\exp(\beta_{i2}x_1 + \dots + \beta_{i2}(x_i + 1) + \dots + \beta_{k2}x_k)}{\exp(\beta_{i2}x_1 + \dots + \beta_{i2}x_i + \dots + \beta_{k2}x_k)} = \exp \beta_{i2} \quad 3.8$$

Thus the relative risk ratio for outcome m given a one-unit change in an independent variable is equal to the exponential value of the coefficient. This result can also be interpreted as the expected change in the odds of outcome m relative to the base category (new vehicles) for a unit change in x_i holding all other variables constant. For dummy variables the relative risk ratio of outcome m relative to the base category is calculated as:

$$\frac{\left[\frac{\Pr(y = m)}{\Pr(y = 1)} \right]_{DummyVariable=1}}{\left[\frac{\Pr(y = m)}{\Pr(y = 1)} \right]_{DummyVariable=0}} \quad 3.9$$

The relative risk ratio does not depend on the level of the variable of interest or on the level of any other independent variable which makes it an attractive measure for interpretation. However, all three measures of interpretation are included in the discussion that follows. For further details regarding the derivation, estimation and interpretation of the multinomial logit model see Long (1997, Chapter 6) and Greene (2000, pp. 859-862).

I estimate three separate multinomial logit models for this analysis as described above. The baseline model includes a dummy variable indicating whether or not the state had some form of a motor vehicle wealth tax. I then estimate additional models that

include the ratio and difference in new and used wealth tax liabilities for a Honda Accord to test the robustness of the baseline model.

The estimation procedure requires the expansion of the original Polk data file such that each of the 48 states has one line of data for each of the 25 possible age outcomes. The estimation of each of these models uses frequency weights equal to the number of vehicles from a state's fleet that are in each respective age category. I have corrected the standard errors estimated by the model for heteroskedasticity using a robust standard errors option that is similar to White's correction.²⁵ I merged numerous state-level independent variables related to the economic well being, demographic composition, and automobile demand with the Polk data to isolate the effects of motor vehicle wealth taxes on vehicle age distributions. I included three measures of economic well being (gross state product per capita, personal income per capita and the state average unemployment rate) in the model to control for the fact that on average residents in states with better economic conditions can afford newer vehicles. I used state demographic variables in the model include measures of race, education, age, household size and home ownership. I also included state and local average sales tax rates.

I have also included several variables that influence the demand for motor vehicle transportation in the model. These variables include average gas prices, public transportation trips per capita, and total miles driven per household. To some extent,

²⁵ The model was also estimated using a robust cluster option that relaxes the assumption that the error terms within a group (i.e. state in this analysis) are independent to control for heteroskedasticity. Given that the variables on the right-hand side of the model are identical within a group, the fixed effect nature of the robust cluster option results in coefficients that fail to be statistically significantly different from zero.

each of these variables may affect state vehicle age distributions. Higher gas prices may increase the demand for newer, more fuel-efficient vehicles.²⁶ The availability and frequent use of public transportation as an alternative mode of transportation may result in older vehicle fleets, as households are likely to be less reliant upon their vehicles. Vehicle fleets in states with higher average total miles traveled per year by household experience more wear and tear and as a result may have a more rapid turnover.

Inspection and maintenance programs are frequently included as part of state strategies to decrease emissions from motor vehicles and improve air quality. Most of these programs require either annual or biennial tests of the performance of the emissions control systems of all vehicles registered in the region. Older vehicles are more likely to fail these tests due to less sophisticated or deteriorating emissions control systems. Owners of vehicles that fail to pass these tests must either make repairs necessary to meet emissions standards or must salvage their vehicles.²⁷ As a result of this additional ownership cost, households in areas with I/M programs may be less likely to own older vehicles. To control for this possibility, I included a variable that measures the fraction of a state's population that lives in an area with mandatory inspections in the model.

It is entirely possible that weather conditions in various regions of the country also affect vehicle age distributions. Vehicles in states that use larger amounts of road salt during the course of a winter may age prematurely as a result of corrosion caused by

²⁶ Newer vehicles are more fuel-efficient, all else constant, as the National Highway Traffic Safety Administration periodically increases the Corporate Average Fuel Economy (CAFE) standards. For an overview of the CAFE standards see www.nhtsa.dot.gov/cars/rules/CAFE/overview.htm.

²⁷ For more information on Inspection/Maintenance Programs see the information provided by the Environmental Protection Agency at www.epa.gov/otaq/im.htm.

the salt. According to a report by the Transportation Research Board (1991), states throughout the U.S. use nearly 10 million tons of salt each year as part of their deicing strategies. Over 50 percent of deicing salt is applied to roadways in states in the New England and Great Lakes regions, where average annual salt loading rates are 15.23 and 9.36 tons per lane mile respectively.²⁸ In an attempt to control for the effects of regional weather conditions, I included a set of regional dummy variables in the model. I defined the region dummies to correspond to the regions used in the report by the Transportation Research Board (1991). The Great Lakes region serves as the reference category in the model given its frequent use of road salt and relatively large fraction of the nation's vehicle fleet. Of course, these regional dummy variables also serve to control for any unobservable factors that are correlated across states within a region that affect vehicle age distributions. Again, Table 3.1 provides a complete list of the independent variables used in the model as well as their definitions and sources.

An Overview of the Multinomial Logit Model Results

The discussion that follows analyzes the results of three separate multinomial logit models of vehicle age. The primary focus of the discussion is on the results from the baseline model that includes a wealth tax dummy variable. Results of separate models that include a ratio and difference of tax liabilities between new and used vehicles as measures of the wealth tax are briefly presented to highlight the robustness of the baseline model. Estimating these models is mathematically straightforward; however, the nonlinearity of the multinomial logit model makes interpreting the results quite

²⁸ For additional details regarding the official salt use policies in various states see Transportation Research Board (1991)

challenging. A large number of outcomes further adds to the complexity of identifying the effects of individual variables on the distribution of vehicles across age outcomes. The model I used in this analysis contains 25 dependent categories and 27 explanatory variables. As a result each model provides estimates for 672 parameters. I illustrate the effects of motor vehicle wealth taxes and other factors on vehicle age distributions by analyzing calculations of predicted probabilities, discrete changes and relative risk ratios. Simulations designed to identify the effects of changes in the use and structure of motor vehicle wealth taxes on vehicle age distributions also facilitate the interpretation of the estimated parameters.

Basic Results of the Model

The coefficients of the multinomial logit model of vehicle age are reported in Table 3.5. The independent variables used in the model are all highly statistically significant in determining vehicle age. The vast majority of the variables are statistically significant at the one-percent level or better for each of the vehicle age outcomes as indicated by the lack of bold type or asterisk.²⁹ The presence of a wealth tax on motor vehicles has a statistically significant effect on the distribution of vehicle age holding all other variables constant. The coefficient on the wealth tax dummy variable is significant at the one-percent level for all outcomes except ten-year-old vehicles. Coefficients that are not statistically significant are limited to only nine independent variables and are scattered across age outcomes. Median age, home ownership rate, region 2 and region 8 coefficients are more likely not to be statistically significant. However, no real patterns

²⁹ Given the extremely large number of observations used in the model (129,266,768), it is not surprising that the model is very efficient.

seem to emerge in terms of effects on vehicle age. Determining whether a variable has no effect on the vehicle age distribution requires a test that all 24 of its coefficients are simultaneously equal to zero. Results of separate Wald tests indicate that the hypothesis that the coefficients associated with each of the independent variables are simultaneously equal to zero is rejected at the 0.01 level for all twenty-seven variables.³⁰

Each coefficient represents the expected change in the logit of outcome m versus the base outcome, new vehicles, for a unit change in the independent variable. For example, a one-year increase in a state's median age would decrease the logit of two-year old vehicles to new vehicles by -0.074 . The coefficients on the other independent variables have similar interpretations. However, this interpretation of the results is unsatisfactory since it is difficult to convey the meaning of a change in the log of the odds. Other methods of interpretation are explored below in order to determine whether the variables that were found to be statistically significant also have economically significant effects on vehicle age distributions.

The prevalence of coefficients that are statistically significant in the model may suggest that the model is an excellent predictor of vehicle age distributions. In fact a chi-squared test of all coefficients indicates that the model is highly statistically significant. However various other measures of goodness of fit do not provide strong support for this claim. McFadden's adjusted R^2 has a value of 0.0024 for this model, which suggests little improvement over a model that includes only an intercept. The adjusted count R^2 ,

³⁰ According to Long and Freese (2003), the likelihood-ratio test is superior to the Wald test. However the computational costs of the LR test can be prohibitive for complex models such as the one estimated in this analysis. Considering that the LR and Wald tests are asymptotically equivalent, the LR test would likely lead to the same results reported here given the sample size.

which compares observed and predicted outcomes to evaluate the model, has a value of 0.004 suggesting only 0.4 percent of the observations have a correctly-predicted age outcome. However given the format of the data used to estimate the model, it is not entirely clear as to whether these measures of fit are appropriate representations of the performance of the model. Because the data include twenty-five observations with identical values for the independent variables for each state, the predicted probabilities of each age outcome are identical for all observations within each state.³¹

A more appropriate test of the performance of the model may be to compare the actual vehicle age distribution derived from the Polk data to the predicted vehicle age distribution estimated by the MNLM model. Figure 3.2 provides an illustration of both actual and predicted age distributions at the national level. Overall, the model does a good job of predicting the national vehicle age distribution. For the majority of age outcomes the difference between these distributions is very small. In fact the largest absolute value of their difference is less than 0.007 or approximately three-fourths of a percentage point. The largest differences occur for age outcomes between one and four years of age, which suggests that the predicted age distribution slightly favors older vehicles. Figures 3.3 and 3.4 provide a similar comparison for wealth tax and non-wealth-tax states respectively. Wealth tax states have a predicted vehicle age distribution that performs slightly better than that of non-wealth-tax states. Differences between these distributions are slightly larger for non-wealth-tax states. The largest absolute value of their differences is 0.007 for non-wealth-tax states and only 0.005 for wealth tax

³¹ A more traditional data set for the MNLM includes only one line of data for each individual. Thus it would be nearly impossible for any two observations to have identical values for the predicted probabilities of each outcome.

states. However, the overall patterns in the differences are the same for both figures, which suggests that any errors in prediction that occur are non-random. Similar errors will occur in the prediction of vehicle age distributions for wealth tax and non-wealth-tax states. As a whole these three figures suggest that the multinomial logit model estimated in this analysis is a fairly good predictor of vehicle age distributions.

Predicted Probabilities

Figure 3.5 shows predicted vehicle age distributions by wealth tax status. At first glance these distributions appear to be nearly identical. However, a closer inspection reveals differences in the proportion of vehicles in the newer age groups. These differences suggest that vehicle fleets in wealth tax states are slightly older than those in states without a wealth tax, which is consistent with the hypothesis of this analysis. The presence of a wealth tax on motor vehicles has little effect on the proportion of vehicles that are brand new. In contrast, the wealth tax appears to have at least some effect on the proportion of vehicles in used age groups. Vehicles in non-wealth-tax states are more likely to be between the ages of two and four, while a larger fraction of vehicles are between the ages of five and ten in wealth tax states. Figure 3.6 highlights the differences between wealth and non-wealth-tax states over this portion of the age distribution. Magnifying the differences does little to hide the fact that their magnitudes are very small. The largest difference in these fractions, 0.0031 (less than a third of a percentage point) occurs for two-year old vehicles. Thus while differences do exist between these age distributions, it is unlikely that they would lead to noticeable environmental consequences. Wealth and non-wealth-tax states have virtually the same

fraction of vehicles in each age group beyond the age of thirteen. This result is perhaps unsurprising considering that motor vehicle wealth taxes are generally phased out or reach a minimum for vehicles 12 years of age or older in most states and thus remove any tax incentive that may have existed to hold older vehicles.

National vehicle age distributions that would result from a uniform national tax policy further illustrate the effects of motor vehicle wealth taxes on fleet age in Figure 3.7. If all states were to impose some form of a motor vehicle wealth tax, the model simulates a national vehicle age distribution that is represented by the solid black line. On the other hand, if all forms of the wealth tax used across states were removed, the model simulates a national vehicle age distribution that is represented by the broken gray line. Differences between these distributions run counter to the hypothesis proposed by this analysis. Interestingly, under a uniform wealth tax policy a slightly larger fraction of vehicles would be brand new even though their owners would pay higher taxes relative to vehicles of other ages. However, the magnitude of this difference as well as those for the first 10 age groups is rather modest. The largest differences occur between the ages of 10 and 16 and the 25 plus age group. Vehicles are much more likely to be between the ages of 10 and 16 under a national wealth tax policy. The fraction of vehicles that are 15 years of age under the wealth tax policy is nearly 8 percent larger than the fraction of vehicles of this age under the no wealth tax policy. Moving from no tax to a wealth tax policy would also increase the fraction of vehicles that are 13, 14, or 16 years of age by 6 percent respectively. However such a move would decrease the fraction of vehicles in the older age categories. The magnitudes of these differences are quite a bit smaller with

the exception of vehicles that are 25 years old or older. A uniform policy to tax vehicles would result in a fraction of vehicles in this age group that is 16 percent smaller than the fraction that would result from a no tax policy. This result is interesting in that it suggests that the average age of vehicles in the nation might possibly increase if states removed their wealth taxes. Given this information, the effects of a move from a uniform wealth tax policy to a no tax policy (or vice versa) on emission levels remain ambiguous. Although the fraction of vehicles in older age groups increases under a no tax policy, emissions may not necessarily increase as these vehicles tend to be driven less often than are newer vehicles. Thus emission levels may be higher under the presence of the tax given the larger fraction of vehicles between the ages of 10 and 16.

Relative Risk Ratios

As mentioned above it is often useful to present relative risk ratios to assess the magnitudes of the effects of the independent variables due to the limitations of the discrete change calculations. Table 3.6 reports the relative risk ratios for the independent variables included in the model calculated using equations 3.8 and 3.9 and new vehicles as the reference outcome.³² The first line of this table presents the results for the wealth tax dummy variable. A value greater than one indicates that the relative risk of the respective age outcome versus a new vehicle is greater in the presence of a wealth tax and vice versa. For example, with a value of 0.96, the relative risk of a vehicle being two years old versus brand new is lower in wealth tax states than in non-wealth-tax states. In

³² The relative risk ratio results differ based on the reference group chosen. Thus there are 25 sets of different results that exist for this analysis. However, for the purposes of this analysis, new vehicles are likely the better reference group. Due to the rapid depreciation of vehicles in the first year, the wealth tax is likely to have its largest effect on the purchase of new vehicles relative to other vehicles and emissions for new vehicles are much smaller relative to emissions of vehicle of other ages.

other words, vehicles in wealth tax states have a higher probability of being brand new versus being two years old than do vehicles in non-wealth-tax states. In fact, the presence of a motor vehicle wealth tax decreases the odds of vehicle age outcomes two through nine and eleven relative to a new vehicle, which certainly contradicts the hypothesis of this analysis. However, the results indicate that the risk of outcomes 12 through 16 relative to new vehicles is higher in wealth tax states, which provides some support for the main hypothesis. Statistical significance of the coefficient on the wealth tax dummy for each of these age outcomes suggests that these relative risk ratios are statistically significantly different from one; however, these values have little economic significance. The odds that a vehicle is 15 years of age relative to one year of age are 1.05 times greater in wealth tax states, all else constant. Thus if the ratio of 15-year-old vehicles to one-year-old vehicles is 0.1 in non-wealth-tax states, this ratio would have a value of only 0.105 in wealth tax states. Interestingly, vehicles in wealth tax states have a lower risk of being in the oldest age groups relative to the risk of being a new vehicle. Given that wealth taxes are phased out entirely or reach their minima well before the age of 18, this result is certainly surprising. It may perhaps suggest that a variable that affects the distribution of vehicles in older age groups and that is correlated with motor vehicle wealth taxes has been excluded from the analysis. The statistical significance of the relative risk ratios mirrors that of the coefficient estimates. Since the coefficient on the wealth tax dummy fails to be statistically significantly different from zero for outcome ten, the corresponding relative risk ratio is not statistically different from 1.

Changes in average gas prices and the percent of the state's population that is between the ages of 15 and 21 have the largest effects on the odds ratios reported in Table 3.6. If the average gas price were to increase by one dollar (which would represent a very large increase), the odds of a vehicle being brand new versus being two years of age would change by a factor of 0.77. Thus the probability that a vehicle is brand new would increase relative to the probability that the vehicle is two years of age. The decreasing relative risk ratios across age outcomes suggest that increasing average gas prices increase the probability of a new vehicle versus an older vehicle at an increasing rate. Thus, increases in average gas prices would result in older, higher polluting vehicles being traded in for new vehicles. Increasing a state's 15 to 21 year old population increases the odds ratios of vehicles of all ages relative to new vehicles. The largest effect occurs for 14 and 15-year-old vehicles. If a state's young driver population were to increase by one percentage point the odds of 14 to one-year-old vehicles and odds of 15 to one-year-old vehicles would increase by a factor of 1.57. These results indicate that states with larger percentages of residents between the ages of 15 and 21 have vehicle age distributions that are skewed towards older vehicles, all else constant.

Relative risk ratios allow for the quick identification of variables that have little or no economically significant effects on vehicle age distributions. A relative risk ratio with a value of one indicates that changes in the independent variable would have no effect on the odds of the two outcomes. Thus even a quick glance at Table 3.6 identifies inspection/maintenance programs and per capita public transportation trips as variables with no economic effects on vehicle age. Other variables, such as race, education, home

ownership rates, MSA residency and total miles driven by households, have very little effect on vehicle age distributions as their respective relative risk ratio values deviate only slightly from one.

Discrete Changes in Probabilities

Table 3.7 contains estimates of the effects of discrete changes in individual variables on predicted probabilities calculated using equation 3.5 above. The first set of values in the table gives the discrete change in probabilities as the listed dummy variables change from zero to one. Holding all other variables at their means, the presence of a motor vehicle wealth tax actually increases the probability of owning a new vehicle by one tenth of a percentage point, a rather small effect yet one that contradicts the main hypothesis of this analysis. The presence of a wealth tax decreases the probability that a vehicle is between the ages of 5 and 7 and increases the probability that a vehicle is between the ages of 9 and 16. On average the wealth tax has little effect on vehicle age distributions as evidenced by the modest value (0.001517) of the average absolute change reported in column 1 of this table. By comparison the remaining dummy variables have larger effects on vehicle age than does the wealth tax. Location in region 9 (Pacific West) has the largest average absolute change with a value of 0.0089 percentage points. Vehicles located in this region are less likely to be in any of the first 14 age groups than are vehicles in the Great Lakes region (region 5, the reference category) holding all other variables constant. In fact, only vehicles in the South and Lower Plains (regions 4 and 6) are more likely to be in the first six age groups than are vehicles in region 5.

Table 3.7 also shows the effects of a one-unit increase in each of the six variables listed. Of these variables an increase in the average household size has the largest overall effect on vehicle age distributions as indicated by the larger value of the average absolute change. Increasing the average household by one additional member would increase the fraction of vehicles between the ages of one and four and decrease the fraction of vehicles between the ages of 6 and 11. The effect of average household size is largest on the probability of new vehicles, where the expected change of a one-unit increase is 2.4 percentage points.

Of the remaining variables in this set of results, median age and average gas price have the largest effects. The average absolute change for a one-unit increase is 0.0025 for median age and 0.0066 for the average gas price variable. Increasing the median age of residents in a state by one year would slightly increase the fraction of vehicles in the older age categories. As average gas prices increase across a state the demand for more fuel-efficient vehicles is expected to increase. The results reported in Table 3.7 support this hypothesis as a one-unit increase in the average gas price shifts the vehicle age distribution in favor of newer (and perhaps more fuel-efficient) vehicles.

An increase in both state and local sales tax rates has little effect on the distribution of motor vehicles across age outcomes. The average absolute change for a one-unit increase in each variable is below one-tenth of a percentage point. Interestingly, what little effects do exist appear to be in opposite directions. A one-unit increase in the state sales tax rate increases the probability that vehicles are in each of the first twelve

age groups, while an equal increase in the average local sales tax rate in the state decreases these probabilities.

Table 3.7 also reports the discrete change in probabilities of various age outcomes resulting from a one-standard-deviation change in the remaining variables used in the model. Of these variables, a change in per capita income has the largest average absolute effect on vehicle age distributions with a rather modest value of 0.0054. However, the individual effects across probabilities indicate that increases in per capita income result in older vehicle fleets which is certainly counter-intuitive. The fraction of a state's population that is between the ages of 15 and 21 also has a larger effect than the majority of variables in this set. Increasing the percentage of the population that is in this age group decreases the fraction of vehicles between the ages of one and eight years old as expected. The effect is largest for the first three age outcomes, which is also consistent with the theory that parents are less likely to purchase newer vehicles for younger drivers. As expected, increasing gross state product per capita increases the fraction of vehicles in newer age categories; however, the effects are again rather modest.

Effects of Wealth Taxes on State Vehicle Age Distributions

The discussion of the results has thus far been limited to an analysis of the effects of wealth taxes and other factors on national or hypothetical vehicle age distributions. Of much greater interest and importance are the effects on the age distributions of vehicle fleets in individual states. State and local governments determine motor vehicle wealth tax policies and design and implement plans to combat emissions. Therefore the results

of the model should be evaluated at the state level if they are to have any impact on policy.

Figures 3.8 through 3.15 provide vehicle age distributions for six states with the most severe ozone problems in the U.S. as classified by the Environmental Protection Agency.³³ I added Tennessee to this group due to the potential classification of several of its metropolitan statistical areas as non-attainment zones in the near future, but mostly for the more obvious reason. I also added Georgia due to recent proposals to remove or reduce its motor vehicle wealth tax and its continued air quality concerns in the Atlanta MSA. Included in each figure are three separate vehicle age distributions. The first is the state's actual vehicle age distribution as determined from the Polk data. The second is the predicted age distribution under the state's current wealth tax regime (i.e. wealth tax or no wealth tax) derived using the coefficients generated by the model and the state's respective values of the independent variables. The third is the vehicle age distribution that results after simulating a change in the wealth tax regime. Thus each figure identifies how well the multinomial logit model performs for individual states and identifies the effects of a wealth tax on the state's vehicle age distribution. Comparing the predicted wealth tax vehicle age distribution to the predicted non-wealth tax age distribution identifies the effects of motor vehicle wealth taxes, holding all else constant. A comparison of actual age distributions would fail to isolate the effects of motor vehicle wealth taxes.

³³ For a map of non-attainment areas, see the Environmental Protection Agency's *Air Trends* report available at www.epa.gov/airtrends/non.html. Several states such as Illinois and Texas had relatively small areas that were classified as non-attainment zones in 2002. However, these states do not have motor vehicle wealth taxes and thus could not potentially reduce emissions by removing the tax; therefore, they are not highlighted by this analysis.

A comparison of Tennessee's actual and predicted vehicle age distributions in Figure 3.8 reveals that the model fails to perform as well at the state level as it does at the national level. The model over-predicts the fraction of vehicles below the age of 12 and under-predicts the fraction of vehicles in older age groups. However, the magnitudes of the differences between the actual and predicted (i.e. status quo) age distributions are never more than half of a percentage point and the prediction follows the trends of the actual distribution. The effect on the age of the vehicle fleet of imposing a motor vehicle wealth tax in Tennessee is represented by the difference between the status quo age distribution and the distribution labeled "Change". If Tennessee were to impose an annual wealth tax on vehicles, the fraction of vehicles between the ages of 10 and 16 would increase by nearly a quarter of a percentage point for each age. This increase is countered by a reduction in the fraction of vehicles in the 17 plus age categories. The figure reveals few differences for the remaining age groups. As before, it is impossible to determine the effects of such a change on emissions given that change in tax policy does not unilaterally skew the vehicle age distribution in one direction or another.

California is an interesting case study due to recent discussions in the state legislature to further reduce or even remove the wealth tax on motor vehicles in the wake of the 1998 reduction in the wealth tax rate.³⁴ Figure 3.9 reveals that the model offers an accurate prediction of California's vehicle age distribution. A comparison of the status quo vehicle age distribution to the distribution that would result if the tax were completely removed indicates that very little change would occur in the fraction of

³⁴ In 1998, the state legislature enacted a 25 percent reduction in the motor vehicle wealth tax. The state legislature further reduced the tax in 2000 by implementing a 67.5 percent offset (California State Senate Republican Caucus, 2002).

vehicles in the first eleven age groups. Beyond the eleventh age group there are two main changes that occur. First, the fraction of vehicles between the ages of 12 and 16 would decrease. The largest decrease, 0.0036 percentage points, would occur for vehicles of the age of thirteen. The overall effect of this reduction on emissions depends upon how the vehicle age distribution adjusts to accommodate this change. The second major change that occurs in the age distribution as a result of the removal of the wealth is that the fraction of vehicles between the ages of 18 and 25 would increase. The largest increase, 0.0078 percentage points, occurs in the 25 plus age category, which is not surprising given the results presented thus far. The effect of removing the wealth tax on emissions remains ambiguous without information on the annual vehicle miles traveled for vehicles in these age groups.

The vehicle age distributions presented in the figures for the remaining six states tend to follow some general patterns.³⁵ The model fails to perform as well for the smaller states including Connecticut, Massachusetts, Maryland and Rhode Island. This is presumably due to the fact that these states contain a much smaller fraction of the national vehicle fleet. As a result, the multinomial logit model places less weight on these observations; therefore, they have less influence on the parameter estimates. The model performs much better for states that have a larger number of registered vehicles (California, Georgia and New Jersey). For the most part, the vehicle age distributions that result from the status quo wealth tax policy and a change in the tax policy are

³⁵ The fact that the vehicle age distributions across these eight states follow the same general pattern is not surprising given the method for calculating the fraction of vehicles in each age group. The only element that distinguishes one state's calculation from another is the use of individual values of the independent variables. Each calculation uses the same coefficients generated by the model.

virtually identical for the first ten vehicle age outcomes. It is not until the eleventh age category that the wealth tax policy appears to have any effect. Wealth tax policies result in a larger fraction of vehicles between the ages eleven and sixteen. A policy of no wealth tax appears to result in a larger fraction of vehicles between the ages of 17 and 25 plus. In general, however, the magnitudes of the differences between the wealth tax and no wealth tax age distributions are rather modest. It remains to be seen whether these modest differences affect emissions and, if so, which is the preferred tax policy in terms of air quality.

Alternative Wealth Tax Specifications

I re-estimated the baseline multinomial logit model using different measures of the wealth tax to test the robustness of the results discussed above. In the first of these models I replace the wealth tax dummy variable with the ratio of the 2001 wealth tax liabilities for a new and used representative vehicle. In the second model the wealth tax variable of interest is the difference between the 2001 wealth tax liabilities for a new and used representative vehicle.³⁶ Table 3.8 provides a comparison of the coefficients generated from these models. The pattern of statistical significance of the coefficients in the wealth tax ratio model is very similar to that of the wealth tax dummy model. In addition to the coefficient for age outcome ten remaining insignificant, the coefficient for outcome eight also fails to be statistically significantly different from zero. However, the signs of the coefficients in the ratio model differ from those from the wealth tax dummy model across several of the age outcomes. The pattern of significance for the wealth tax

³⁶ The results reported here are from models that use a 2001 Honda Accord and 1998 Honda Accord as the respective new and used vehicles. The results are robust to the use of a 2001 Ford Taurus and a 1998 Ford Taurus as the representative vehicles.

difference model is quite different from that of the baseline model. The coefficients for outcomes three, thirteen and fifteen fail to be statistically significant, while the category of statistical significance decreases for outcomes two, six and twelve. Again the signs of several of the coefficients from this model differ from those of the baseline model. However, Figure 3.16 reveals that these differences as well as differences in the magnitudes of the coefficients fail to significantly affect the vehicle age distributions generated by these models. The resulting vehicle age distributions from all three models are for all practical purposes identical to one another.

As mentioned above, there are a variety of methods that could be employed to interpret the results of these additional multinomial logit models. However, plotting predicted probabilities generated from the results of the model is perhaps the most effective. The effects of motor vehicle wealth taxes on vehicle age distributions are easily identified by simulating the effects of a complete removal of the tax on fleet age. Figure 3.17 shows the results of this simulation for the wealth tax ratio model. The solid black line in this figure represents the vehicle age distribution that I generated using the coefficients of the MNLM and the mean values of the independent variables across wealth tax states including the actual mean ratio of wealth tax liabilities in 2001. The broken gray line is the vehicle age distribution that results from simulating the removal of the wealth tax. I also generated it using the coefficients of the model and the mean values of the independent variables; however, I set the ratio of wealth tax liabilities equal to one in this calculation. A wealth tax ratio of one indicates that new and used vehicles are treated equally by the tax system, which could also be interpreted as a complete removal

of the motor vehicle wealth tax. For the most part these distributions are quite similar to one another. The differences that do exist suggest that removing the wealth tax may even slightly increase the average age of a state's vehicle fleet. The fraction of vehicles between the ages of 1 and 7 is slightly lower after the removal of the wealth tax. The removal of the wealth tax does slightly reduce the fraction of vehicles between the ages of 11 and 15 which would reduce emissions and improve air quality, all else constant. However, due to the nature of probabilities these reductions must translate into increases in some portion of the age distribution. These increases take place between the ages of 17 and 25. As a whole, little emphasis should be placed on the shifts in the vehicle age distribution in wealth tax states that takes place due to the elimination of the tax as the average absolute difference between the two distributions across age outcomes is only 0.0015. Thus, on average the difference between these distributions is less than two tenths of a percentage point at any position along the distribution.

Figure 3.18 presents the results of a similar comparison generated from simulations using the coefficients estimated by the MNLM that includes the difference in wealth tax liabilities as the policy measure. Here the broken gray line represents the vehicle age distribution that would result if tax policies were changed such that the difference between the tax liabilities of a new and used vehicle was equal to zero, or in other words a repeal of the wealth tax. The solid black line represents the distribution that results given the average tax liability difference in 2001. The average absolute difference between these distributions is 0.0013, which again suggests that motor vehicle wealth taxes have little effect on vehicle age distributions.

Conclusions Regarding the Effects of Motor Vehicle Wealth Taxes on Vehicle Age Distributions

The primary hypothesis that motor vehicle wealth taxes skew vehicle age distributions towards older vehicles is not supported by the results from multinomial logit models of vehicle age. The model itself is a relatively good predictor of vehicle age distributions and includes many parameters that are highly statistically significant. Although the coefficient on the wealth tax dummy variable is highly statistically significant in the model, this statistical significance does not translate into economic significance. On average the wealth tax has little effect on vehicle age distributions as evidenced by a modest value of the average absolute discrete change. A comparison of predicted vehicle age distributions reveals only a few slight differences for wealth tax states and non-wealth-tax states. A uniform national wealth tax policy would increase the fraction of vehicles between the ages of 10 and 16 and decrease the fraction of vehicles in older age categories relative to a uniform national policy not to tax vehicles. Overall, the magnitudes of these differences are very small and quite possibly do not translate into effects for emissions levels.

Alternative specifications of the motor vehicle wealth tax measure suggest that the conclusions of the baseline model are robust. These alternative specifications replace the motor vehicle wealth tax dummy variable with continuous measures of wealth tax liabilities that better reflect the dynamic structure of motor vehicle wealth taxes. Predicted vehicle age distributions that result from these additional models are nearly identical to the vehicle age distribution generated by the baseline model. Simulating the effects of a complete removal of the wealth tax in these models reveals only modest

changes in vehicle age distributions. Once again, the largest effects occur for vehicles in the oldest age categories.

Results of separate state-level analyses echo the conclusions of the national model. Simulations of vehicle age distributions in states with extreme ozone problems reveal that changes to motor vehicle wealth tax policies are unlikely to be solutions to their emissions problems. States that decide to repeal their motor vehicle wealth taxes might see a slight decrease in the fraction of middle-aged vehicles but also a slight increase in the fraction of vehicles in the oldest age categories. Further analysis is necessary to determine whether these slight changes affect emissions. The direction of any such effect may very well depend on the distribution of vehicle miles traveled across vehicle age categories.

Chapter 4

Effects of Motor Vehicle Wealth Taxes on Emissions

Introduction to the Emissions Analysis

The results of the previous chapter suggest that motor vehicle wealth taxes have two distinct effects on vehicle age distributions. First, the presence of a motor vehicle wealth tax increases the fraction of vehicles that are between the ages of 10 and 16. This effect increases emissions, all else constant, as vehicles in these age categories pollute more than newer vehicles. However, states with motor vehicle wealth taxes are also likely to have smaller fractions of vehicles in the oldest age categories. This results in lower emissions, all else constant, as vehicles in these age categories are the dirtiest in the fleet. To the extent that vehicles between the ages of 17 and 25 pollute more than middle-aged vehicles, these results imply that emissions may actually be lower and air quality better in states with a motor vehicle wealth tax. However, this conclusion fails to take into consideration the fact that older vehicles tend to be driven less often. The distribution of vehicle miles traveled across age categories may be a key determinant in estimating the effects of wealth taxes on emissions. If vehicles between the ages of 10 and 16 are driven more often than are older vehicles, emission levels would be higher in wealth tax states as a result of the increase in the fraction of vehicles in these age categories.

Figure 4.1 shows the distribution of average annual miles traveled by vehicles in various age categories. The results presented in this figure represent an average of the total annual miles households in the 2001 National Household Transportation Survey

reported for their automobiles.³⁷ On average, households drive brand-new vehicles roughly 14,000 miles in the first year. Annual vehicle miles traveled then declines steadily with vehicle age. Vehicles between the ages of 10 and 16 are driven nearly 8,000 miles per year, while vehicles in older age categories are driven only 5,000 miles per year on average.³⁸ Thus, overall emissions in motor vehicle wealth tax states may increase as households drive vehicles between the ages of 10 and 16 more miles each year than they drive older vehicles. However, the overall effect is still ambiguous and further analysis is necessary to determine whether the rather modest differences between vehicle age distributions in wealth tax and non-wealth tax states affect emissions.

The objective of this portion of the analysis is to identify how motor vehicle wealth taxes affect emissions. I use the MOBILE6 emissions model i to estimate emission factors for three criteria pollutants (hydrocarbons, carbon monoxide and nitrogen oxide) using various vehicle age distributions generated from the results of the previous chapter. I then compare emission factors that result from various wealth tax scenarios to identify the effects of wealth taxes on emissions. As in Chapter 3, I also conduct a state-level analysis to identify the potential effects of changes in state motor vehicle wealth tax policies on emissions levels.

MOBILE6 Emissions Model

MOBILE6 is a software application program designed by the Environmental Protection Agency to provide estimates of emissions from mobile sources. This model

³⁷ Mini-vans, SUVs and trucks were excluded from these calculations so that the results would correspond to the types of vehicles used in the Polk analysis.

³⁸ Pickrell and Schimck (1998) provide evidence from the 1995 National Personal Transportation Survey that older vehicles are driven fewer miles in a year.

represents the state of the art in emissions models. State and local regional planning agencies use it to develop mobile source emission control strategies, improve transportation planning and develop environmental impact statements. The model is capable of calculating average emission factors for three main criteria pollutants: hydrocarbons, carbon monoxide, and nitrogen oxides for calendar years between 1952 and 2050.³⁹ The model's inputs include travel indicators such as vehicle age distributions, mileage accumulation rates, vehicle miles traveled, fuel volatility, and climate conditions as well as other factors that affect emissions. National default values are available for a large majority of these factors which simplify the task of estimating emissions. At a minimum the user must supply the year, minimum and maximum daily temperatures, and a fuel volatility measure.

Replacing the national default values with information that better describes local conditions generates more precise estimates of local emissions. For example, the model is capable of using vehicle age distributions that reflect the status of motor vehicle wealth tax policies. Inserting commands that give the fraction of vehicles in each of twenty-five age categories allows for the calculation of emissions for specific vehicle age distributions. Vehicle age is calculated according to the following equation: $\text{age} = \text{calendar year} - \text{model year} + 1$.⁴⁰ The final age category consists of all vehicles that are 25 years of age or older. The model uses decimals to represent vehicle age fractions for each of the 25 model years. Thus, the sum of the 25 values must equal 1.0.

³⁹ Mobile6 is also capable of providing estimates of carbon dioxide; however, the EPA admits that the calculations are rather simplistic. Thus, these results are not reported here.

⁴⁰ This is the same age calculation that is used in the analysis of the Polk data.

The output of the model reports emission rates for each pollutant in grams of pollutant per vehicle mile traveled. Multiplying these results by estimates of total vehicle miles traveled provides estimates of total emissions for each pollutant. MOBILE6 is capable of providing emission factors for 16 different vehicle classes based on vehicle type, weight and fuel class. However, the vehicle age distributions generated in the Polk analysis are limited to passenger vehicles; therefore, the emissions factors presented in this analysis are limited to light-duty gasoline vehicles.⁴¹

Comparing the emission factors generated by models that use different vehicle age distributions identifies the effects of motor vehicle wealth taxes on emissions. Therefore, it is essential that all other inputs are identical across models in order to isolate the effects of wealth taxes. Such a comparison demands that even the minimum required inputs be the same for models whose results are being compared. All models used in this analysis estimate emission factors for July of 2001. The minimum temperature is set to 64° F and the maximum is set to 92° F. A fuel volatility measure of 7.0 psi is used in each of the models. These assumptions are nearly identical to those used in Miller et al. (2002) to model the effects of county-level vehicle age distributions on emission factors. Again, the model estimates more accurate emission factors if local values of the inputs are used. However, the primary objective of this analysis is not to model emissions as accurately as possible but to identify the effects of motor vehicle wealth taxes. To achieve this objective, the most straightforward course of action is to use national default

⁴¹ Further details on the structure and use of the MOBILE6 emissions model can be obtained from the User's Guide to Mobile 6.1 and Mobile 6.2 available at www.epa.gov/otaq/models/mobile6/420r03010.pdf.

values for all input parameters. The only feature that distinguishes one model from another is a unique vehicle age distribution.⁴²

MOBILE6 Results

Table 4.1 provides estimates of emission factors in grams per mile traveled by pollutant type for various scenarios modeled by MOBILE6. The first set of results reports emission factors for two national vehicle fleet scenarios. The first column reports results from a scenario that uses the actual vehicle age distribution provided by the Polk data to model emission factors. The results indicate that on average a light-duty gasoline vehicle fleet with this particular age distribution would emit 2.00 grams of hydrocarbons (measured here as volatile organic compounds) per vehicle mile traveled. The emission factors for carbon monoxide and nitrogen oxide are 20.55 and 1.41 grams per vehicle mile traveled respectively. The second column reports results from a scenario that uses the national vehicle age distribution predicted by the multinomial logit model to estimate emission factors. The predicted vehicle age distribution is slightly skewed in favor of older vehicles relative to the actual age distribution, which results in higher emission factors for each of the pollutants. However, the differences in the emission factors between the two scenarios are rather modest. The third column presents the difference as a percentage of the emission factors from the actual vehicle age distribution scenario. Emission factors from the predicted age distribution are never more than 6.2 percent larger than the emission factors from the actual age distribution.

The remaining sets of results in Table 4.1 report similar estimates by motor vehicle wealth tax status. The emissions model generates emission factors using average

⁴² The MOBILE6 input files I used to generate the results of this analysis are included in Appendix D.

actual and predicted vehicle age distributions for wealth tax and non-wealth tax states. The percent error column indicates that the difference between actual and predicted emission factors is a smaller percentage of the actual emission factors in wealth tax states than in non-wealth tax states. Although the magnitudes of the errors in the emission factor estimates differ based on wealth tax status, the general patterns are the same. The largest error in the calculation of emission factors occurs for hydrocarbons in both wealth tax and non-wealth tax states, while nitrogen oxide emission factors have the smallest error.

The differences in both actual and predicted emission factors suggest that on average wealth tax states have slightly higher emission factors for each criteria pollutant. The largest difference occurs in the emission factors for carbon monoxide. Wealth tax states have a predicted carbon monoxide emission factor of 21.62 g/mile traveled, while the estimate for non-wealth tax states is 21.53 g/mile traveled. However, the difference of 0.09 is extremely small and represents less than 0.5 percent of the emission factor for non-wealth tax states. Furthermore, the magnitude of the difference is well within the error range of the carbon monoxide emission factor estimate for both wealth tax and non-wealth tax states. The differences for the hydrocarbon and nitrogen oxide emission factors are equally as small.

The final set of results in Table 4.1 is perhaps the most interesting. The results reported in this portion of the table compare emission factors generated under a national motor vehicle wealth tax policy to the emission factors generated under a national policy of no wealth tax. The vehicle age distributions used in these scenarios hold other factors

that affect vehicle age constant. Thus, these results isolate the effects of motor vehicle wealth taxes on emissions. Interestingly, the emission factors for each of the criteria pollutants is lower under a national wealth tax policy, which suggests that wealth taxes may actually improve air quality. Recall that a national wealth tax policy would slightly increase the fraction of vehicles between the ages of 10 and 16 and slightly decrease the fraction of vehicles in the older age categories relative to the vehicle age distribution under a uniform no wealth tax policy. Although households drive older vehicles less often, this slight shift in the age distribution decreases emissions factors. However, the magnitudes of the differences between the emission factors under these policies are rather modest. In fact, the difference as a percentage of the non-wealth tax policy emission factors are lower than the percent errors reported for non-wealth tax states. Thus, the effects of motor vehicle wealth taxes on emissions identified here are well within the model's range of error.

Table 4.2 provides results from the MOBILE6 emissions model for individual states. The vehicle age distributions for each respective state shown in Figures 3.8 through 3.15 were used in separate scenarios of the emissions model. The first column of the table provides the emission factors for the criteria pollutants generated using each state's actual vehicle age distribution provided by the Polk data. The second column presents emission factors generated using each state's predicted vehicle age distribution from the multinomial logit model. Overall, the predicted emission factors are very similar to the actual emission factors. Column three of this table presents the difference as a percent of the actual emission factor. The difference is never larger than 8.1 percent

of the actual emission factor. Notice the predictions are more accurate for California, Georgia and Massachusetts.

Column 4 of Table 4.2 provides estimates of emission factors that result from simulating the effects of changes in each states' status quo wealth tax policy on its vehicle age distribution. For example the model predicts that emission factors for all three criteria pollutants would slightly increase if Tennessee were to impose a wealth tax on motor vehicles. However, these differences are rather modest; in fact, the differences as a percentage of the predicted emission factor are less than the model's error. A change in California would imply a removal of its motor vehicle wealth tax and would increase emission factors by a modest amount. The increase in the emission factor for hydrocarbons represents only 5 percent of the predicted emission factor, while the increases for the other pollutants are even smaller. The simulations predict similar trends for the remaining six states. The effects of a change in the wealth tax policy on emission factors are rather modest. For a majority of the states the change in emission factors as a percent of their predicted values is less than the expected error of the model.⁴³

Conclusions Regarding the Effects of Motor Vehicle Wealth Taxes on Emissions

The results of scenarios estimated by the MOBILE6 emissions model suggest that the slight differences that exist between vehicle age distributions by wealth tax status have virtually no effect on emissions. Emission factors for hydrocarbons, carbon monoxide, and nitrogen oxide that correspond to a national motor vehicle wealth tax policy are nearly identical to those associated with a national policy of no motor vehicle

⁴³ The complete MOBILE6 output file for this analysis appears in Appendix E.

wealth tax. The slight differences that do exist were less than 4.7 percent of the emission factors resulting from either policy.

State-level simulations reveal that adjustments to motor vehicle wealth tax policies are unlikely to be viable substitutes or even complements to existing emissions control strategies. A comparison of emission factors corresponding to the status quo wealth tax policy to those corresponding to a change in the wealth tax policy revealed only small differences. Moreover, in most cases these differences were smaller in magnitude than the differences between the emission factors generated from actual vehicle age distributions and emission factors generated from predicted age distributions.

Chapter 5

Conclusions, Caveats and Directions for Future Research

General Conclusions

This analysis is perhaps the first to model the effects of motor vehicle wealth taxes on household vehicle purchase decisions, state vehicle age distributions and emissions and air quality. My primary hypothesis is that the use of motor vehicle wealth taxes skews state vehicle age distributions towards older vehicles as households have the incentive to delay the purchase of a new vehicle or to enter the used vehicle market, thus increasing emissions from mobile sources. As hypothesized, motor vehicle wealth taxes have a statistically significant and negative, yet somewhat modest, effect on household vehicle purchase decisions. Marginal effects from a probit model of 2001 vehicle purchase decisions indicate that households are not only responsive to the presence of a motor vehicle wealth tax but also respond to the relative tax treatments of new versus used vehicles.

Specifically, the presence of a motor vehicle wealth tax decreases the probability that a household purchases a vehicle by nearly 4.6 percent. Although the marginal effect for the wealth tax ratio variable is highly statistically significant, the magnitude of effect is rather modest. A one-percent increase in the ratio of the present value of a ten-year stream of tax liabilities of a new versus used vehicle would decrease the probability that a vehicle is purchased by only 0.10 percent. These results are fairly robust to various specifications of the model and to the use of an alternative representative vehicle, which lends further support to the conclusion that motor vehicle wealth taxes affect the timing of vehicle purchases. However, the hypothesis that households in motor vehicle wealth

tax states purchase older vehicles to avoid higher tax liabilities is not supported by the results of the analysis. All three wealth tax measures fail to be statistically significant in the baseline multivariate regression model of vehicle age, as well as all alternative specifications of the model. Thus, once a household has decided to purchase a vehicle neither the presence of a motor vehicle wealth tax nor the relative tax treatments of new versus used vehicles affects its choice of vehicle age.

Contrary to my hypothesis that vehicle age distributions in states with motor vehicle wealth taxes would be skewed towards older vehicles, motor vehicle wealth taxes appear to have only a modest effect on state vehicle age distributions. My analysis of the vehicle registration data from R.L. Polk and Company in Chapter 3 allows for states' entire vehicle age distributions to be examined; whereas, my analysis in Chapter 2 only studies recently purchased vehicles. Although the household analysis predicts that households living in motor vehicle wealth tax states are likely to delay the purchase of a new vehicle, which could theoretically impact vehicle age distributions over time, this effect appears to have little impact on fleet age.

Many of the coefficients from the multinomial logit model are highly statistically significant, including those for each of the wealth tax measures. However, this statistical significance does not translate into economic significance. A comparison of predicted vehicle age distributions for wealth tax and non-wealth tax states reveals only slight differences. Simulations of vehicle age distributions for various wealth tax regimes suggest that a complete removal of the motor vehicle wealth tax would lead to a slight decrease in the fraction of vehicles between the ages of 10 and 16 and an increase in the

fraction of older vehicles. The results of separate state-level analyses echo the conclusions of the national model, suggesting that states cannot significantly affect the age of their fleets by adjusting motor vehicle wealth tax policies.

Results from the MOBILE6 emissions model suggest that the slight shift in the average vehicle age distribution that would result from the removal of the motor vehicle wealth tax would have virtually no impact on emissions. The vehicle age distributions that would result if all states were to impose a motor vehicle wealth tax generate nearly identical emission factors for carbon monoxide, hydrocarbons and nitrogen oxide as vehicle age distributions that would result if no state had a motor vehicle wealth tax. The results of state-level simulations reveal that adjustments to motor vehicle wealth tax policies are unlikely to be viable substitutes or even complements to existing emissions control strategies. The good news is that the results of this analysis suggest that states that impose a motor vehicle wealth tax are not faced with unintended environmental consequences stemming from the economic incentives associated with the tax that encourages households to keep older vehicles.

Caveats and Directions for Future Research

In this analysis, I have focused on identifying the potential effects of motor vehicle wealth taxes on fleet turnover that may affect emissions and air quality. Although the results of this analysis provide strong support for the conclusion that wealth taxes do not affect vehicle age, these taxes may very well affect other vehicle consumption decisions that may have environmental consequences. Therefore, future research should consider the effects of motor vehicle wealth taxes on other household

vehicle consumption decisions. Specifically, the presence of a motor vehicle wealth tax may affect households' vehicle ownership levels (i.e. the number of vehicles owned by the household). Such a tax effectively raises the cost of owning vehicles and thus may discourage households from owning multiple vehicles. Obviously, the fewer vehicles there are on the road the lower the pollution levels, all else constant. Therefore, to the extent that motor vehicle wealth taxes decrease the size of vehicle stocks they may also be beneficial to the environment.

An analysis of the effects of wealth taxes on households' vehicle ownership decisions is beyond the intended scope of my analysis but could be completed in future research. The 2001 National Household Travel Survey contains a wealth of information on individual households' vehicle stocks (including a count of vehicles owned by the household) that could be used with several econometric approaches to model vehicle ownership levels. Perhaps the most common econometric method used for modeling vehicle ownership is the multinomial logit model.⁴⁴ A second possible econometric approach would be either a poisson or negative binomial model, where the dependent variable in the model represents a count of the vehicles owned by the individual household. Of course, an analysis of the effect of wealth taxes on aggregate state vehicle stocks would also be required.

If motor vehicle wealth taxes are found to have statistically and economically significant effects on vehicle stocks, a further investigation would be required to determine how this result affects annual vehicle miles traveled and thus emissions and air quality. Although motor vehicle wealth taxes may reduce the number of vehicles owned

⁴⁴ For examples see Johnson (1978) and Manski & Sherman (1980).

by households, if the annual vehicle miles traveled for these households is similar to those with a larger number of vehicles there would be no environmental benefits.

Motor vehicle wealth taxes may also affect the types of vehicles households choose to purchase, all else constant. Households may be less likely to select the more expensive (often less fuel-efficient) luxury and sports utility vehicles given that their tax liability would be a function of the value of the vehicle. Therefore, to the extent that wealth taxes encourage households to purchase smaller, more fuel-efficient vehicles, they may offer positive environmental externalities. I could also test this hypothesis using the data from the National Household Travel Survey. The data set includes a variable that classifies each of the vehicles owned by the household into one of several vehicle types, including automobile, van, sports utility vehicle, and pickup truck. However, the data also include information on the make and model of each vehicle, which would allow for a reclassification of vehicles, based on fuel efficiency rates if so desired.

In future research, I could use the multinomial logit model to examine the effects of motor vehicle wealth taxes on household vehicle type decisions. This model might include variables that describe the characteristics of the household and respective vehicle types. Alternative-specific variables might include the average carrying capacity, engine displacement or fuel-efficiency of the average vehicle in each category. Such a model would have characteristics of both a multinomial logit model and a conditional logit model as it would include both individual-specific and alternative-specific variables. A mixed model, as described by Long and Freese (2001, p.243), would allow for the use of characteristics of the vehicle type and the characteristics of the household.

In future research, I could also explore a joint estimation of households' vehicle ownership, type and vehicle age decisions. The nested logit model would be the perfect candidate for the estimation procedure used by such an analysis. For example, I could estimate a nested logit model to examine the distribution of vehicles across types conditioned on the number of vehicles in the household's stock. In fact, these household vehicle consumption decisions could be paired and modeled using several different methods.

A panel data set would be ideal for future research, as it would allow for a survival analysis of household vehicle holdings, as well as many other ideas. Households in motor vehicle wealth tax states are expected to hold on to their current vehicles longer to avoid higher tax liabilities, all else constant. A survival analysis would be useful for modeling the effects of wealth taxes on the probability that a household purchases a new vehicle at various points in time. Although the National Household Travel Survey is conducted roughly every five years, it does not represent a true panel data set as a new random sample of households is drawn for each survey.⁴⁵ Panel data techniques could also be used to model state vehicle age distributions if multiple years of vehicle registration data were available. Such an analysis would allow me to take advantage of recent changes in motor vehicle wealth tax provisions in several states that have occurred in recent years to identify the effects of the wealth taxes on vehicle age distributions. However, the cost of acquiring vehicle registration data from R.L. Polk & Company currently prevents an analysis of even a short panel that spans two or three years.

⁴⁵ Prior to 2001, the National Household Travel Survey was referred to as the National Personal Transportation Survey.

In future research, I might explore the effects of motor vehicle wealth taxes in a transactions model. Unfortunately, the National Household Travel Survey does not include detailed data on the transactions of motor vehicles. The data allow for the identification of households that purchased a vehicle in 2001; however, there is no information that indicates whether the acquisition represents a trade-in or an addition to the households' vehicle fleet. This information would be useful as households in wealth tax states are probably less likely to make additions to their vehicle stocks and may even trade in newer vehicles for older ones to reduce their tax liabilities. To complete such an analysis, I will need to search for additional data as all data sets involving vehicle transactions discovered thus far lack the state-level variation that would be required to identify the effects of wealth taxes.

The current analysis also suffers from the exclusion of some information. In particular, households living in Virginia are excluded from the analysis of the NHTS data and Virginia and Rhode Island are excluded from the models of vehicle age distributions that include the continuous wealth tax measures due to the unavailability of motor vehicle wealth tax data. Wealth taxes in these states have undergone several changes in the past several years. Although information is available on the structure of the tax prior to 2001, these data do not accurately reflect the status of the tax as of 2001. The states were excluded only after numerous attempts to contact state officials to obtain the necessary information.

Recall that light-duty trucks have been excluded from the analysis of vehicle age distributions due to an inability to separate non-commercial vehicles from commercial

vehicles. Motor vehicle wealth tax provisions often differ for commercial vehicles. Thus it would be inappropriate to include them in this analysis given the unavailability of wealth tax data for commercial vehicles. The exclusion of these vehicles may have biased vehicle age distributions towards older vehicles. Pickrell and Schmick (1998) present evidence from the 1995 National Personal Transportation Survey that indicates that light-duty trucks have aged more slowly as a group than passenger vehicles. This is largely due to lower average ages of vans and sports utility vehicles, which appears to reflect the increasing substitution of first mini-vans and then sports utility vehicles for passenger cars. It is unclear as to how the exclusion of light-duty trucks might affect the results reported for the motor vehicle wealth tax measures.

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Appendices

Appendix A: Figures

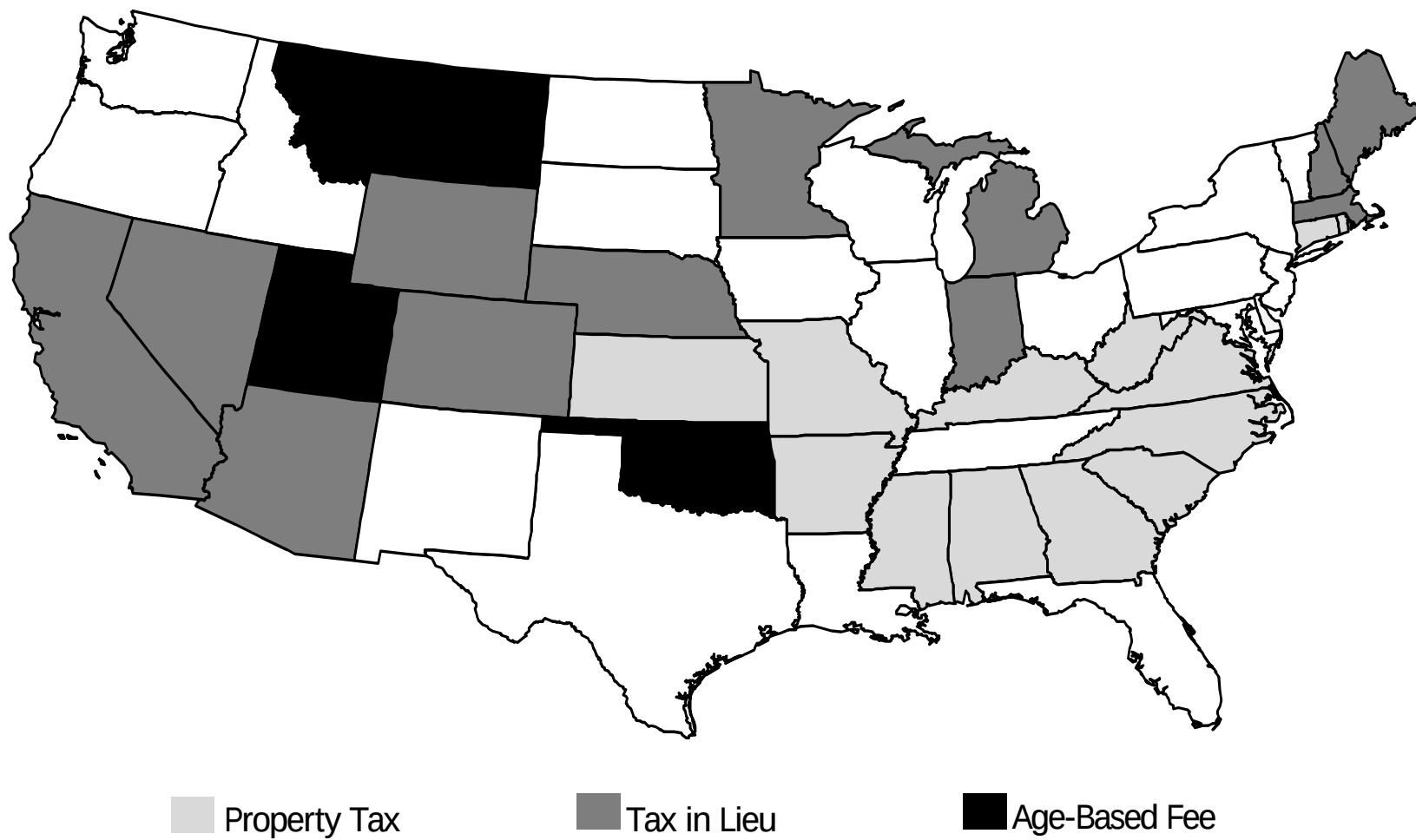


Figure 1.1: States with Motor Vehicle Wealth Taxes in 2001

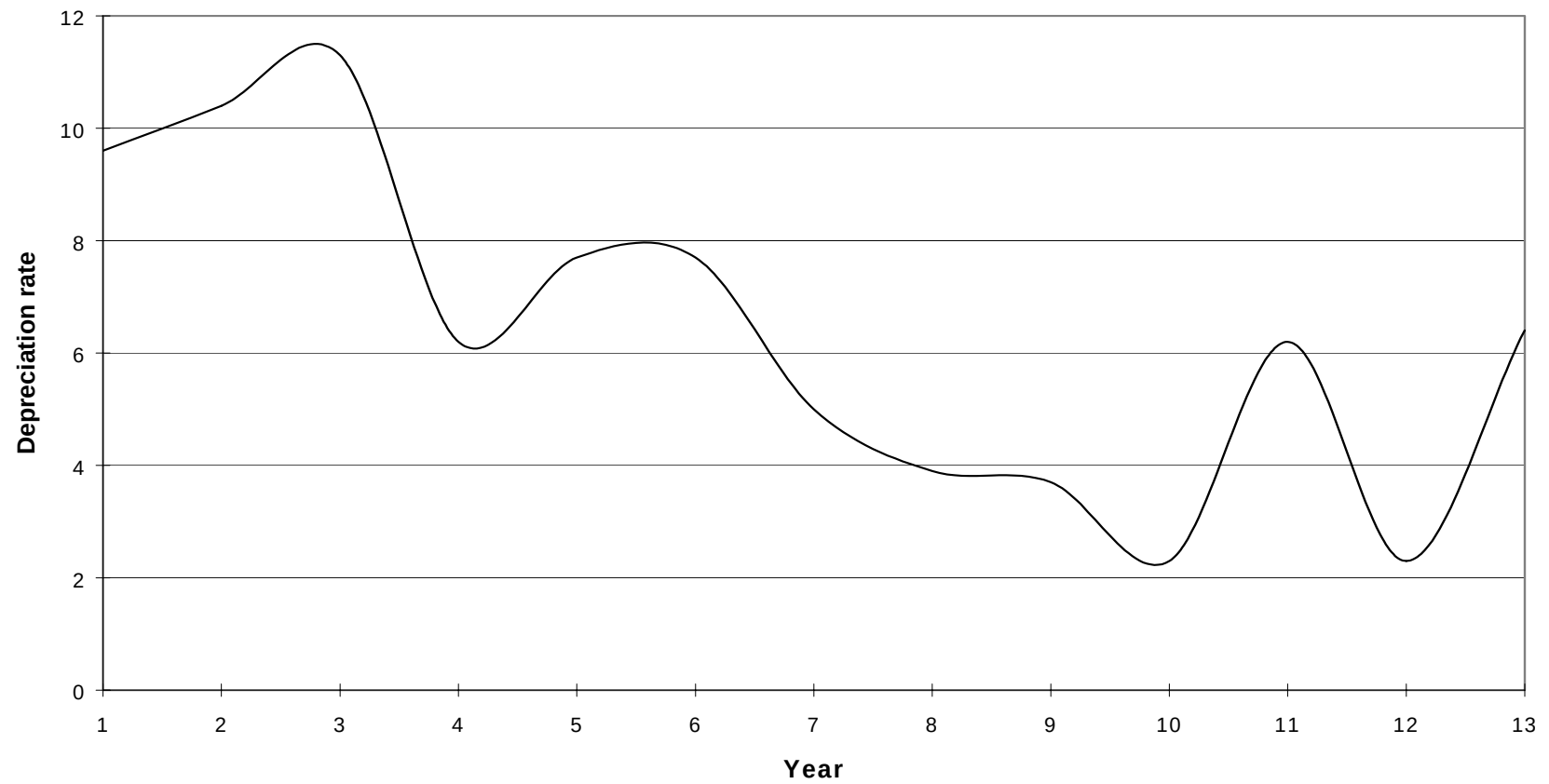


Figure 1.2: Honda Depreciation Schedule

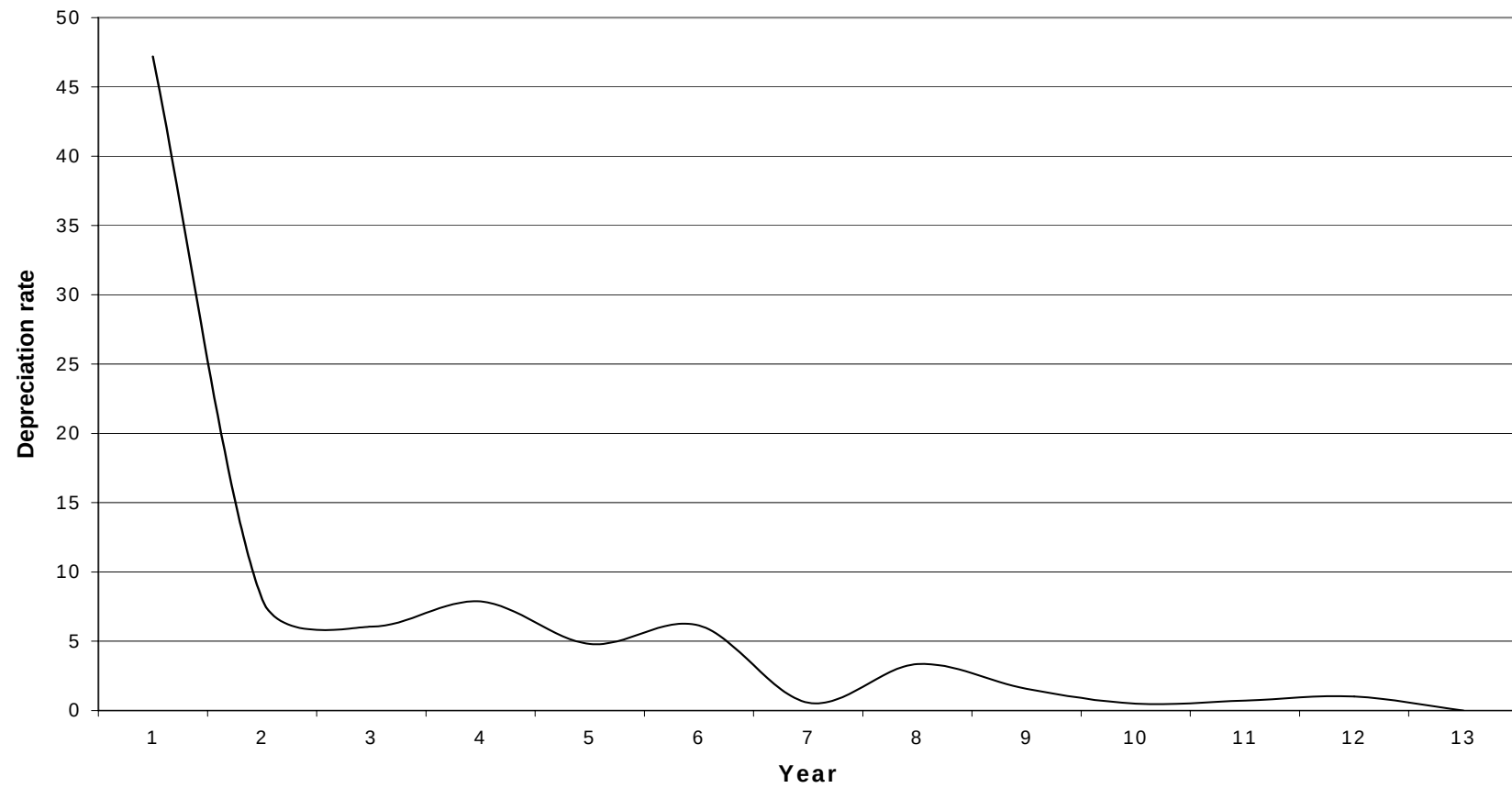


Figure 1.3: Taurus Depreciation Schedule

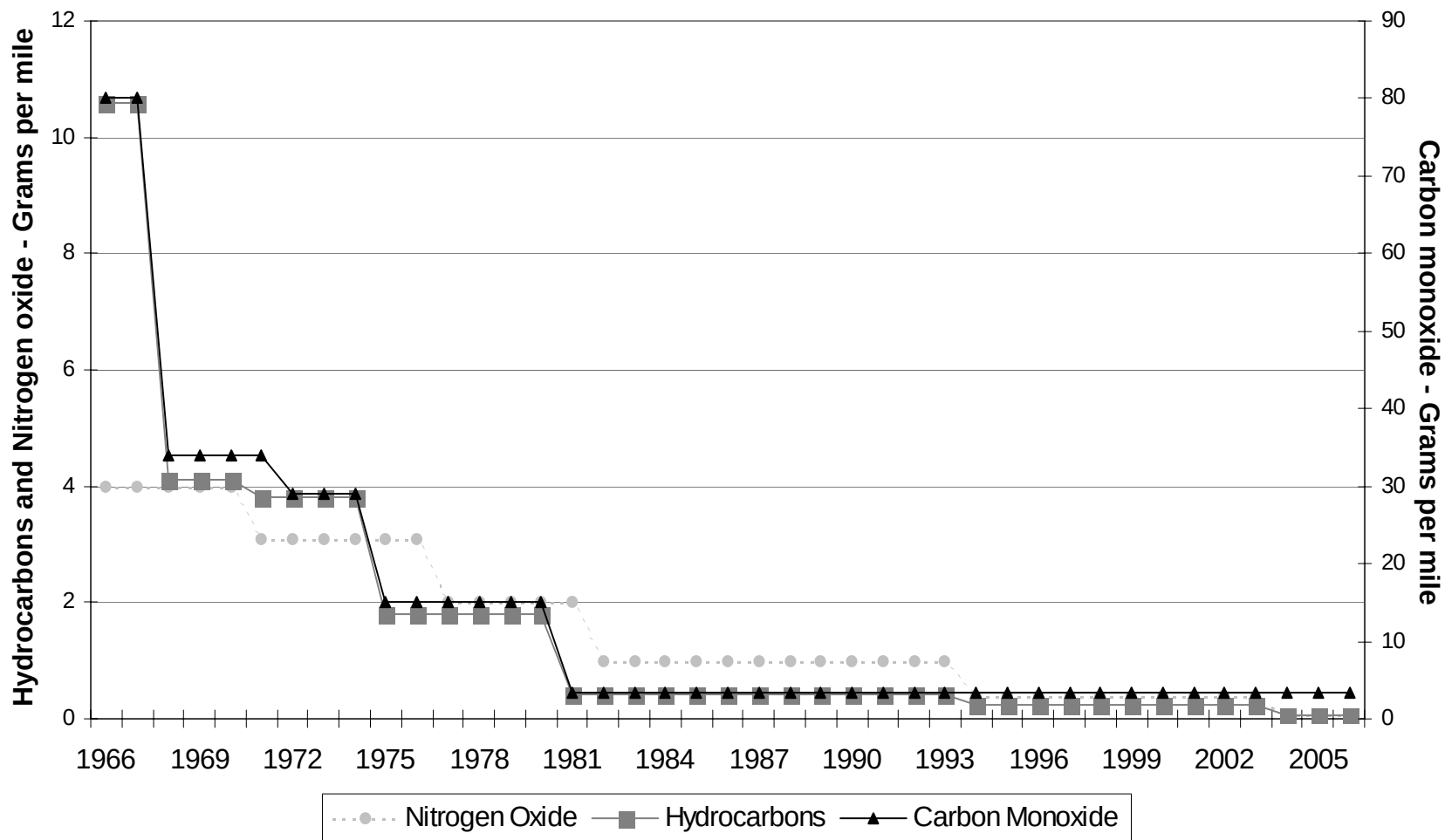


Figure 1.4: Federal Emission Standards

Source: Federal Highway Administration. Retrived on 1/21/04 from <http://www.fhwa.dot.gov/environmental/aqfactbk/factbk12.htm>

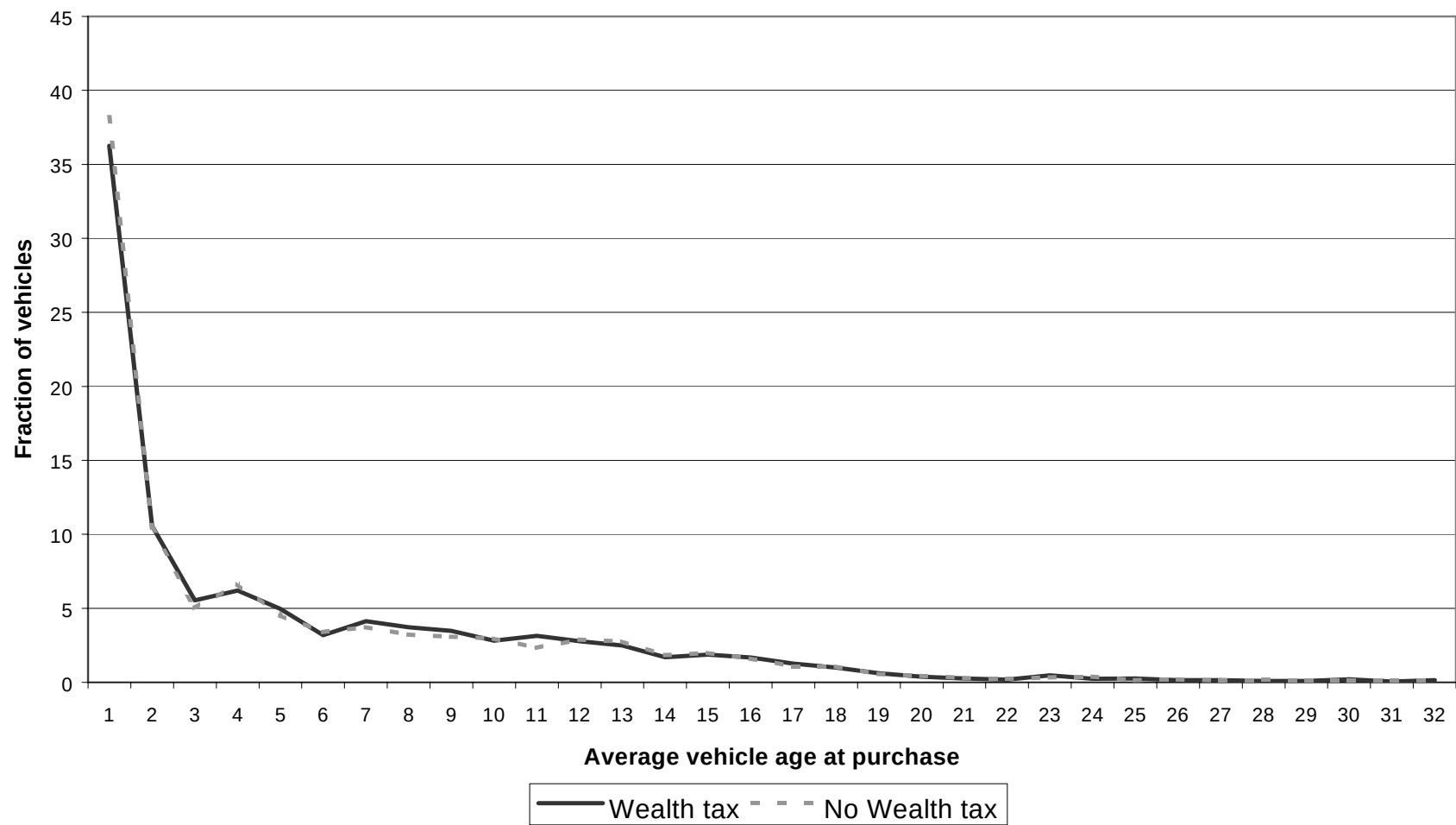


Figure 2.1: Vehicle Age at Purchase by Motor Vehicle Wealth Tax Status

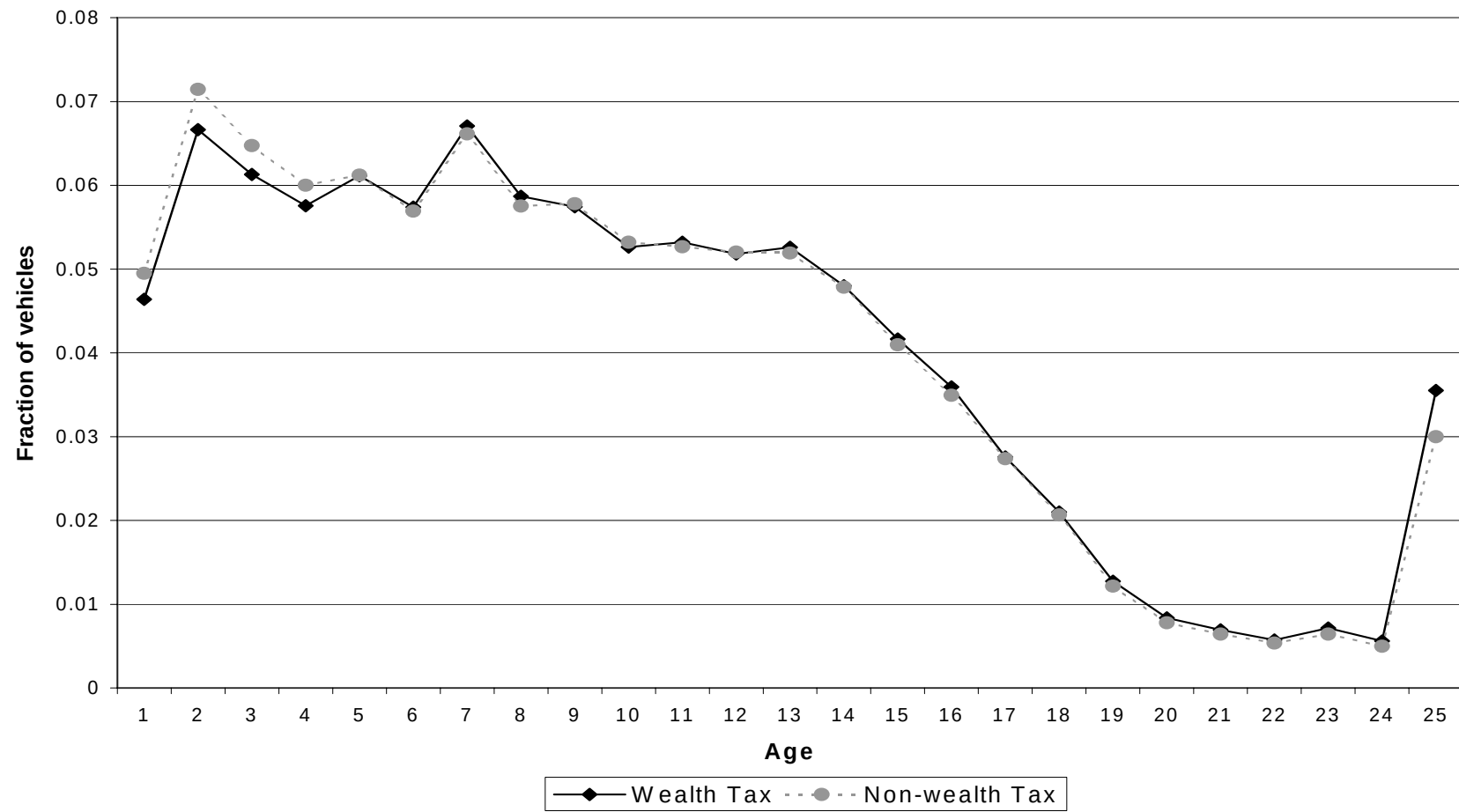


Figure 3.1: Actual Vehicle Age Distribution by Wealth Tax Status

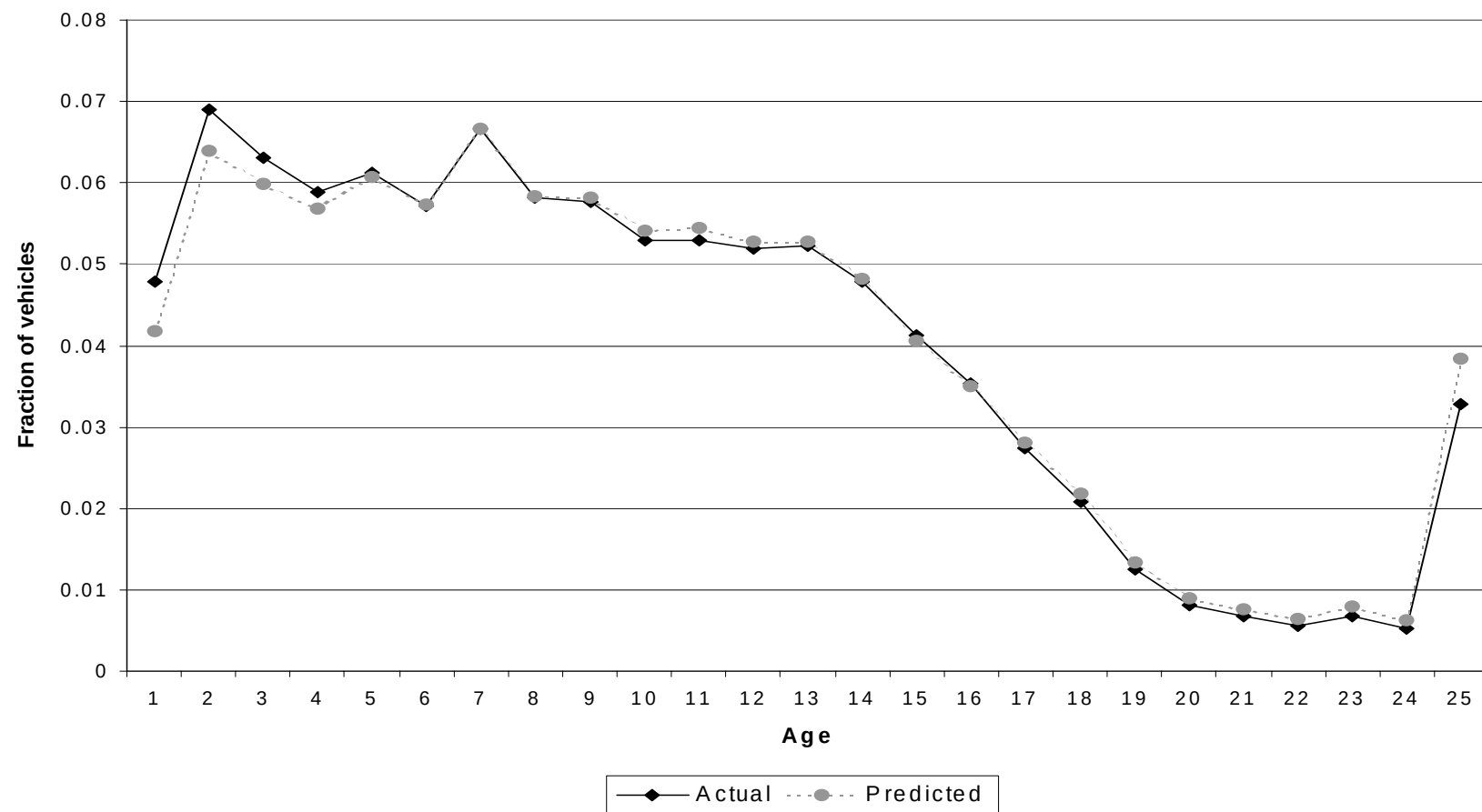


Figure 3.2: Actual versus Predicted National Vehicle Age Distribution

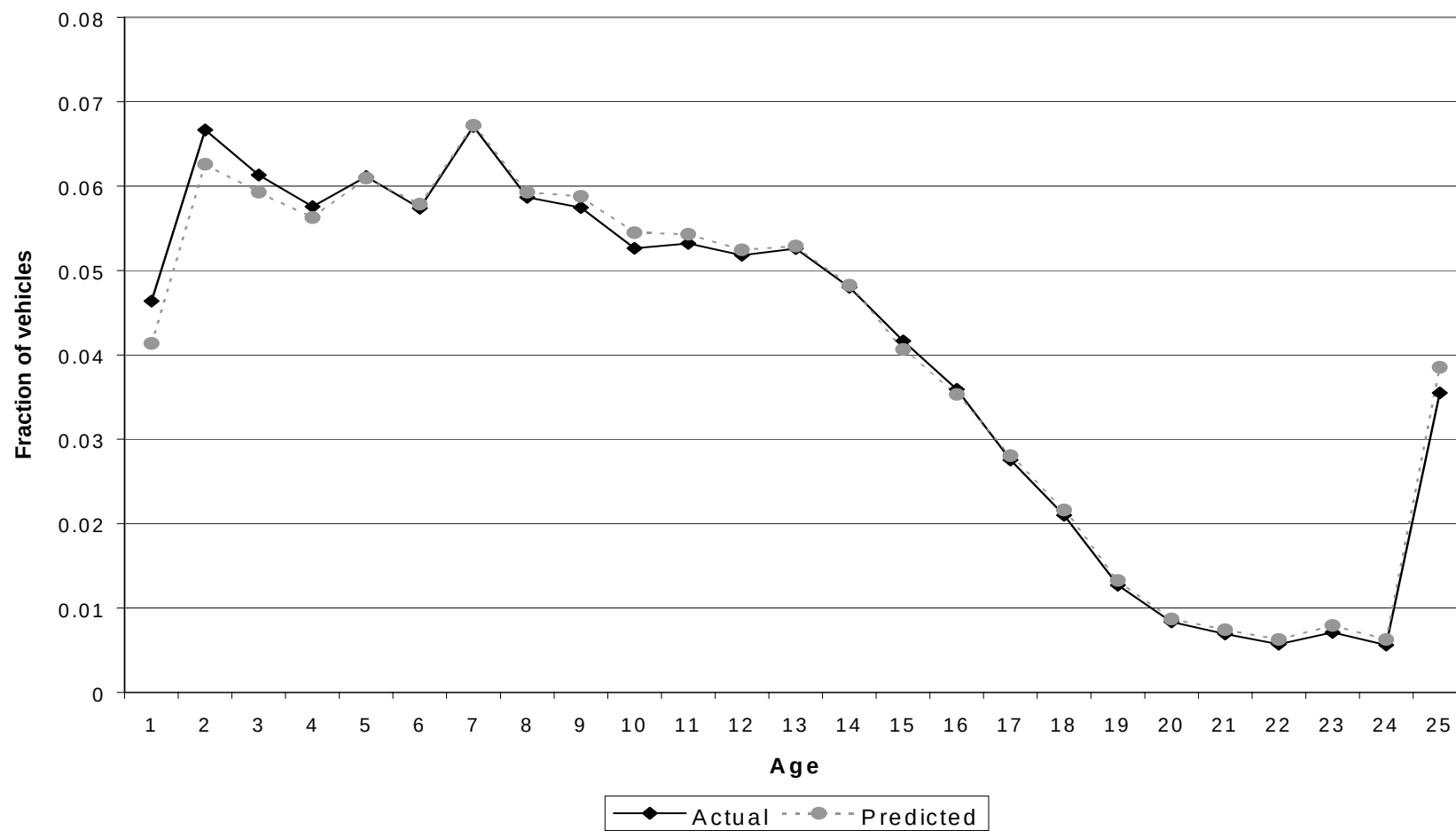


Figure 3.3: Actual versus Predicted Vehicle Age Distribution for Wealth Tax States

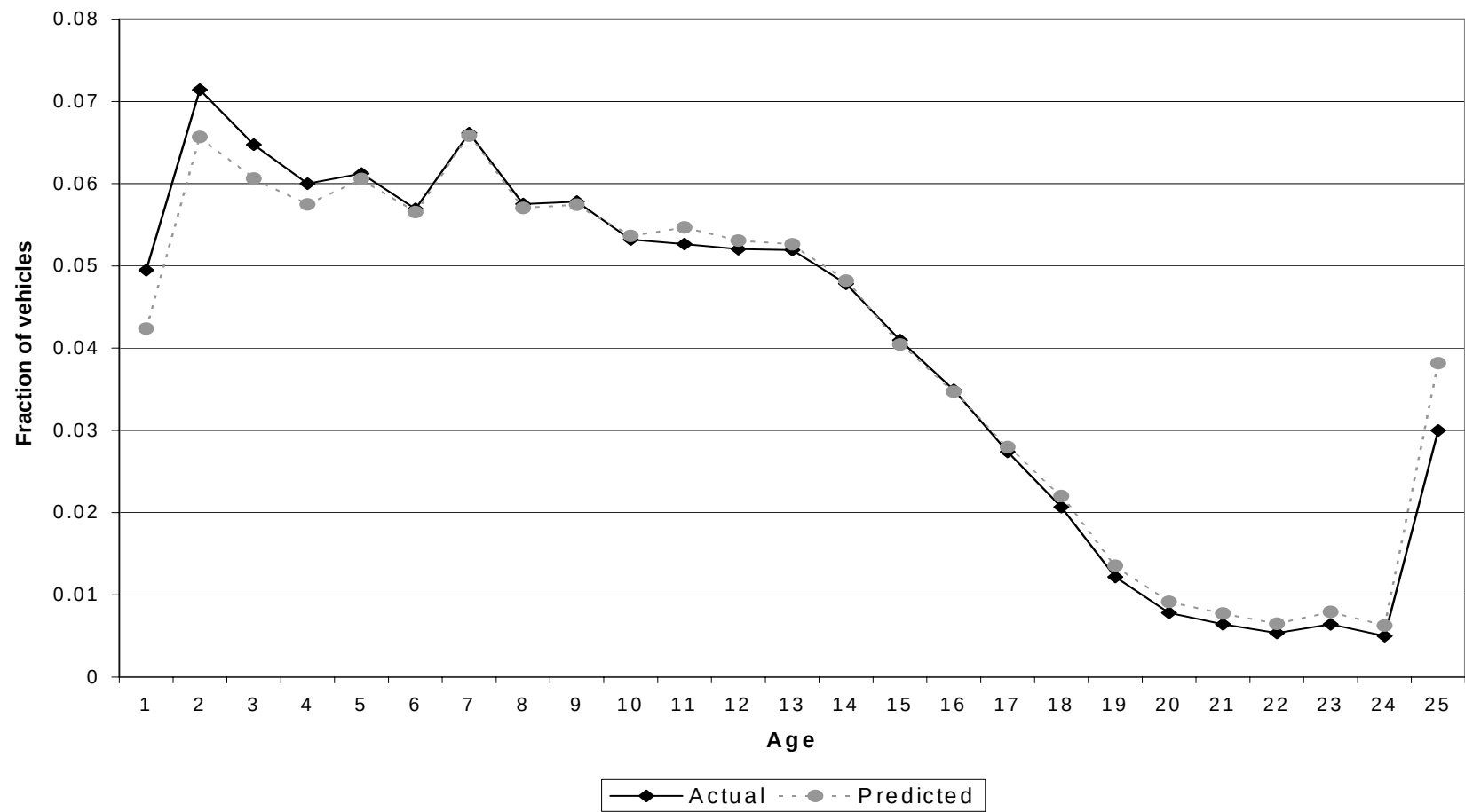


Figure 3.4: Actual versus Predicted Vehicle Age Distribution for Non-wealth-tax States

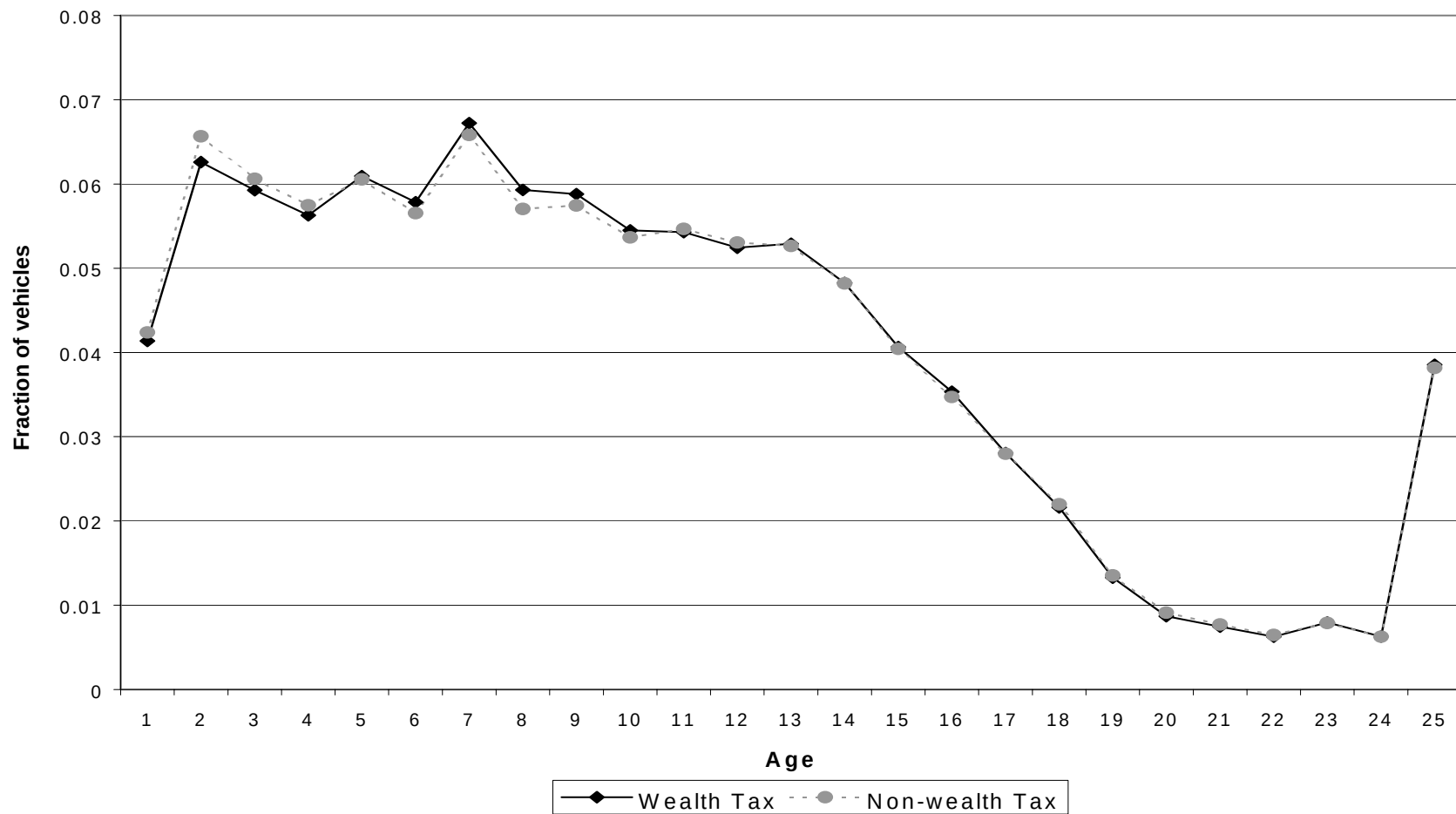


Figure 3.5: Predicted Vehicle Age Distribution by Wealth Tax Status

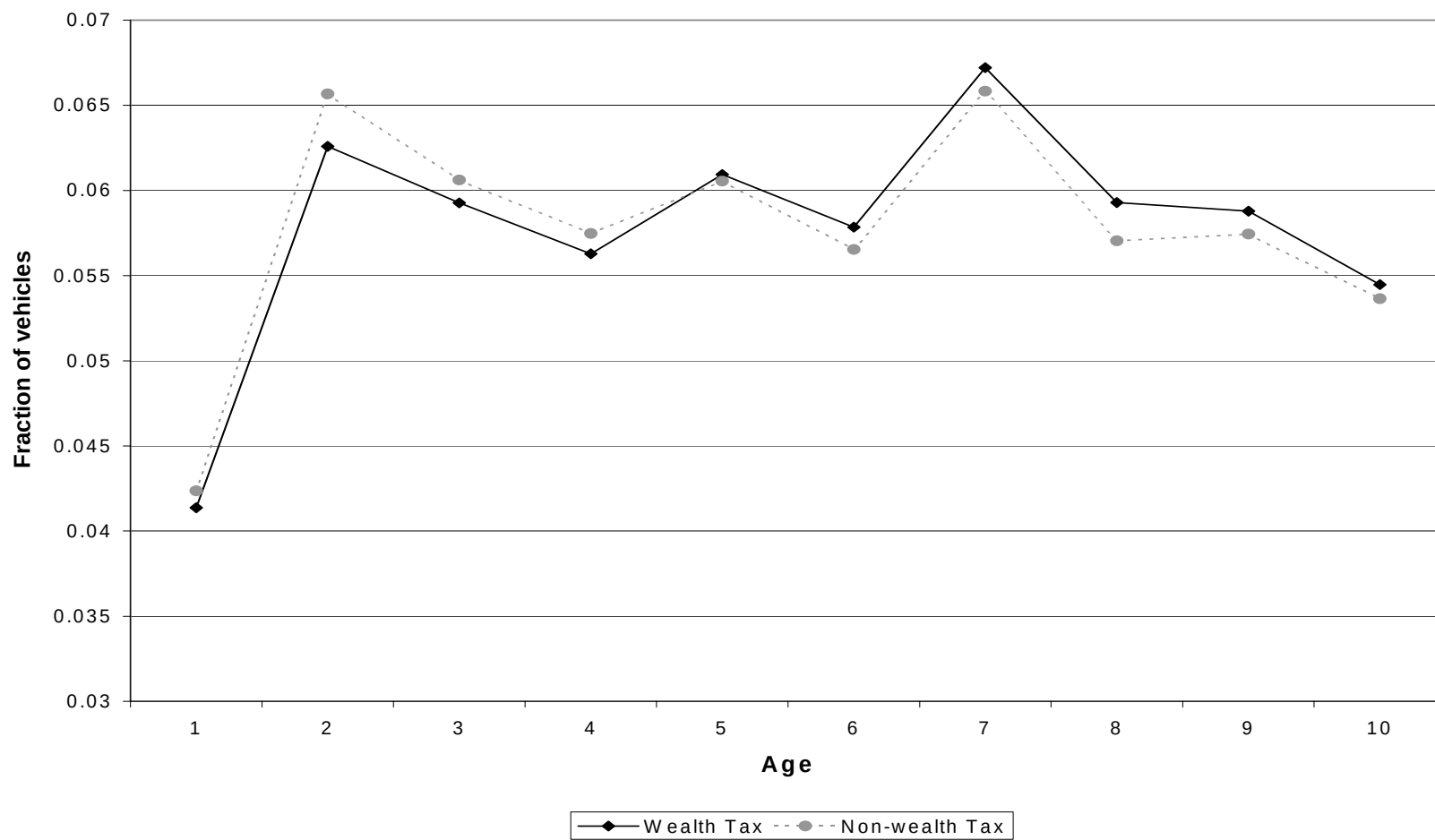


Figure 3.6: Differences in Predicted Vehicle Age Distributions for Wealth Tax and Non-wealth-tax States

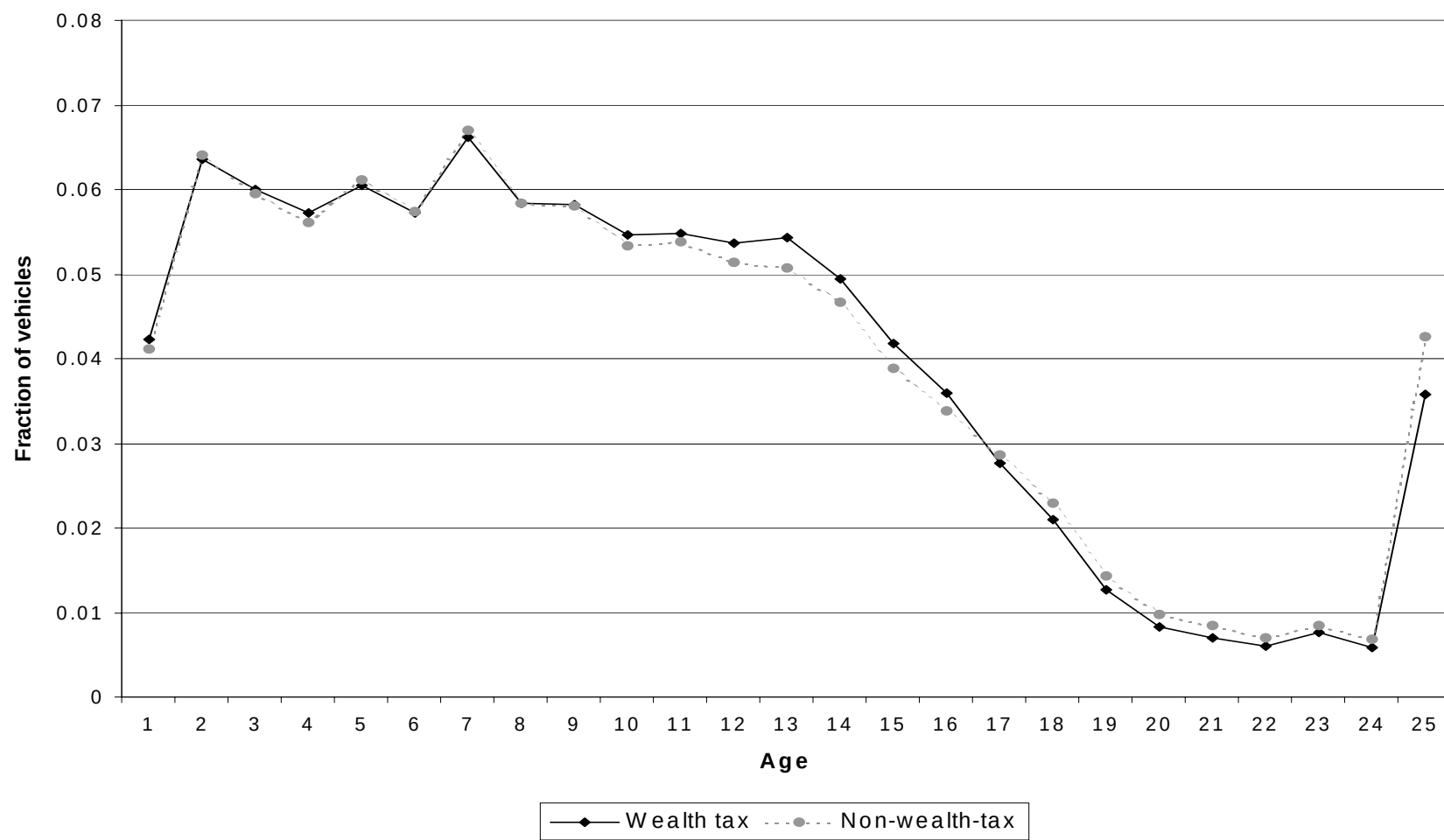


Figure 3.7: Predicted Vehicle Age Distribution Under a Uniform Tax Policy Across States

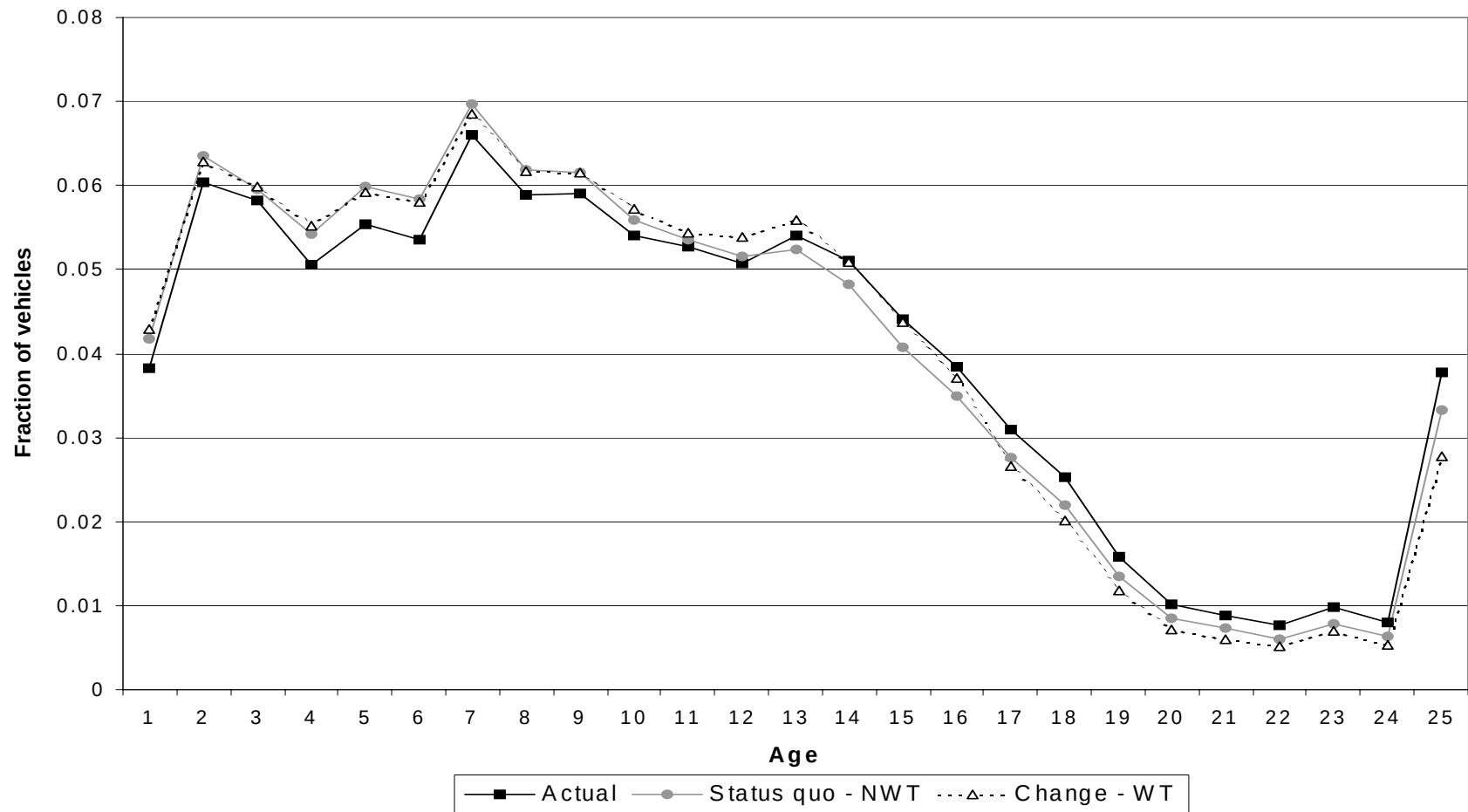


Figure 3.8: Tennessee's Vehicle Age Distribution

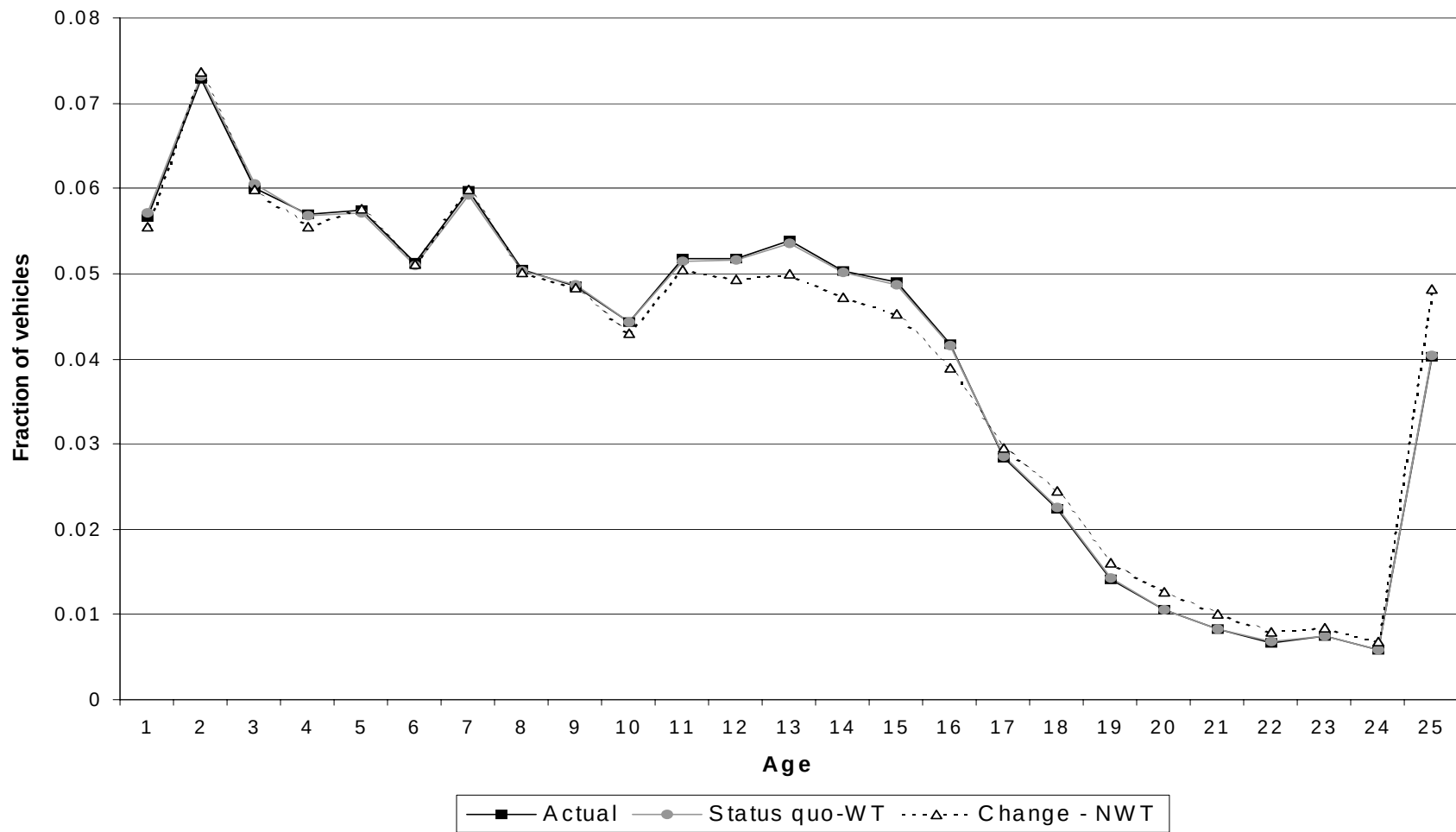


Figure 3.9: California's Vehicle Age Distribution

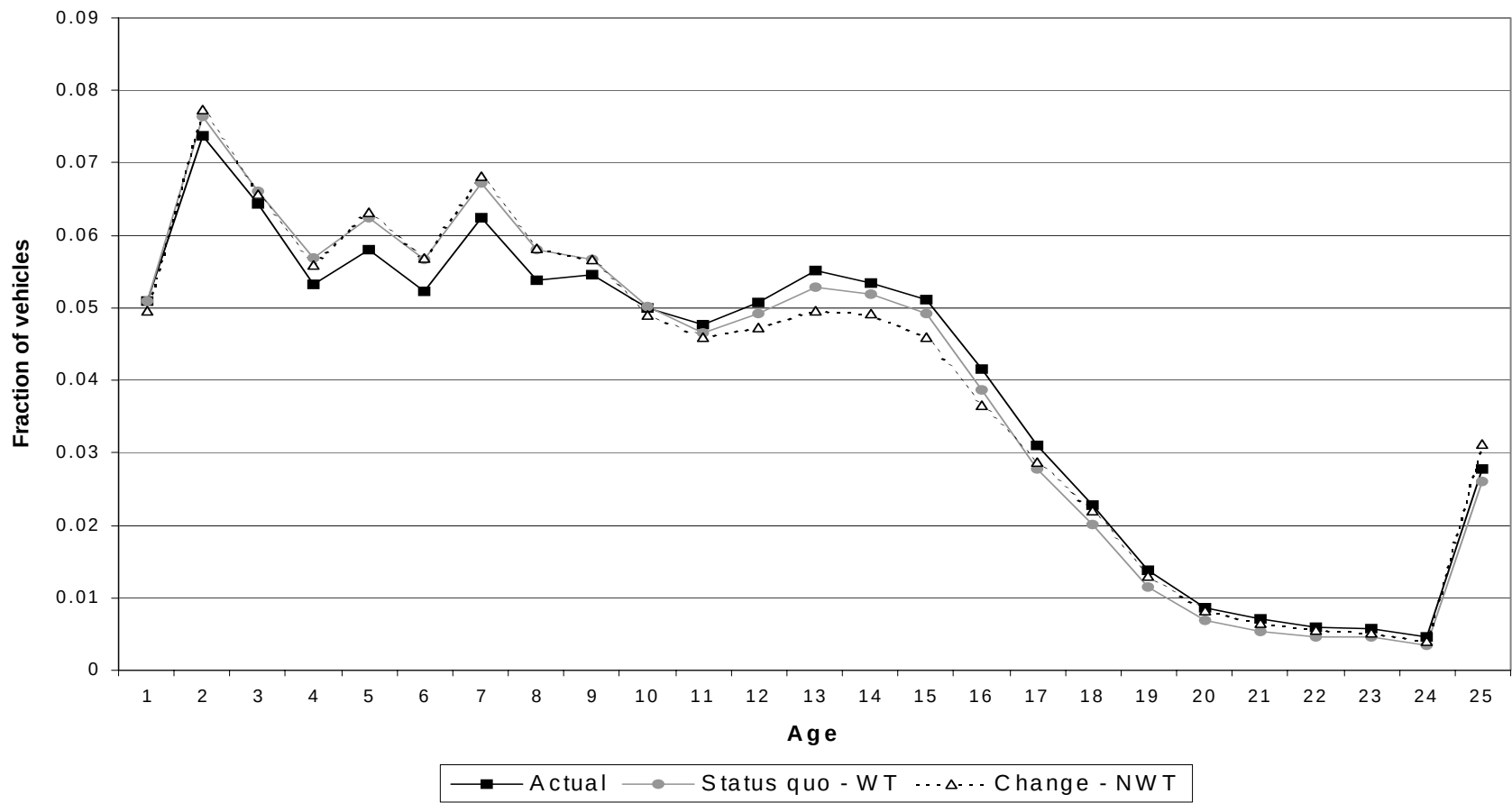


Figure 3.10: Connecticut's Vehicle Age Distribution

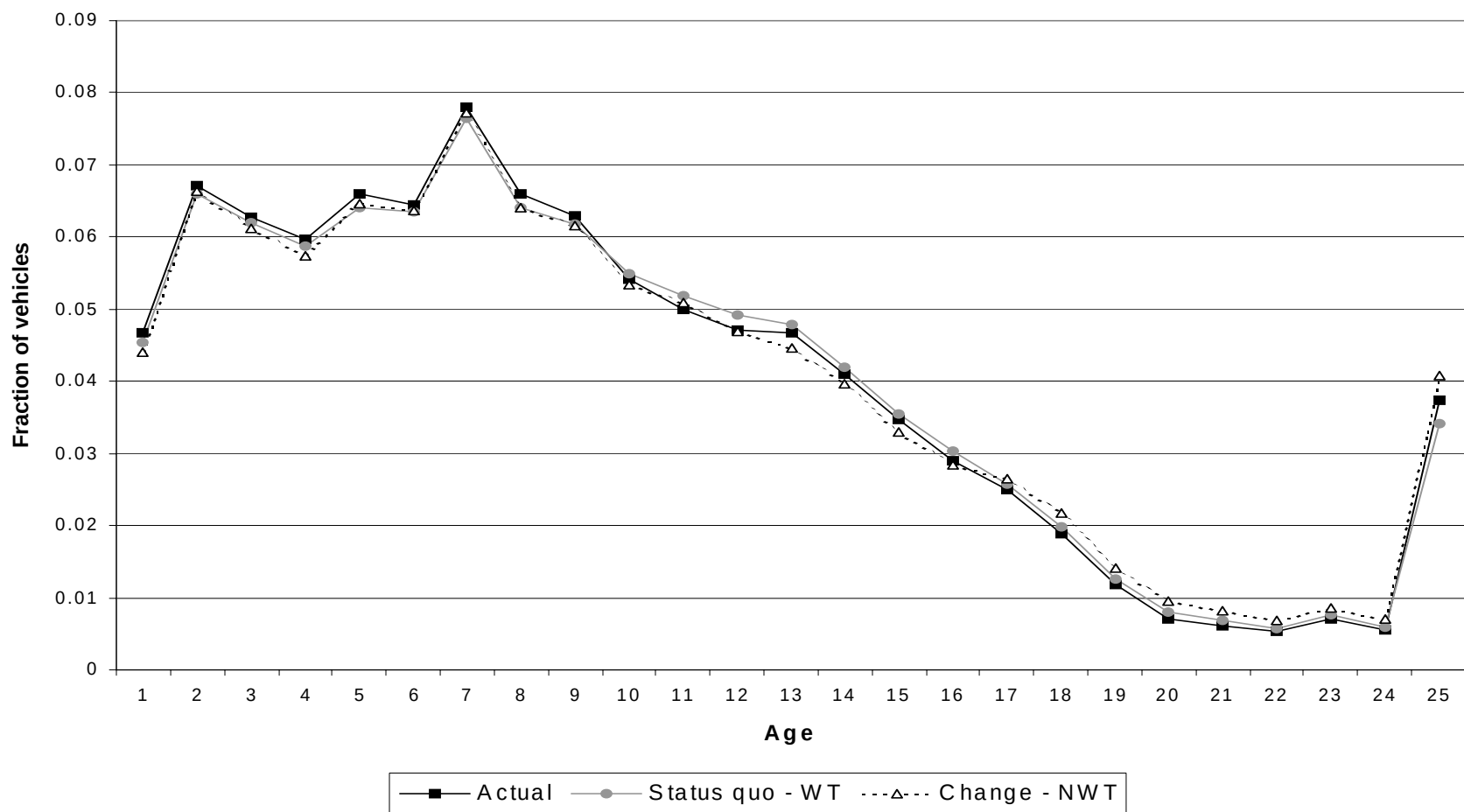


Figure 3.11: Georgia's Vehicle Age Distribution

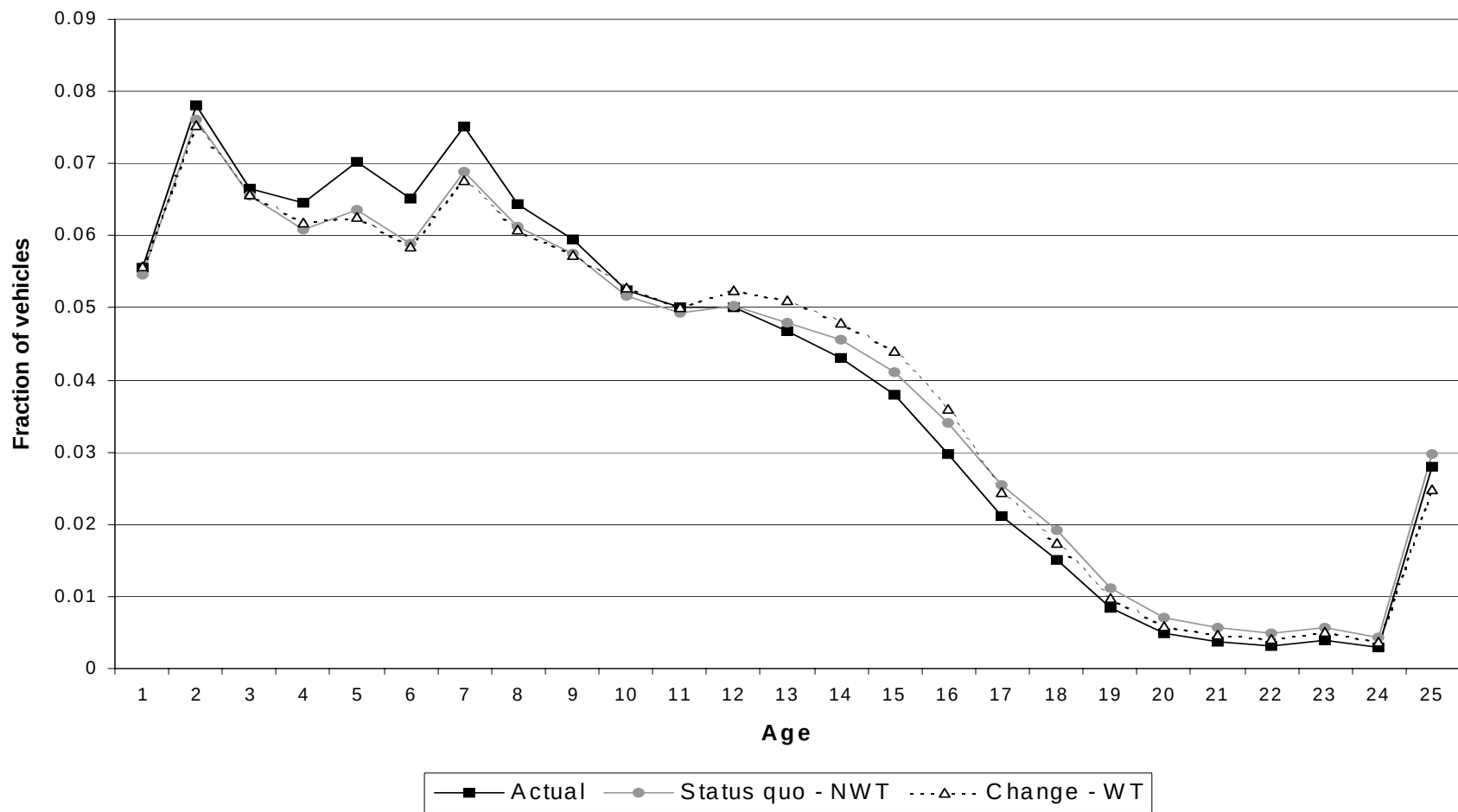


Figure 3.12: Maryland's Vehicle Age Distribution

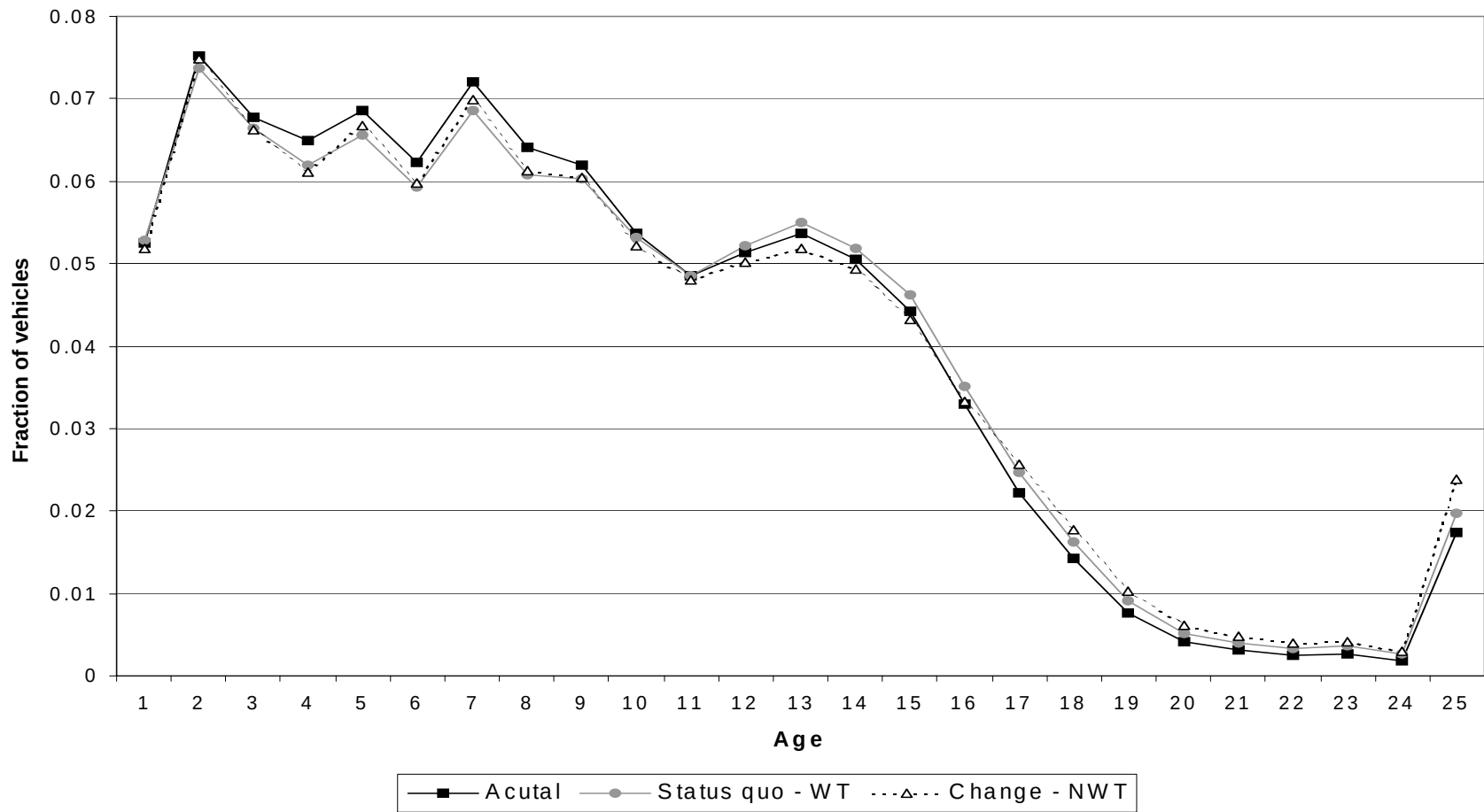


Figure 3.13: Massachusetts' Vehicle Age Distribution

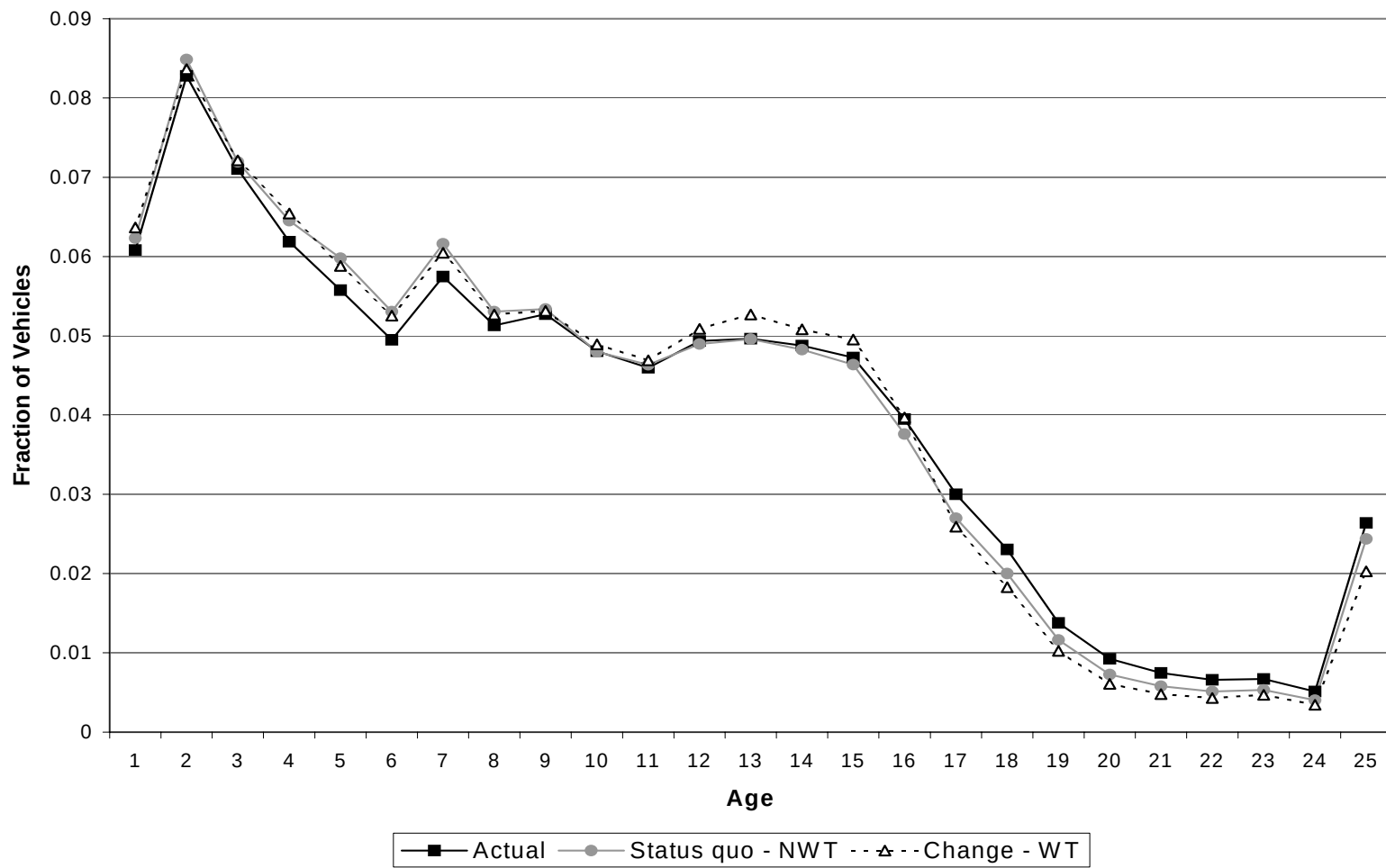


Figure 3.14: New Jersey's Vehicle Age Distribution

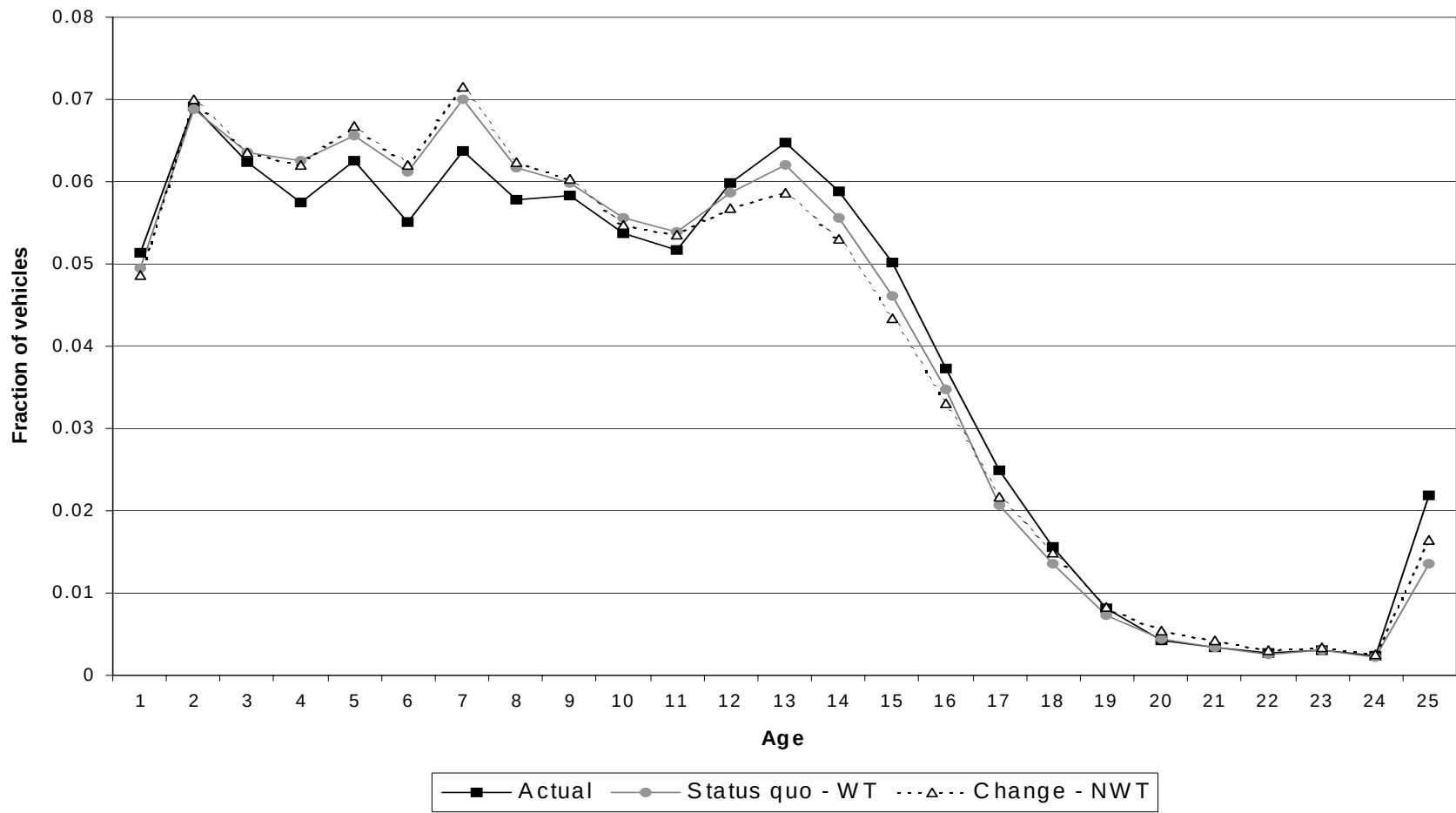


Figure 3.15: Rhode Island's Vehicle Age Distribution

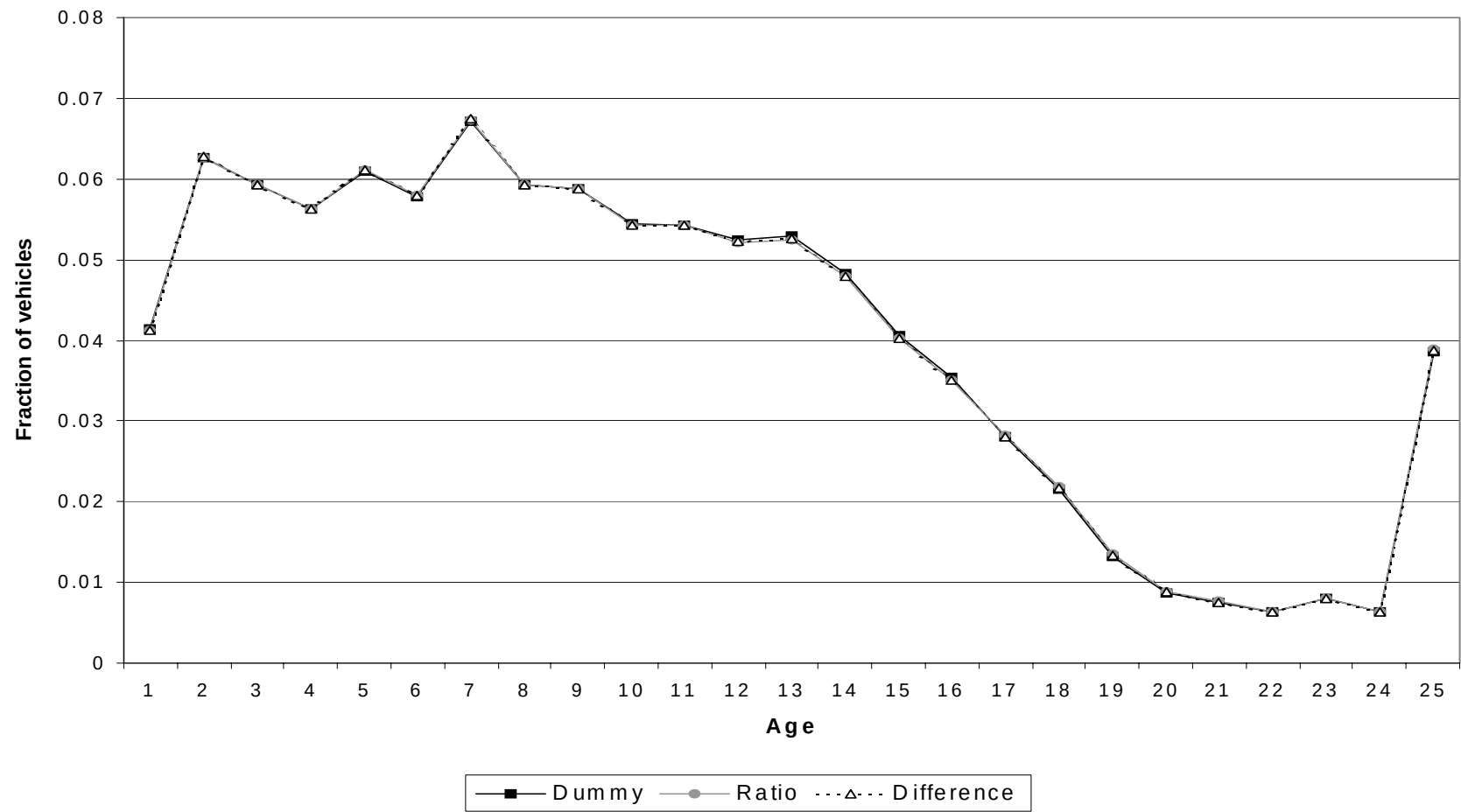


Figure 3.16: Vehicle Age Distribution for Wealth Tax States by Wealth Tax Measure

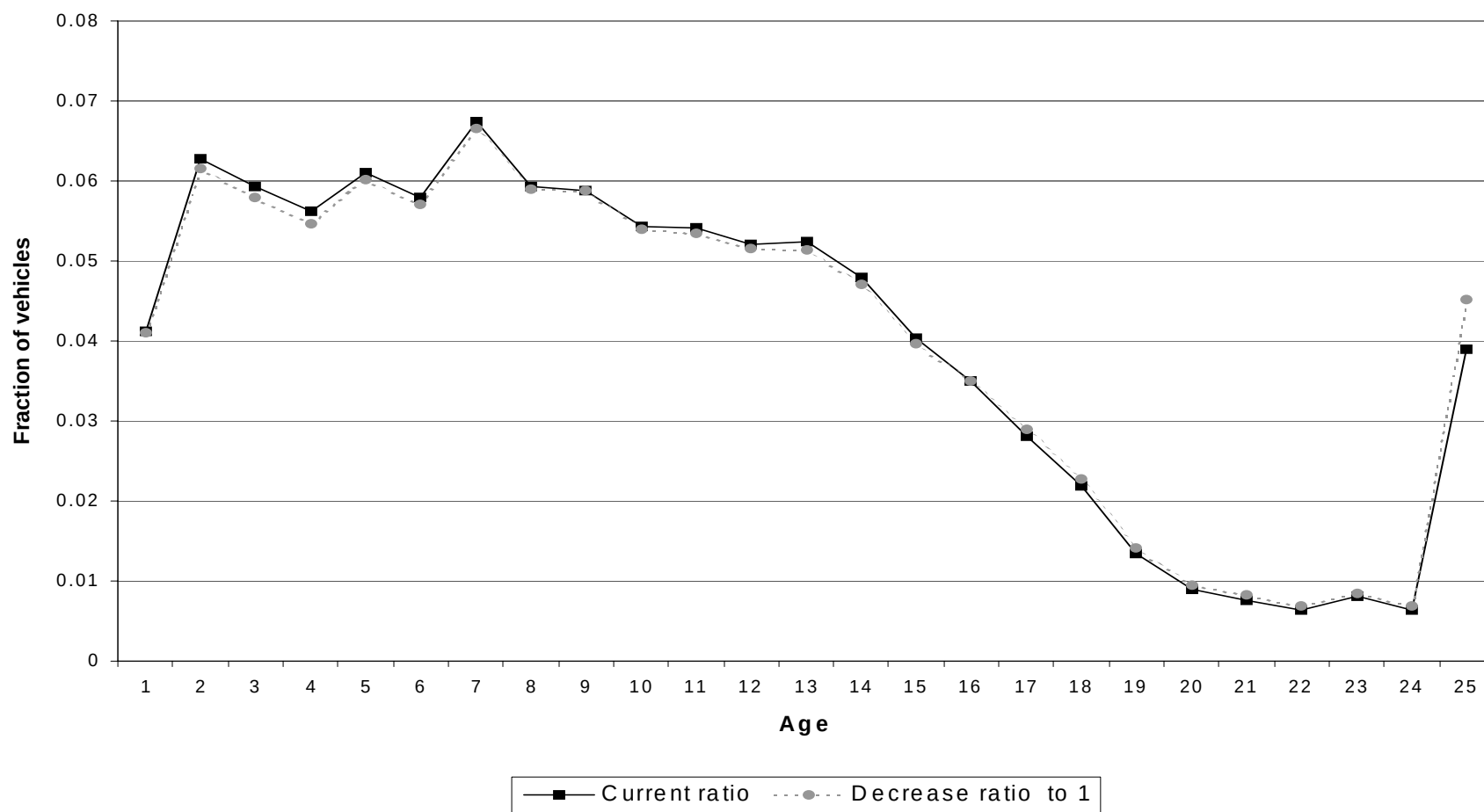


Figure 3.17: Effects of Removing the Wealth Tax on Vehicle Age Distributions in Wealth Tax States –Wealth Tax Ratio

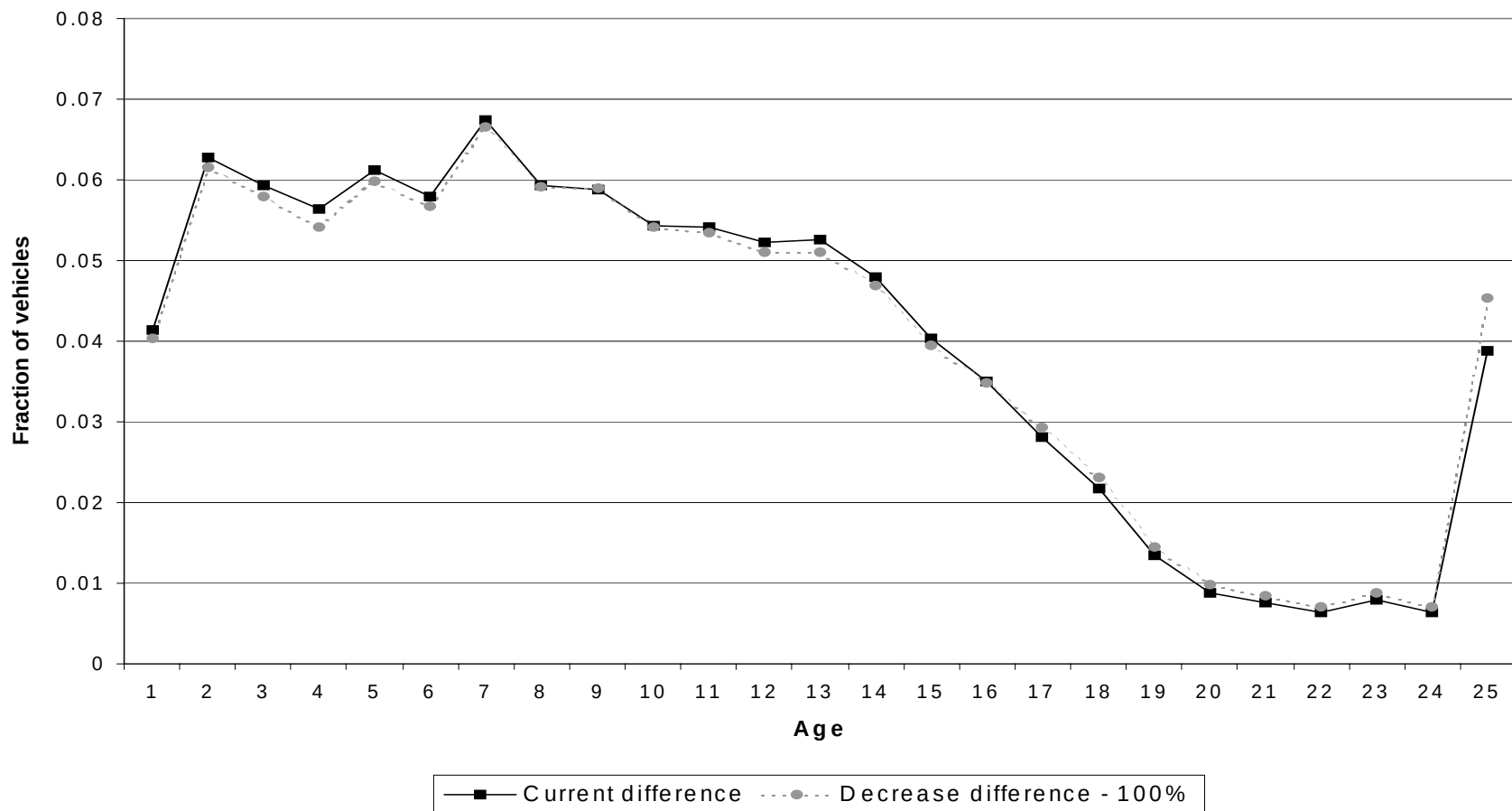


Figure 3.18: Effects of Removing the Wealth Tax on Vehicle Age Distributions in Wealth Tax States – Wealth Tax Difference

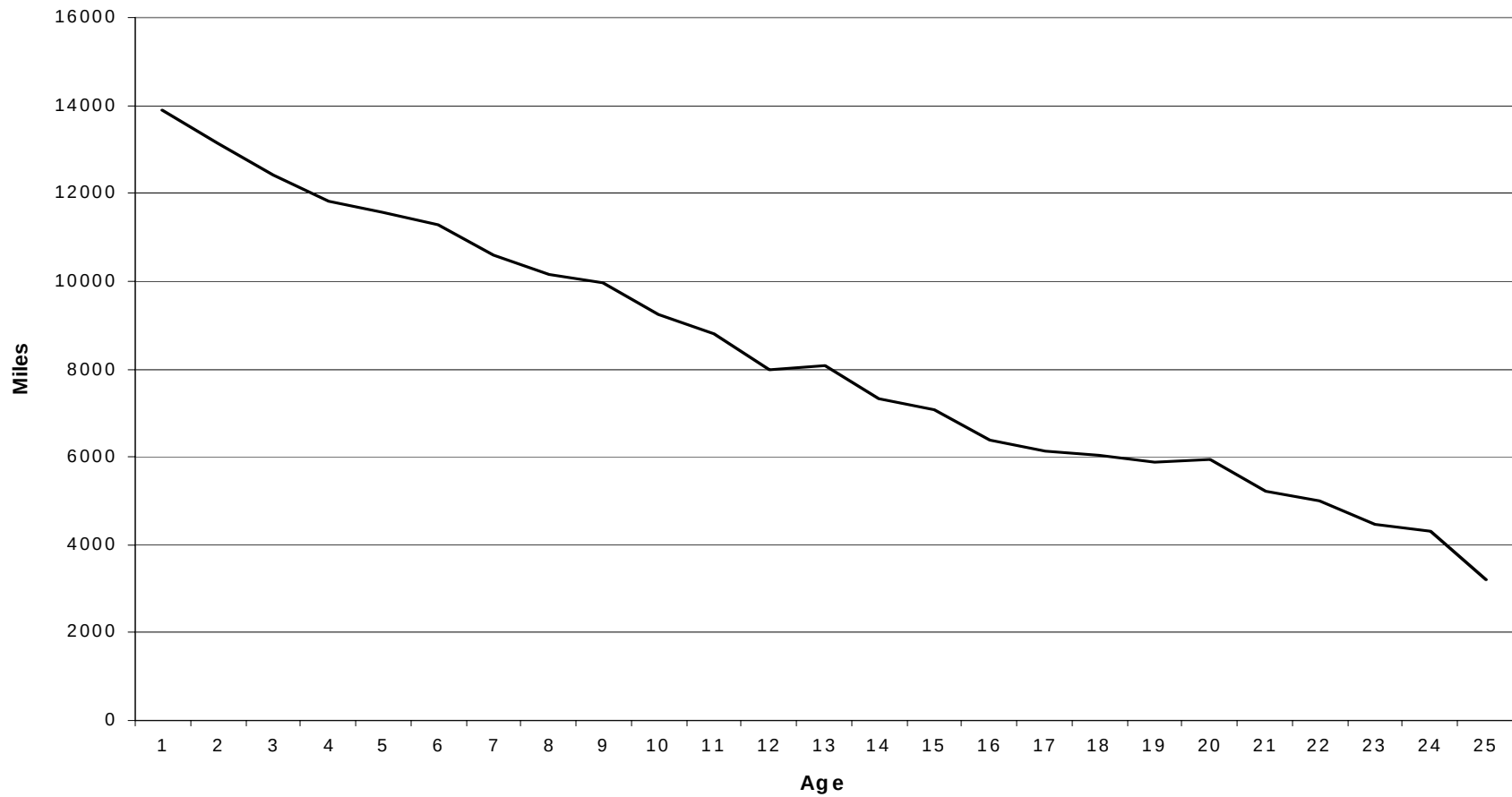


Figure 4.1: Average Vehicle Miles Traveled by Vehicle Age

Appendix B: Tables

Table 1.1: Description of Motor Vehicle Wealth Tax Provisions

State	Valuation Method	Assessment Ratio	Tax rate / Mill rate	Minimum tax	Other Comments
Alabama	NADA Blue Book	15%	Ave. = 39.16 mills Max = 57.91mills Min = 18.5 mills		
Arizona	MSRP	60% Assessed value reduced by 16.25 % for each year since vehicle was first registered in the state	\$28(new), \$28.9(used) for every \$1,000 of assessed value		
Arkansas	NADA blue book	20%	Ave. = 42.2 mills Max = 131.173 mills Min = 36.574 mills		
California	Purchase price	Varies by year of registration 1- 100% 2- 90 % 3- 80% 4- 70% 5- 60% 6- 50% 7- 70% 8- 30% 9- 25% 10- 20% 11- 15% 12+ - 15%	0.65%		Assesment ratios start over at year one if the vehicle is purchased used
Colorado	MSRP	85%	Year 1 = 2.10 % Year 2 = 1.50 % Year 3 = 1.20 % Year 4 = 0.9 % Year 5 - 9 = 0.45 % Year 10 + = \$3		
Connecticut	Average retail value as determined by local assessor	70%	Ave. = 24.84 mills Max = 62.4 mills Min = 0.27 mills		
Georgia	Value determined by Revenue Commissioner on an annual basis	40%	Ave. = 30 mills Max = 48 mills Min = 0 mills		
Indiana	Factory delivered price	100%			The amount of the tax is based on the value classification of the vehicle and the age of the vehicle in accordance with a schedule

Table 1.1: Continued

State	Valuation Method	Assessment Ratio	Tax rate / Mill rate	Minimum tax	Other Comments
Kansas	MSRP	85%	State = 1.5 mills Max combined = 131.173 Min combined = 36.574	\$24.00	Discount factors that differ by vehicle age are applied to determine the taxable value of the vehicle
Kentucky	NADA blue book	100%	State = 4.5 mills Ave. local = 9.8 mills Max local = 11 mills Min local = 0		
Maine	MSRP	100%	First or current year 24 Year 2 - 17.5 mills Year 3 - 13.5 mills Year 4 - 10 mills Year 5 - 6.5 mills Year 6 + - 4 mills	\$5.00	
Mass.	MSRP	Year prior to manufacture 50% Year 1 - 90% Year 2 - 60% Year 3 - 40% Year 4 - 25% Year 5+ - 10%	2.5%	\$5.00	
Michigan	List price	100%	Year 1 0.5 % of price; Year 2,3 and 4 - equals 90% of prior years tax; Thereafter remains the same		All vehicles with model year 1983 and earlier are taxed based upon vehicle weight.
Minnesota	MSRP	Year 1 and 2 - 100% Year 3 and 4 - 90% Year 5 and 6 - 75% Year 7 - 60% Year 8 - 40% Year 9 - 30% Year 10 - 10%	\$10 plus 1.25 % of assessed value		No Maximum tax year 1 Max for 1st renewal period = \$189 Max tax for subsequent renewal = \$99 Minimum tax = \$35 Flat tax for vehicles over ten years old=\$35
Mississippi	MSRP	Year 1 - 30 % Year 2 - 23 % Year 3 - 19 % Year 4 - 15 % Year 5 - 12 % Year 6 - 9 % Year 7 - 7% Year 8 - 5% Year 9 - 4% Year 10 - 3%	Ave. = 112 mills		5 % of assessed value is deducted if tax is paid on time. Minimum assessed value is \$100

Table 1.1: Continued

State	Valuation Method	Assessment Ratio	Tax rate / Mill rate	Minimum tax	Other Comments
Missouri	NADA blue book	33.33%	Ave. = 59.9 mills Max = 80 mills Min = 30 mills		
Montana			Years 0-4 = \$195 Years 5-10 = \$65 11 years old \$6		Age based fee became effective on January 1, 2001. In addition counties may levy up to a 0.7% tax as a local option
Nebraska	MSRP	Base tax is set in model year Then depreciated every year	Year 2 90% of base tax Year 3- 80% Year 4-70% Year 5- 60% Year 6- 51% Year 7-42% Year 8-33% Year 9-24% 10,11-15% 12,13-7% 14+ -0		Base tax ranges from \$1460 for vehicles with values of \$78,000 or greater to \$60 for vehicles with values of \$9,999 or less
Nevada	MSRP	Year 1 - 35% * MSRP Year 2 - 35%*85%*MSRP Year 3 - 35%*75% Year 4 - 35%*55% Year 5 - 35%*45% Year 6 - 35%*35% Year 7 - 35%*25% Year 8 - 35%*15% Year 9 - 35%*5%	4%	\$6	Counties may impose a supplemental services tax of not more than 1%
New Hamp.	MSRP		Current year - 18 mills Year 2 - 15 mills Year 3 - 12 mills Year 4 - 9 mills Year 5 - 6 mills Year 6+ - 3 mills	\$5	
N. Carolina	Retail market value as determined by the local county assessor	100%	Ave. = 10.5 mills Max = 19.5 mills Min = 4.2 mills		
Oklahoma			Year 1 - 4 = \$91 Year 5 - 8 = \$81 Year 9 - 12 = \$61 Year 13 - 16 = \$41 Year 17 + = \$21	\$21	
S. Carolina	NADA blue book may not exceed 95% of previous year's value	10.50%	Ave. = 268 mills (2002)		Discounts are allowed for high mileage.

Table 1.1: Continued

State	Valuation Method	Assessment Ratio	Tax rate / Mill rate	Minimum tax	Other Comments
Utah			Less than 3 = \$150 Year 3-5 = \$110 Year 6-8 = \$80 Year 9-11 = \$50 Year 12 + = \$10		Age base fee effective January 1, 1999. Old policy was a 1.5 % fee on fair market value
W. Virginia	Amount property would be worth in a sale between a buyer and seller	60%	Ave. = 26.1 mills		

Table 1.2: Motor Vehicle Wealth Tax Liabilities for the Honda Accord

	2001 Honda Accord	1998 Honda Accord	Difference (01-98)	Ratio (01/98)
Alabama	\$704	\$510	\$194	1.38
Arizona	1,738	1,073	665	1.62
Arkansas	1,011	733	278	1.38
California	724	519	205	1.39
Colorado	1,374	585	789	2.35
Connecticut	2,083	1,509	574	1.38
Georgia	1,450	1,050	400	1.38
Indiana	1,080	444	636	2.43
Kansas	1,365	613	752	2.23
Kentucky	1,713	1,241	472	1.38
Maine	1,850	971	879	1.91
Massachusetts	1,419	572	847	2.48
Michigan	627	477	150	1.31
Minnesota	1,043	629	414	1.66
Mississippi	1,909	636	1,273	3.00
Missouri	2,368	1,716	652	1.38
Montana	1,011	537	474	1.88
Nebraska	1,662	975	687	1.70
Nevada	1,267	604	663	2.10
New Hampshire	1,518	790	728	1.92
North Carolina	1,258	911	347	1.38
Oklahoma	668	583	85	1.15
South Carolina	3,372	2,443	929	1.38
Utah	823	547	276	1.50
West Virginia	1,876	1,359	517	1.38
Wyoming	1,640	1,010	630	1.62

Note: Tax liabilities represent the present value of a ten-year stream of tax liabilities.

Table 1.3: Motor Vehicle Wealth Tax Liabilities for the Ford Taurus

	2001 Ford Taurus	1998 Ford Taurus	Difference (01-98)	Ratio (01/98)
Alabama	\$342	\$187	\$155	1.83
Arizona	1,392	823	569	1.69
Arkansas	491	269	222	1.83
California	580	224	356	2.59
Colorado	1,100	450	650	2.44
Connecticut	1,012	554	458	1.83
Georgia	704	386	318	1.82
Indiana	1,080	444	636	2.43
Kansas	753	284	469	2.65
Kentucky	832	456	376	1.82
Maine	1,482	745	737	1.99
Massachusetts	1,136	438	698	2.59
Michigan	502	366	136	1.37
Minnesota	972	609	363	1.60
Mississippi	1,533	499	1,034	3.07
Missouri	1,151	630	521	1.83
Montana	1,011	537	474	1.88
Nebraska	1,271	746	525	1.70
Nevada	1,015	463	552	2.19
New Hampshire	1,216	605	611	2.01
North Carolina	611	335	276	1.82
Oklahoma	668	583	85	1.15
South Carolina	1,638	897	741	1.83
Utah	823	547	276	1.50
West Virginia	912	499	413	1.83
Wyoming	1,313	774	539	1.70

Note: Tax liabilities represent the present value of a ten-year stream of tax liabilities.

Table 2.1: Distribution of NHTS Households Across Various Characteristics

		All HHs Percent	HHs without a purchase	HHs with a purchase	Average vehicle purchase age
Motor vehicle wealth tax	Yes	49.29	24.95	24.75	5.24
	No	50.71	75.05	75.25	5.42
Purchased vehicle in 2001	Yes	24.81			
	No	75.19			
Number of vehicles purchased	1			86.26	5.16
	2			12.22	6.32
	3			1.21	7.02
	4			0.23	8.59
	5			0.08	8.40
Household size	1	21.70	25.18	11.13	5.12
	2	38.46	39.06	36.63	4.63
	3	16.00	14.53	20.46	5.31
	4	14.65	13.28	18.80	5.80
	5 or more	9.19	7.95	12.98	6.84
Race of HH respondent	Black	7.02	7.48	5.60	6.83
	White	80.87	80.40	82.28	5.08
	Other	12.12	12.12	12.12	6.34
Household income	0 - \$9,999	7.26	8.45	3.79	10.12
	\$10,000 - \$19,999	11.67	12.77	8.46	8.30
	\$20,000 - \$29,999	13.60	14.41	11.24	7.10
	\$30,000 - \$39,999	13.42	13.53	13.10	6.58
	\$40,000 - \$49,999	11.35	11.12	11.99	5.46
	\$50,000 - \$59,999	9.64	9.34	10.50	4.85
	\$60,000 - \$69,999	7.00	6.64	8.08	4.16
	\$70,000 - \$79,999	6.14	5.71	7.38	4.29
	\$80,000 or more	19.92	18.03	25.45	3.35
Education of HH respondent	Less than high school graduate	9.37	9.97	7.58	8.44
	High school graduate, or GED	30.62	30.47	31.06	5.91
	Vocational/technical training	4.08	4.10	4.05	5.75
	Some college	17.78	17.50	18.59	5.65
	Associate's Degree	7.09	6.79	7.97	5.12
	Bachelor's Degree	17.40	17.15	18.15	3.90
	Some graduate school	2.30	2.31	2.27	4.15
	Professional degree	11.37	11.71	10.33	3.69
College Degree	Yes	38.15	37.96	38.72	4.02
	No	61.85	62.04	61.28	6.13
Age of household respondent	17-25	6.27	5.41	8.87	6.67
	26-35	15.43	14.39	18.57	5.86
	36-45	21.11	19.69	25.42	5.76
	46-55	20.49	19.99	22.02	5.16
	56-65	15.31	15.85	13.68	4.50
	66 or older	21.39	24.67	11.44	3.82

Table 2.1: Continued

		All HHs Percent	HHs without a purchase	HHs with a purchase	Average vehicle purchase age
Household life cycle	No children	32.86	35.55	32.86	4.88
	Youngest child 15 or younger	39.57	29.06	39.57	6.01
	Youngest child 21 or younger	9.40	4.61	9.40	6.04
	Retired adults	18.17	30.78	18.17	4.32
Home ownership	Own	81.52	77.86	81.52	4.89
	Rent	18.07	21.72	18.07	7.33
	Provided by job or military	0.39	0.33	0.39	6.43
	Other	0.02	0.09	0.02	1.00
Number of drivers in HH	1	3.79	5.03	0.00	5.95
	2	27.77	31.24	17.25	4.93
	3	55.33	53.44	61.05	5.88
	4 or more	13.12	10.30	21.70	6.23
Number of workers in HH	0	22.99	26.44	12.54	4.77
	1	32.91	34.23	28.91	5.60
	2	36.06	33.20	44.72	5.06
	3 or more	8.02	6.12	13.83	6.17
Motor vehicle transaction tax	Yes	98.30	98.27	98.39	5.31
	No	1.70	1.73	1.61	6.98
Local option transaction tax	Yes	51.58	51.59	51.54	5.10
	No	48.42	48.41	48.46	5.55
Trade-in credit	Yes	75.84	75.60	76.56	5.30
	No	24.16	24.40	23.44	5.29
MSA category	More than 1 mil, heavy transit	15.66	16.55	12.94	3.99
	More than 1 mil, no transit	40.18	40.03	40.63	4.80
	Less than 1 mil	23.80	23.48	24.77	5.75
	Not in MSA	20.36	19.93	21.66	6.66
MSA size category	Less than 250,000	7.17	7.08	7.45	5.97
	250,000-499,999	8.60	8.50	8.93	5.78
	500,000-999,999	8.02	7.90	8.39	5.52
	1,000,000-2,999,999	22.63	22.69	22.45	4.92
	3 million or more	33.21	33.90	31.11	4.37
	Not in MSA	20.36	19.93	21.66	6.66
Public transportation use	Yes	20.22	20.80	18.47	5.17
	No	79.78	79.20	81.53	5.37
Other than auto	Automobile				5.03
	Van				5.61
Average distance to work	Less than 5 miles	54.83	57.97	45.30	5.64
	5 - 9 miles	16.96	16.07	19.65	5.21
	10 -19 miles	17.20	15.92	21.09	4.97
	20 or more miles	11.01	10.04	13.95	5.05

Table 2.1: Continued

		All HHs Percent	HHs without a purchase	HHs with a purchase	Average vehicle purchase age
Estimated annual miles	Less than 4,000				9.08
	4,000-7,999				6.07
	8,000-11,999				4.76
	12,000-19,999				3.80
	20,000 or more				3.83
Average HH fleet age	1 - 3 years	14.96	14.24	17.37	3.65
	4 - 6 years	26.45	27.16	24.11	4.01
	7 - 9 years	25.14	25.44	24.14	5.12
	10 - 12 years	16.77	16.95	16.17	6.04
	13 or more years	16.68	16.22	18.20	7.39
Total HH annual miles	Less than 11,000	34.45	39.74	21.02	6.88
	11,000 - 19,999	24.28	25.05	22.32	4.80
	20,000 - 29,999	20.09	18.29	24.66	4.68
	30,000 - 39,999	11.34	9.86	15.08	4.65
	40,000 or more	9.84	7.06	16.91	4.67

Table 2.2: Summary Statistics of Wealth Tax Measures for All NHTS Households

Variable	Number of observations	Mean	Standard deviation	Minimum	Maximum
Motor vehicle wealth tax dummy	23,278	0.48	0.50	0	1
2001 Honda Accord tax liability	23,278	588.62	750.77	0	3,372
1998 Honda Accord tax liability	23,278	380.13	507.2	0	2,443
Ratio (01/98)	23,278	1.29	0.43	1	3
Difference (01-98)	23,278	208.48	285.4	0	1,273

Table 2.3: Definitions for Variables Used in the Analysis of Household Vehicle Purchase and Age Decisions

Variable	Definition
Age	Age of the household respondent in years
Average age of HH fleet	Average age of the vehicles owned by the household excluding vehicles that were purchased in 2001 and 2002
Ave. distance to work	Average distance to work for household workers (in 10s of miles)
Ave. local transaction tax rate	Average value of the local transaction tax rates imposed by local taxing jurisdictions
College degree	Dummy variable indicating that the household respondent received a college degree
Driver count	Count of drivers in the household
Estimated miles driven	Estimated number of miles the new vehicle will be driven in the first year (in 1,000 miles)
HH black	Dummy variable indicating that the household respondent was black
HH other	Dummy variable indicating that the household respondent was not black or white
HH size	Count of all household members
Income	Income is reported in the NHTS files as a categorical variable. Households were assigned an income equal to the mid-point of their respective category
Life cycle 1	Dummy variable indicating that the household members are not retired and have no kids.
Life cycle 2	Dummy variable indicating that the household has a youngest child younger than 16
Life cycle 3	Dummy variable indicating that the household has a youngest child between the ages of 16 and 21 (Used as the reference group in the models)
Life cycle 4	Dummy variable indicating that the household is retired
MSA 1mil +, heavy trans	Dummy variable indicating that the household lives in an MSA with a population greater than one million and a heavy transit system (such as a metro line) (Used as the reference group in the model)
MSA 1mil +, no heavy trans	Dummy variable indicating that the household lives in an MSA with a population greater than one million but does not have a heavy transit system
MSA smaller than 1mil.	Dummy variable indicating that the household lives in an MSA with a population that is less than one million
Not in MSA	Dummy variable indicating that the household does not live in an MSA
Other than auto	Dummy variable indicating that at least one of the vehicles the household purchase in 2001 was something other than an automobile (such as an SUV or truck)
Own home	Dummy variable indicating that the household owned its place of residence

Table 2.3: Continued

Variable	Definition
Public transportation	Dummy variable indicating that at least one member of the household has used public transportation at least once in the past two months
Ratio vehicles to drivers	Ratio of vehicles to the number of drivers in the household
Ratio vehicles to workers	Ratio of vehicles to the number of workers in the household
State transaction tax rate	2001 transaction tax rate in the household's state of residence
Trade in credit	Dummy variable indicating that the state of the household's state of residence allowed the value of trade-in vehicles to be credited against the sales price of a newly purchased vehicle for purposes of transaction tax calculations
Total annual miles driven by HH	Total miles driven by the household in a year (in 1,000 of miles)
Wealth tax	Dummy variable indicating that the household lived in a state that imposed a wealth tax on motor vehicles in 2001
Wealth tax difference	Present value of the ten-year tax liability stream for a new 2001 Accord minus the present value of the ten-year tax liability stream for a used 1998 Accord (in \$100s)
Wealth tax ratio	Present value of the ten-year tax liability stream for a new 2001 Accord divided by the present value of the ten-year tax liability stream for a used 1998 Accord
Worker count	Count of household members with jobs

Table 2.4: Summary Statistics of Wealth Tax Measures for NHTS Households That Purchased A Vehicle

Variable	Number of observations	Mean	Standard deviation	Minimum	Maximum
Motor vehicle wealth tax dummy	5,783	0.48	0.50	0	1
2001 Honda Accord tax liability	5,783	597.02	762.85	0	3,372
1998 Honda Accord tax liability	5,783	389.37	520.15	0	2,443
Ratio (01/98)	5,783	1.28	0.42	1	3
Difference (01-98)	5,783	207.65	281.77	0	1,273

Table 2.5: Marginal Effects for the 2001 Vehicle Purchase Decision

Variable	Model		
	1	2	3
Wealth tax dummy	-0.0123** (0.0062)		
Wealth tax ratio		-0.0214*** (0.0074)	
Wealth tax difference (in \$100s)			-0.0017 (0.0011)
HH black	-0.0012 (0.0134)	-0.0022 (0.0133)	-0.0012 (0.0134)
HH other	-0.0013 (0.0099)	-0.0020 (0.0099)	-0.0022 (0.0098)
Income (in \$1,000s)	0.0007*** (0.0001)	0.0007*** (0.0001)	0.0007*** (0.0001)
College degree	-0.0274*** (0.0067)	-0.0274*** (0.0067)	-0.0274*** (0.0067)
Age	-0.0030*** (0.0003)	-0.003*** (0.0003)	-0.003*** (0.0003)
Life cycle 1 - no kids	-0.0569*** (0.0136)	-0.0571*** (0.0136)	-0.0569*** (0.0135)
Life cycle 2 - youngest less than 16	-0.0561*** (0.0147)	-0.0561*** (0.0147)	-0.056*** (0.0145)
Life cycle 4 - retired	-0.0264* (0.0160)	-0.0268* (0.0160)	-0.0267* (0.0160)
Own home	-0.0337*** (0.0090)	-0.0337*** (0.0090)	-0.0335*** (0.0091)
HH size	0.0113** (0.0048)	0.0112** (0.0048)	0.0112** (0.0047)
Worker count	0.0127** (0.0054)	0.0129** (0.0054)	0.0128** (0.0054)
Ratio vehicles to drivers	0.0983*** (0.0063)	0.098*** (0.0063)	0.0979*** (0.0058)
State transaction tax rate	0.0020 (0.0025)	0.0013 (0.0025)	0.0021 (0.0025)
Ave. local transaction tax rate	-0.0027 (0.0029)	-0.0037 (0.0029)	-0.0029 (0.0029)
MSA 1 mil +, no heavy trans.	0.0307*** (0.0098)	0.03*** (0.0098)	0.0303*** (0.0098)
MSA smaller than 1 mil	0.0429*** (0.0112)	0.0429*** (0.0112)	0.0433*** (0.0113)
Not in MSA	0.0432*** (0.0119)	0.0432*** (0.0119)	0.0434*** (0.0119)
Public transportation	-0.0127 (0.0083)	-0.0121 (0.0082)	-0.0124 (0.0082)
Ave. distance to work (in 10s of miles)	0.0075*** (0.0030)	0.0075*** (0.0030)	0.0075*** (0.0030)
Driver Count	0.0688*** (0.0071)	0.0687*** (0.0071)	0.0687*** (0.0070)
Number of observations	21,253	21,253	21,253
Pseudo R-squared	0.0596	0.0598	0.0595
Predicted probability	0.2531	0.2530	0.2531

Notes: Marginal effects that are statistically significantly different from zero at the 1, 5, and 10 percent levels are indicated with a ***, ** and * respectively.

Standard errors have been corrected for heteroskedasticity and are reported in parentheses.

Table 2.6: First Set of Robustness Checks of the Baseline Vehicle Purchase Model

Variables	Additional Variables			4th Quarter Interview		
	1	2	3	1	2	3
Wealth tax dummy	-0.0211 (0.0114)			-0.0089 (0.0062)		
Wealth tax ratio		-0.0224 (0.0115)			-0.0201 (0.0074)	
Wealth tax difference (in \$100s)			-0.0034 (0.0017)			-0.0015 (0.0011)
HH black	-0.0106 (0.0188)	-0.0120 (0.0187)	-0.0106 (0.0188)	-0.0073 (0.0132)	-0.0082 (0.0131)	-0.0073 (0.0132)
HH other	-0.0275 (0.0136)	-0.0276 (0.0136)	-0.0278 (0.0136)	-0.0048 (0.0099)	-0.0053 (0.0098)	-0.0055 (0.0098)
Income (in \$1,000s)	0.0003 (0.0002)	0.0003 (0.0002)	0.0003 (0.0002)	0.0006 (0.0001)	0.0006 (0.0001)	0.0006 (0.0001)
College degree	-0.0344 (0.0098)	-0.0345 (0.0098)	-0.0345 (0.0098)	-0.0284 (0.0067)	-0.0284 (0.0067)	-0.0284 (0.0067)
Age	-0.0039 (0.0004)	-0.0039 (0.0004)	-0.0039 (0.0004)	-0.0029 (0.0003)	-0.0029 (0.0003)	-0.0029 (0.0003)
Life cycle 1 - no kids	-0.0370 (0.0208)	-0.0374 (0.0208)	-0.0377 (0.0208)	-0.0639 (0.0134)	-0.0642 (0.0134)	-0.0640 (0.0134)
Life cycle 2 - youngest less than 16	-0.0222 (0.0229)	-0.0222 (0.0229)	-0.0227 (0.0229)	-0.0609 (0.0145)	-0.0610 (0.0145)	-0.0608 (0.0145)
Life cycle 4 - retired	0.0069 (0.0257)	0.0064 (0.0256)	0.0059 (0.0256)	-0.0293 (0.0159)	-0.0297 (0.0159)	-0.0295 (0.0159)
Own home	0.0039 (0.0128)	0.0036 (0.0128)	0.0037 (0.0128)	-0.0354 (0.0091)	-0.0354 (0.0091)	-0.0352 (0.0090)
HH size	0.0043 (0.0075)	0.0042 (0.0075)	0.0042 (0.0075)	0.0122 (0.0048)	0.0121 (0.0048)	0.0121 (0.0048)
Worker count	0.1411 (0.0191)	0.1410 (0.0191)	0.1412 (0.0191)	0.0146 (0.0054)	0.0148 (0.0054)	0.0147 (0.0054)
Ratio vehicles to drivers	0.1009 (0.0250)	0.1009 (0.0250)	0.1008 (0.0250)	0.0984 (0.0064)	0.0982 (0.0064)	0.0981 (0.0064)
State transaction tax rate	0.0035 (0.0051)	0.0041 (0.0050)	0.0040 (0.0050)	0.0031 (0.0025)	0.0022 (0.0025)	0.0030 (0.0025)
Ave. local transaction tax rate	-0.0002 (0.0044)	-0.0010 (0.0045)	-0.0007 (0.0044)	-0.0022 (0.0029)	-0.0032 (0.0029)	-0.0024 (0.0029)
MSA 1 mil +, no heavy trans.	0.0068 (0.0137)	0.0044 (0.0135)	0.0049 (0.0135)	0.0269 (0.0098)	0.0264 (0.0098)	0.0267 (0.0098)
MSA smaller than 1 mil	0.0158 (0.0158)	0.0133 (0.0157)	0.0142 (0.0157)	0.0398 (0.0112)	0.0394 (0.0112)	0.0402 (0.0112)
Not in MSA	0.0131 (0.0173)	0.0104 (0.0171)	0.0113 (0.0171)	0.0416 (0.0120)	0.0414 (0.0119)	0.0418 (0.0120)
Public transportation	-0.0203 (0.0116)	-0.0194 (0.0116)	-0.0200 (0.0116)	-0.0103 (0.0083)	-0.0099 (0.0083)	-0.0101 (0.0083)
Ave. distance to work (in 10s of miles)	-0.0024 (0.0044)	-0.0024 (0.0044)	-0.0024 (0.0044)	0.0075 (0.0030)	0.0074 (0.0030)	0.0074 (0.0030)
Trade in credit	0.0005 (0.0134)	0.0112 (0.0114)	0.0126 (0.0113)			
Ratio vehicles to workers	0.1423 (0.0216)	0.1420 (0.0216)	0.1423 (0.0216)			
Average age of hh fleet	-0.0016 (0.0012)	-0.0016 (0.0012)	-0.0016 (0.0012)			

Table 2.6: Continued

Variables	Additional Variables			4th Quarter Interview		
	1	2	3	1	2	3
Total annual miles driven by HH	0.0021 (0.0004)	0.0021 (0.0004)	0.0021 (0.0004)			
Driver Count	0.0700 (0.0154)	0.0701 (0.0154)	0.0699 (0.0154)	0.0694 (0.0070)	0.0693 (0.0070)	0.0693 (0.0070)
Sept. 2001				0.1800 (0.0057)	0.1801 (0.0057)	0.1801 (0.0057)
Number of observations	9,449	9,449	9,449	21,253	21,253	21,253
Pseudo R-squared	0.1595	0.1595	0.1595	0.0948	0.0951	0.0948
Predicted probability	0.2262	0.2262	0.2262	0.2438	0.2438	0.2439

Notes: Marginal effects that are significant at the 10 percent level or better appear in bold type.
Standard errors have been corrected for heteroskedasticity and are reported in parentheses.

Table 2.7: Second Set of Robustness Checks of the Baseline Vehicle Purchase Model

Variables	Households w/ two or More Vehicles			Ford Taurus Tax Liabilities	
	1	2	3	2	3
Wealth tax dummy	-0.0151 (0.0078)				
Wealth tax ratio		-0.0271 (0.0093)		-0.0208 (0.0050)	
Wealth tax difference (in \$100s)			-0.0027 (0.0014)		-0.0035 (0.0013)
HH black	0.0163 (0.0190)	0.0152 (0.0189)	0.0165 (0.0190)	-0.0020 (0.0133)	-0.0014 (0.0133)
HH other	-0.0052 (0.0126)	-0.0060 (0.0126)	-0.0064 (0.0126)	0.0013 (0.0100)	-0.0014 (0.0099)
Income (in \$1,000s)	0.0006 (0.0001)	0.0006 (0.0001)	0.0006 (0.0001)	0.0007 (0.0001)	0.0007 (0.0001)
College degree	-0.0341 (0.0084)	-0.0342 (0.0084)	-0.0341 (0.0084)	-0.0271 (0.0067)	-0.0273 (0.0067)
Age	-0.0032 (0.0004)	-0.0031 (0.0004)	-0.0031 (0.0004)	-0.0030 (0.0003)	-0.0030 (0.0003)
Life cycle 1 - no kids	-0.0743 (0.0160)	-0.0747 (0.0160)	-0.0745 (0.0160)	-0.0572 (0.0136)	-0.0570 (0.0136)
Life cycle 2 - youngest less than 16	-0.0734 (0.0177)	-0.0735 (0.0177)	-0.0734 (0.0177)	-0.0564 (0.0146)	-0.0563 (0.0147)
Life cycle 4 - retired	-0.0587 (0.0189)	-0.0594 (0.0189)	-0.0594 (0.0189)	-0.0265 (0.0160)	-0.0267 (0.0160)
Own home	-0.0384 (0.0128)	-0.0382 (0.0128)	-0.0380 (0.0128)	-0.0350 (0.0090)	-0.0338 (0.0090)
HH size	0.0081 (0.0060)	0.0080 (0.0060)	0.0080 (0.0060)	0.0113 (0.0048)	0.0113 (0.0048)
Worker count	0.0114 (0.0066)	0.0117 (0.0066)	0.0116 (0.0066)	0.0128 (0.0054)	0.0128 (0.0054)
Ratio vehicles to drivers	0.0877 (0.0077)	0.0874 (0.0077)	0.0872 (0.0077)	0.0986 (0.0063)	0.0980 (0.0063)
State transaction tax rate	0.0027 (0.0031)	0.0017 (0.0031)	0.0024 (0.0032)	0.0014 (0.0025)	0.0018 (0.0025)
Ave. local transaction tax rate	0.0003 (0.0037)	-0.0009 (0.0037)	0.0000 (0.0037)	-0.0022 (0.0029)	-0.0028 (0.0029)
MSA 1 mil +, no heavy trans.	0.0294 (0.0125)	0.0286 (0.0125)	0.0291 (0.0125)	0.0285 (0.0098)	0.0303 (0.0098)
MSA smaller than 1 mil	0.0433 (0.0142)	0.0430 (0.0142)	0.0441 (0.0142)	0.0400 (0.0112)	0.0429 (0.0112)
Not in MSA	0.0431 (0.0148)	0.0429 (0.0148)	0.0436 (0.0148)	0.0400 (0.0119)	0.0430 (0.0119)
Public transportation	-0.0074 (0.0106)	-0.0066 (0.0106)	-0.0071 (0.0106)	-0.0125 (0.0083)	-0.0125 (0.0083)
Ave. distance to work (in 10s of miles)	0.0072 (0.0037)	0.0071 (0.0037)	0.0071 (0.0037)	0.0077 (0.0030)	0.0075 (0.0030)
Driver Count	0.0638 (0.0094)	0.0637 (0.0094)	0.0636 (0.0094)	0.0688 (0.0071)	0.0687 (0.0071)
Number of observations	15,007	15,007	15,007	21,253	21,253
Pseudo R-squared	0.0336	0.0339	0.0336	0.0601	0.0597
Predicted probability	0.3127	0.3126	0.3184	0.2529	0.253

Notes: Marginal effects that are significant at the 10 percent level or better appear in bold type.
Standard errors have been corrected for heteroskedasticity and are reported in parentheses.

Table 2.8: OLS Regression Results for Vehicle Age Decision

Variables	Households w/ two or More Vehicles			Ford Taurus Tax Liabilities	
	1	2	3	2	3
Wealth tax dummy	-0.0151 (0.0078)				
Wealth tax ratio		-0.0271 (0.0093)		-0.0208 (0.0050)	
Wealth tax difference (in \$100s)			-0.0027 (0.0014)		-0.0035 (0.0013)
HH black	0.0163 (0.0190)	0.0152 (0.0189)	0.0165 (0.0190)	-0.0020 (0.0133)	-0.0014 (0.0133)
HH other	-0.0052 (0.0126)	-0.0060 (0.0126)	-0.0064 (0.0126)	0.0013 (0.0100)	-0.0014 (0.0099)
Income (in \$1,000s)	0.0006 (0.0001)	0.0006 (0.0001)	0.0006 (0.0001)	0.0007 (0.0001)	0.0007 (0.0001)
College degree	-0.0341 (0.0084)	-0.0342 (0.0084)	-0.0341 (0.0084)	-0.0271 (0.0067)	-0.0273 (0.0067)
Age	-0.0032 (0.0004)	-0.0031 (0.0004)	-0.0031 (0.0004)	-0.0030 (0.0003)	-0.0030 (0.0003)
Life cycle 1 - no kids	-0.0743 (0.0160)	-0.0747 (0.0160)	-0.0745 (0.0160)	-0.0572 (0.0136)	-0.0570 (0.0136)
Life cycle 2 - youngest less than 16	-0.0734 (0.0177)	-0.0735 (0.0177)	-0.0734 (0.0177)	-0.0564 (0.0146)	-0.0563 (0.0147)
Life cycle 4 - retired	-0.0587 (0.0189)	-0.0594 (0.0189)	-0.0594 (0.0189)	-0.0265 (0.0160)	-0.0267 (0.0160)
Own home	-0.0384 (0.0128)	-0.0382 (0.0128)	-0.0380 (0.0128)	-0.0350 (0.0090)	-0.0338 (0.0090)
HH size	0.0081 (0.0060)	0.0080 (0.0060)	0.0080 (0.0060)	0.0113 (0.0048)	0.0113 (0.0048)
Worker count	0.0114 (0.0066)	0.0117 (0.0066)	0.0116 (0.0066)	0.0128 (0.0054)	0.0128 (0.0054)
Ratio vehicles to drivers	0.0877 (0.0077)	0.0874 (0.0077)	0.0872 (0.0077)	0.0986 (0.0063)	0.0980 (0.0063)
State transaction tax rate	0.0027 (0.0031)	0.0017 (0.0031)	0.0024 (0.0032)	0.0014 (0.0025)	0.0018 (0.0025)
Ave. local transaction tax rate	0.0003 (0.0037)	-0.0009 (0.0037)	0.0000 (0.0037)	-0.0022 (0.0029)	-0.0028 (0.0029)
MSA 1 mil +, no heavy trans.	0.0294 (0.0125)	0.0286 (0.0125)	0.0291 (0.0125)	0.0285 (0.0098)	0.0303 (0.0098)
MSA smaller than 1 mil	0.0433 (0.0142)	0.0430 (0.0142)	0.0441 (0.0142)	0.0400 (0.0112)	0.0429 (0.0112)
Not in MSA	0.0431 (0.0148)	0.0429 (0.0148)	0.0436 (0.0148)	0.0400 (0.0119)	0.0430 (0.0119)
Public transportation	-0.0074 (0.0106)	-0.0066 (0.0106)	-0.0071 (0.0106)	-0.0125 (0.0083)	-0.0125 (0.0083)
Ave. distance to work (in 10s of miles)	0.0072 (0.0037)	0.0071 (0.0037)	0.0071 (0.0037)	0.0077 (0.0030)	0.0075 (0.0030)
Driver Count	0.0638 (0.0094)	0.0637 (0.0094)	0.0636 (0.0094)	0.0688 (0.0071)	0.0687 (0.0071)
Number of observations	15,007	15,007	15,007	21,253	21,253
Pseudo R-squared	0.0336	0.0339	0.0336	0.0601	0.0597
Predicted probability	0.3127	0.3126	0.3184	0.2529	0.253

Notes: Marginal effects that are significant at the 10 percent level or better appear in bold type.
Standard errors have been corrected for heteroskedasticity and are reported in parentheses.

Table 2.9: First Set of Robustness Checks of the Vehicle Age Model

Variable	Additional Variables			Purchased in 4th Quarter		
	1	2	3	1	2	3
Wealth tax dummy	0.1684 (0.2251)			0.1416 (0.1387)		
Wealth tax ratio		-0.0041 (0.2339)			0.1018 (0.1616)	
Wealth tax difference (in \$100s)			0.0001 (0.0004)			0.0004 (0.0002)
HH black	0.7611 (0.5432)	0.7672 (0.5417)	0.7652 (0.5426)	0.8493 (0.3398)	0.8562 (0.3395)	0.8432 (0.3396)
HH other	0.1655 (0.3017)	0.1597 (0.3018)	0.1618 (0.3020)	0.3845 (0.2145)	0.3910 (0.2147)	0.3949 (0.2146)
Income (in \$1,000s)	-0.0293 (0.0037)	-0.0292 (0.0037)	-0.0292 (0.0037)	-0.0385 (0.0025)	-0.0385 (0.0025)	-0.0385 (0.0025)
College degree	-0.6340 (0.1940)	-0.6377 (0.1940)	-0.6367 (0.1940)	-0.9641 (0.1407)	-0.9650 (0.1407)	-0.9660 (0.1407)
Age	-0.0183 (0.0084)	-0.0184 (0.0084)	-0.0184 (0.0084)	-0.0251 (0.0060)	-0.0252 (0.0060)	-0.0253 (0.0060)
Life cycle 1 - no kids	-0.8039 (0.3500)	-0.8046 (0.3499)	-0.8031 (0.3502)	-1.0688 (0.2649)	-1.0676 (0.2647)	-1.0633 (0.2649)
Life cycle 2 - youngest less than 16	-0.6659 (0.4083)	-0.6699 (0.4078)	-0.6686 (0.4079)	-1.0645 (0.2789)	-1.0663 (0.2787)	-1.0624 (0.2789)
Life cycle 4 - retired	-1.2088 (0.4669)	-1.2120 (0.4672)	-1.2084 (0.4676)	-1.5359 (0.3359)	-1.5313 (0.3361)	-1.5231 (0.3362)
Own home	-0.8766 (0.3188)	-0.8746 (0.3193)	-0.8736 (0.3193)	-1.5016 (0.2072)	-1.5007 (0.2072)	-1.5010 (0.2072)
HH size	0.5235 (0.1555)	0.5236 (0.1557)	0.5238 (0.1556)	0.6001 (0.0919)	0.6012 (0.0919)	0.6015 (0.0918)
Worker count	-0.5938 (0.2521)	-0.5914 (0.2525)	-0.5917 (0.2525)	-0.0101 (0.1046)	-0.0102 (0.1046)	-0.0111 (0.1046)
Ratio vehicles to drivers	1.4059 (0.3747)	1.4031 (0.3748)	1.4036 (0.3748)	1.5768 (0.1507)	1.5786 (0.1507)	1.5810 (0.1507)
State transaction tax rate	0.2396 (0.1038)	0.2041 (0.1009)	0.2124 (0.1011)	4.0771 (6.2936)	3.6564 (6.2987)	4.8005 (6.3220)
Ave. local transaction tax rate	0.1946 (0.0922)	0.1842 (0.0939)	0.1880 (0.0929)	9.9706 (6.4052)	10.0910 (6.4743)	10.3690 (6.4152)
MSA 1 mil +, no heavy trans.	0.8515 (0.2549)	0.8869 (0.2500)	0.8816 (0.2506)	0.7942 (0.1898)	0.8069 (0.1885)	0.7960 (0.1888)
MSA smaller than 1 mil	1.6522 (0.3043)	1.6741 (0.3035)	1.6717 (0.3036)	1.3741 (0.2156)	1.3792 (0.2158)	1.3670 (0.2158)
Not in MSA	2.0945 (0.3419)	2.1266 (0.3403)	2.1215 (0.3405)	1.9715 (0.2401)	1.9818 (0.2400)	1.9667 (0.2399)
Public transportation	0.3565 (0.2324)	0.3521 (0.2324)	0.3527 (0.2324)	0.4397 (0.1791)	0.4342 (0.1788)	0.4406 (0.1789)
Other than auto	-0.9874 (0.1939)	-0.9849 (0.1939)	-0.9853 (0.1938)	-0.7935 (0.1404)	-0.7913 (0.1404)	-0.7952 (0.1404)
Ave. distance to work (in 10s of miles)	-0.0391 (0.0939)	-0.0417 (0.0941)	-0.0412 (0.0940)	-0.1321 (0.0626)	-0.1317 (0.0626)	-0.1316 (0.0625)
Estimated miles driven (in 1,000s of miles)	-0.2118 (0.0169)	-0.2118 (0.0169)	-0.2117 (0.0169)			
Trade in credit	0.2672 (0.2569)	0.1699 (0.2294)	0.1704 (0.2297)			
Ratio vehicles to workers	-0.4445 (0.2952)	-0.4411 (0.2957)	-0.4415 (0.2957)			
Average age of hh fleet	0.1746 (0.0245)	0.1746 (0.0244)	0.1745 (0.0244)			
Total annual miles driven by HH	0.0538 (0.0095)	0.0540 (0.0095)	0.0539 (0.0095)			
Purchased in 4th quarter				-0.4404 (0.1429)	-0.4413 (0.1429)	-0.4400 (0.1429)
Constant	4.9637 (1.1542)	5.2961 (1.1919)	5.2321 (1.1097)	6.4852 (0.6506)	6.4289 (0.7052)	6.4364 (0.6514)
Number of observations	2,505	2,505	2,505	5,656	5,656	5,656
R-squared	0.2564	0.2562	0.2562	0.1719	0.1718	0.1721

Notes: Coefficients that are significant at the 10 percent level or better appear in bold type.
Standard errors have been corrected for heteroskedasticity and are reported in parentheses.

Table 2.10: Second Set of Robustness Checks of the Vehicle Age Model

Variable	Households w/ two or More Vehicles			Ford Taurus Tax Liabilities	
	1	2	3	2	3
Wealth tax dummy	0.0809 (0.1501)				
Wealth tax ratio		0.1161 (0.1792)		0.1684 (0.1163)	
Wealth tax difference (in \$100s)			0.0003 (0.0003)		0.0004 (0.0003)
HH black	1.0860 (0.4037)	1.0922 (0.4030)	1.0791 (0.4037)	0.8544 (0.3399)	0.8457 (0.3398)
HH other	0.3855 (0.2366)	0.3891 (0.2369)	0.3948 (0.2370)	0.3719 (0.2144)	0.3898 (0.2142)
Income (in \$1,000s)	-0.0368 (0.0027)	-0.0368 (0.0027)	-0.0368 (0.0027)	-0.0388 (0.0025)	-0.0388 (0.0025)
College degree	-0.8928 (0.1519)	-0.8937 (0.1520)	-0.8937 (0.1519)	-0.9658 (0.1406)	-0.9667 (0.1406)
Age	-0.0210 (0.0067)	-0.0212 (0.0067)	-0.0212 (0.0067)	-0.0250 (0.0060)	-0.0251 (0.0060)
Life cycle 1 - no kids	-1.2221 (0.2719)	-1.2186 (0.2718)	-1.2170 (0.2719)	-1.0574 (0.2649)	-1.0540 (0.2650)
Life cycle 2 - youngest less than 16	-0.9668 (0.2885)	-0.9665 (0.2883)	-0.9644 (0.2885)	-1.0448 (0.2790)	-1.0411 (0.2790)
Life cycle 4 - retired	-1.4749 (0.3550)	-1.4671 (0.3554)	-1.4631 (0.3553)	-1.5237 (0.3363)	-1.5154 (0.3366)
Own home	-1.4366 (0.2509)	-1.4348 (0.2509)	-1.4354 (0.2509)	-1.5013 (0.2077)	-1.5063 (0.2076)
HH size	0.5080 (0.1024)	0.5091 (0.1023)	0.5091 (0.1023)	0.5983 (0.0920)	0.5980 (0.0920)
Worker count	0.0464 (0.1114)	0.0455 (0.1114)	0.0448 (0.1114)	-0.0148 (0.1047)	-0.0146 (0.1047)
Ratio vehicles to drivers	1.6358 (0.1620)	1.6365 (0.1620)	1.6376 (0.1619)	1.5640 (0.1495)	1.5686 (0.1496)
State transaction tax rate	6.3655 (6.4692)	6.5380 (6.4632)	7.1905 (6.4702)	4.3037 (6.2345)	4.5299 (6.2517)
Ave. local transaction tax rate	3.9607 (6.9391)	4.3190 (6.9865)	4.3271 (6.9348)	9.1733 (6.3677)	9.7938 (6.3901)
MSA 1 mil +, no heavy trans.	0.7173 (0.2088)	0.7226 (0.2076)	0.7159 (0.2079)	0.7846 (0.1878)	0.7705 (0.1883)
MSA smaller than 1 mil	1.3778 (0.2374)	1.3802 (0.2375)	1.3723 (0.2375)	1.3641 (0.2158)	1.3446 (0.2152)
Not in MSA	1.8963 (0.2605)	1.8996 (0.2603)	1.8904 (0.2603)	1.9733 (0.2401)	1.9543 (0.2397)
Public transportation	0.4029 (0.1916)	0.4001 (0.1914)	0.4050 (0.1914)	0.4526 (0.1792)	0.4551 (0.1792)
Other than auto	-0.8860 (0.1496)	-0.8852 (0.1496)	-0.8884 (0.1495)	-0.8072 (0.1406)	-0.8092 (0.1405)
Ave. distance to work (in 10s of miles)	-0.1159 (0.0664)	-0.1155 (0.0664)	-0.1155 (0.0664)	-0.1312 (0.0627)	-0.1310 (0.0626)
Constant	6.1375 (0.7111)	6.0082 (0.7608)	6.0745 (0.7107)	6.2089 (0.6775)	6.3705 (0.6494)
Number of observations	4,778	4,778	4,778	5,656	5,656
R-squared	0.1599	0.1599	0.1600	0.1707	0.1708

Notes: Coefficients that are significant at the 10 percent level or better appear in bold type.
Standard errors have been corrected for heteroskedasticity and are reported in parentheses.

Table 2.11: Third Set of Robustness Checks of the Vehicle Age Model

Variable	Vehicle as Unit of Analysis			Heckman Selection Model		
	1	2	3	1	2	3
Wealth tax dummy	0.0753 (0.1404)			0.1480 (0.1385)		
Wealth tax ratio		0.0520 (0.1652)			0.1331 (0.1716)	
Wealth tax difference (in \$100s)			0.0302 (0.0250)			0.0354 (0.0247)
HH black	0.9547 (0.3476)	0.9580 (0.3474)	0.9500 (0.3475)	0.9860 (0.3021)	0.9947 (0.3025)	0.9813 (0.3022)
HH other	0.2779 (0.2093)	0.2811 (0.2094)	0.2847 (0.2094)	0.4202 (0.2139)	0.4276 (0.2140)	0.4318 (0.2140)
Income (in \$1,000s)	-0.0401 (0.0026)	-0.0401 (0.0026)	-0.0401 (0.0026)	-0.0409 (0.0031)	-0.0409 (0.0031)	-0.0409 (0.0031)
College degree	-0.9377 (0.1448)	-0.9382 (0.1448)	-0.9392 (0.1448)	-0.8996 (0.1610)	-0.8977 (0.1611)	-0.8987 (0.1611)
Age	-0.0259 (0.0061)	-0.0260 (0.0061)	-0.0261 (0.0061)	-0.0184 (0.0088)	-0.0183 (0.0088)	-0.0184 (0.0088)
Life cycle 1 - no kids	-1.1345 (0.2725)	-1.1336 (0.2724)	-1.1280 (0.2726)	-0.9737 (0.3190)	-0.9644 (0.3196)	-0.9615 (0.3193)
Life cycle 2 - youngest less than 16	-1.1588 (0.2833)	-1.1587 (0.2832)	-1.1551 (0.2835)	-0.9524 (0.3551)	-0.9440 (0.3554)	-0.9417 (0.3552)
Life cycle 4 - retired	-1.7627 (0.3376)	-1.7594 (0.3379)	-1.7501 (0.3381)	-1.5065 (0.3418)	-1.4984 (0.3423)	-1.4915 (0.3422)
Own home	-1.4233 (0.2066)	-1.4228 (0.2067)	-1.4229 (0.2066)	-1.5715 (0.1990)	-1.5681 (0.1990)	-1.5693 (0.1989)
HH size	0.6123 (0.0950)	0.6127 (0.0950)	0.6135 (0.0950)	0.5139 (0.1089)	0.5123 (0.1088)	0.5125 (0.1089)
Worker count	-0.0842 (0.1082)	-0.0839 (0.1082)	-0.0859 (0.1083)	-0.0689 (0.1283)	-0.0729 (0.1287)	-0.0733 (0.1285)
Ratio vehicles to drivers	1.5998 (0.1553)	1.6000 (0.1554)	1.6019 (0.1552)	1.3518 (0.2310)	1.3456 (0.2308)	1.3481 (0.2307)
State transaction tax rate	0.0093 (0.0656)	0.0066 (0.0659)	0.0203 (0.0663)	0.0321 (0.0562)	0.0297 (0.0563)	0.0389 (0.0566)
Ave. local transaction tax rate	0.1132 (0.0672)	0.1137 (0.0679)	0.1182 (0.0674)	0.0958 (0.0641)	0.0990 (0.0649)	0.1001 (0.0642)
MSA 1 mil +, no heavy trans.	0.8057 (0.1897)	0.8125 (0.1885)	0.8015 (0.1887)	0.6824 (0.2292)	0.6921 (0.2285)	0.6815 (0.2289)
MSA smaller than 1 mil	1.4066 (0.2189)	1.4093 (0.2191)	1.3991 (0.2190)	1.2100 (0.2596)	1.2113 (0.2594)	1.1987 (0.2602)
Not in MSA	1.9688 (0.2407)	1.9738 (0.2405)	1.9589 (0.2406)	1.7678 (0.2726)	1.7734 (0.2723)	1.7586 (0.2729)
Public transportation	0.4253 (0.1768)	0.4221 (0.1766)	0.4279 (0.1766)	0.5235 (0.1849)	0.5190 (0.1846)	0.5253 (0.1848)
Other than auto	-0.9411 (0.1383)	-0.9402 (0.1383)	-0.9437 (0.1383)			
Ave. distance to work (in 10s of miles)	-0.1186 (0.0626)	-0.1182 (0.0626)	-0.1182 (0.0625)	-0.1529 (0.0643)	-0.1530 (0.0643)	-0.1530 (0.0643)
Constant	6.8598 (0.6605)	6.8348 (0.7139)	6.7757 (0.6629)	7.3549 (1.4766)	7.3065 (1.4472)	7.3643 (1.4811)
Mills ratio				-0.7097 (0.9528)	-0.7500 (0.9541)	-0.7479 (0.9546)
Number of observations	6,551	6,551	6,551	5,656	5,656	5,656
R-squared	0.1647	0.1647	0.1649			

Notes: Coefficients that are significant at the 10 percent level or better appear in bold type.
Standard errors have been corrected for heteroskedasticity and are reported in parentheses.

Table 2.12: Fourth Set of Robustness Checks of the Vehicle Age Model

Variable	Vehicle as Unit of Analysis			Heckman Selection Model		
	1	2	3	1	2	3
Wealth tax dummy	0.0753 (0.1404)			0.1480 (0.1385)		
Wealth tax ratio		0.0520 (0.1652)			0.1331 (0.1716)	
Wealth tax difference (in \$100s)			0.0302 (0.0250)			0.0354 (0.0247)
HH black	0.9547 (0.3476)	0.9580 (0.3474)	0.9500 (0.3475)	0.9860 (0.3021)	0.9947 (0.3025)	0.9813 (0.3022)
HH other	0.2779 (0.2093)	0.2811 (0.2094)	0.2847 (0.2094)	0.4202 (0.2139)	0.4276 (0.2140)	0.4318 (0.2140)
Income (in \$1,000s)	-0.0401 (0.0026)	-0.0401 (0.0026)	-0.0401 (0.0026)	-0.0409 (0.0031)	-0.0409 (0.0031)	-0.0409 (0.0031)
College degree	-0.9377 (0.1448)	-0.9382 (0.1448)	-0.9392 (0.1448)	-0.8996 (0.1610)	-0.8977 (0.1611)	-0.8987 (0.1611)
Age	-0.0259 (0.0061)	-0.0260 (0.0061)	-0.0261 (0.0061)	-0.0184 (0.0088)	-0.0183 (0.0088)	-0.0184 (0.0088)
Life cycle 1 - no kids	-1.1345 (0.2725)	-1.1336 (0.2724)	-1.1280 (0.2726)	-0.9737 (0.3190)	-0.9644 (0.3196)	-0.9615 (0.3193)
Life cycle 2 - youngest less than 16	-1.1588 (0.2833)	-1.1587 (0.2832)	-1.1551 (0.2835)	-0.9524 (0.3551)	-0.9440 (0.3554)	-0.9417 (0.3552)
Life cycle 4 - retired	-1.7627 (0.3376)	-1.7594 (0.3379)	-1.7501 (0.3381)	-1.5065 (0.3418)	-1.4984 (0.3423)	-1.4915 (0.3422)
Own home	-1.4233 (0.2066)	-1.4228 (0.2067)	-1.4229 (0.2066)	-1.5715 (0.1990)	-1.5681 (0.1990)	-1.5693 (0.1989)
HH size	0.6123 (0.0950)	0.6127 (0.0950)	0.6135 (0.0950)	0.5139 (0.1089)	0.5123 (0.1088)	0.5125 (0.1089)
Worker count	-0.0842 (0.1082)	-0.0839 (0.1082)	-0.0859 (0.1083)	-0.0689 (0.1283)	-0.0729 (0.1287)	-0.0733 (0.1285)
Ratio vehicles to drivers	1.5998 (0.1553)	1.6000 (0.1554)	1.6019 (0.1552)	1.3518 (0.2310)	1.3456 (0.2308)	1.3481 (0.2307)
State transaction tax rate	0.0093 (0.0656)	0.0066 (0.0659)	0.0203 (0.0663)	0.0321 (0.0562)	0.0297 (0.0563)	0.0389 (0.0566)
Ave. local transaction tax rate	0.1132 (0.0672)	0.1137 (0.0679)	0.1182 (0.0674)	0.0958 (0.0641)	0.0990 (0.0649)	0.1001 (0.0642)
MSA 1 mil +, no heavy trans.	0.8057 (0.1897)	0.8125 (0.1885)	0.8015 (0.1887)	0.6824 (0.2292)	0.6921 (0.2285)	0.6815 (0.2289)
MSA smaller than 1 mil	1.4066 (0.2189)	1.4093 (0.2191)	1.3991 (0.2190)	1.2100 (0.2596)	1.2113 (0.2594)	1.1987 (0.2602)
Not in MSA	1.9688 (0.2407)	1.9738 (0.2405)	1.9589 (0.2406)	1.7678 (0.2726)	1.7734 (0.2723)	1.7586 (0.2729)
Public transportation	0.4253 (0.1768)	0.4221 (0.1766)	0.4279 (0.1766)	0.5235 (0.1849)	0.5190 (0.1846)	0.5253 (0.1848)
Other than auto	-0.9411 (0.1383)	-0.9402 (0.1383)	-0.9437 (0.1383)			
Ave. distance to work (in 10s of miles)	-0.1186 (0.0626)	-0.1182 (0.0626)	-0.1182 (0.0625)	-0.1529 (0.0643)	-0.1530 (0.0643)	-0.1530 (0.0643)
Constant	6.8598 (0.6605)	6.8348 (0.7139)	6.7757 (0.6629)	7.3549 (1.4766)	7.3065 (1.4472)	7.3643 (1.4811)
Mills ratio				-0.7097 (0.9528)	-0.7500 (0.9541)	-0.7479 (0.9546)
Number of observations	6,551	6,551	6,551	5,656	5,656	5,656
R-squared	0.1647	0.1647	0.1649			

Notes: Coefficients that are significant at the 10 percent level or better appear in bold type.
Standard errors have been corrected for heteroskedasticity and are reported in parentheses.

Table 3.1: Variables Used in the Analysis of Vehicle Age Distributions

Variable	Definition	Source
Age 15 to 21	Percent of the state's population between the ages of 15 and 21	U.S. Census Bureau
Ave. gas price	Average price per gallon as of 7/3/01	Nebraska Department of Roads www.nebraskatransportation.org/transplan.pdfs/mftax7-01.pdf Accessed on 1/12/04
Ave. local sales tax rate	Average local sales tax rate on the transaction of automobiles in 2001	2001 U.S. Master Sales and Use Tax Guide
Average HH size	Average size of households in the state in 2000	U.S. Census Bureau
College degree	Percent of population with at least some type of college degree in 2000	U.S. Census Bureau
GSP per capita	Gross state product per capita 2001(in millions of dollars)	Created from data from the Bureau of Economic Analysis and the U.S. Census
HH age 65	Percent of households with at least one member above the age of 65 in 2000	U.S. Census Bureau
Home ownership rate	Homeownership rate in 2001.	U.S. Census Bureau
I/M Program	Percent of states population that lives in an area subject to an I/M program	Authors calculations based on data collected from the EPA and various state web sites
Income per capita	Income per capita in 2001	Bureau of Economic Analysis
Median age	Median age of the states population in 2000.	U.S. Census Bureau
Percent living in MSA	Percent of a state's population living in an MSA in 2000	U.S. Census Bureau
Percent black	Percent of a state's population that was black in 2000	U.S. Census Bureau
Percent other	Percent of a state's population that was another race in 2000	U.S. Census Bureau
Public transportation trips	Total number of passenger trips on public transportation in the state in 2001 (in 1,000s)	2001 National Transit Database (by the Federal Transit Administration)
Region 1 (New England)	M.E., N.H., V.T., M.A., R.I., C.T.	Transportation Research Board
Region 2 (Upper Mid Atlantic)	N.Y., P.A., N.J., D.E., M.D.	Transportation Research Board
Region 3 (Lower Mid Atlantic)	W.V., V.A., N.C, K.Y., T.N.	Transportation Research Board
Region 4 (South)	S.C., G.A., F.L., A.L., M.S., L.A., T.X.	Transportation Research Board
Region 5 (Great Lakes)	W.I., I.L., I.N., O.H., M.I.	Transportation Research Board
Region 6 (Lower Plains)	K.S., M.O., A.K., O.K.	Transportation Research Board
Region 7 (Upper Plains)	N.D., S.D., N.E., I.O., M.N.	Transportation Research Board

Table 3.1: Continued

Variable	Definition	Source
Region 8 (Mountain)	M.T., W.Y., C.O., N.M., U.T., I.D.	Transportation Research Board
Region 9 (Pacific West)	A.Z., C.A., N.V., O.R., W.A.	Transportation Research Board
State sales tax rate	State sales tax rate on the transaction of automobiles in 2001	2001 U.S. Master Sales and Use Tax Guide
Total miles driven per HH	Total number of miles driven in the state per household in 2001	Created from data from the Federal Highway Administration and the U.S. Census Bureau
Unemployment rate	Unemployment rate in 2001	U.S. Bureau of Labor Statistics

Table 3.2: Mean Vehicle Age by State and Wealth Tax Status

	Wealth Tax States				Non-Wealth Tax States		
	Number of observations	Mean	Standard deviation		Number of observations	Mean	Standard deviation
Alabama	2,173,589	10.19	6.04	Delaware	411,278	9.12	5.80
Arizona	1,892,366	9.66	6.60	Florida	7,993,229	8.74	5.81
Arkansas	1,024,107	9.42	5.75	Idaho	467,609	11.17	6.51
California	14,483,688	9.90	6.32	Illinois	6,205,690	9.28	5.75
Colorado	1,714,662	10.01	6.55	Iowa	1,500,954	10.72	6.39
Connecticut	1,936,393	9.68	6.00	Louisiana	1,884,627	9.74	6.05
Georgia	3,632,941	9.39	6.01	Maryland	2,692,618	8.81	5.69
Indiana	2,972,128	9.92	5.95	New Jersey	4,581,918	9.41	6.13
Kansas	1,225,883	10.30	6.27	New Mexico	721,107	10.24	6.46
Kentucky	1,824,706	9.76	5.74	New York	8,067,403	9.71	5.82
Maine	2,094,789	9.74	6.00	North Dakota	327,241	11.71	6.51
Massachusetts	3,303,218	8.76	5.40	Ohio	6,048,923	9.38	5.73
Michigan	5,211,896	9.66	6.02	Oregon	1,481,621	11.49	7.01
Minnesota	2,273,032	9.57	5.59	Pennsylvania	6,096,801	9.40	5.83
Mississippi	1,064,186	9.67	5.67	South Dakota	378,659	10.90	6.36
Missouri	2,565,450	9.65	6.05	Tennessee	2,602,446	10.23	6.17
Montana	380,662	11.69	6.74	Texas	7,773,282	8.87	5.84
Nebraska	760,163	10.39	6.32	Vermont	319,091	9.20	5.62
Nevada	721,208	9.41	6.61	Washington	2,434,280	10.63	6.50
New Hampshire	707,095	9.42	5.81	Wisconsin	2,570,009	9.35	5.49
North Carolina	3,649,510	9.32	5.83				
Oklahoma	1,504,854	10.28	6.35				
Rhode Island	531,478	9.27	5.56				
South Carolina	1,687,930	9.90	5.94				
Utah	794,540	9.66	5.77				
Virginia	3,642,497	9.41	5.79				
West Virginia	773,223	9.75	5.80				
Wyoming	161,788	11.16	6.74				
All wealth tax	64,707,982	9.71	6.06	All non-wealth tax	64,558,786	9.46	5.96

Table 3.3: Descriptive Statistics by Wealth Tax Status

Variable	All (N=48)				Wealth tax (N=28)				Non-wealth tax (N=20)			
	Mean	Std. Dev.	Minimum	Maximum	Mean	Std. Dev.	Minimum	Maximum	Mean	Std. Dev.	Minimum	Maximum
Ave. gas price	1.58	0.16	1.32	2.01	1.57	0.18	1.32	2.01	1.59	0.11	1.33	1.79
Ave. household size	2.55	0.12	2.39	3.13	2.55	0.14	2.39	3.13	2.55	0.09	2.41	2.74
Ave. local sales tax rate	0.73	1.01	0.00	4.32	0.68	0.83	0.00	2.65	0.81	1.20	0.00	4.32
Car total	2,693,058	2,714,389	161,788	14,500,000	2,310,999	2,630,502	161,788	14,500,000	3,227,939	2,742,135	319,091	8,067,403
College degree	24.84	4.33	15.30	34.60	24.43	5.02	15.30	34.60	25.41	3.04	20.00	32.30
GSP per capita (in millions of \$)	0.034	0.006	0.023	0.051	0.033	0.006	0.023	0.048	0.035	0.005	0.028	0.051
Home ownership rate	70.28	4.91	53.90	77.10	70.94	4.93	58.20	77.10	69.36	4.73	53.90	76.60
I/M Programs	37.19	36.92	0.00	100.00	30.65	37.54	0.00	100.00	46.34	34.02	0.00	100.00
Income per capita	28,976.96	4,463.26	21,653.00	42,377.00	28,657.04	4,761.03	21,653.00	42,377.00	29,424.85	3,970.95	23,081.00	38,625.00
Median age	35.59	1.87	27.10	38.90	35.44	2.08	27.10	38.90	35.80	1.49	32.30	38.70
Percent black	10.21	9.57	0.30	36.34	10.18	9.86	0.30	36.34	10.24	9.15	0.42	32.49
Percent living in MSA	68.34	20.42	27.80	100.00	66.89	19.79	30.00	96.70	70.38	21.13	27.80	100.00
Percent other	8.96	6.81	1.79	33.77	8.49	6.86	1.79	33.77	9.62	6.69	2.72	31.36
Population age 15 to 21	10.25	0.91	8.51	13.69	10.27	0.92	8.69	13.69	10.23	0.90	8.51	11.84
Population over 65	22.85	2.27	17.32	30.02	22.51	2.19	17.32	26.91	23.33	2.30	19.94	30.02
Public transportation trips	16.33	25.61	0.37	163.54	10.77	13.36	0.37	61.45	24.11	34.96	1.27	163.54
Region 1	0.13	0.33	0	1	0.18	0.38	0	1	0.05	0.22	0	1
Region 2	0.10	0.31	0	1	0.00	0.00	0	0	0.25	0.43	0	1
Region 3	0.10	0.31	0	1	0.14	0.35	0	1	0.05	0.22	0	1
Region 4	0.15	0.35	0	1	0.14	0.35	0	1	0.15	0.36	0	1
Region 5	0.10	0.31	0	1	0.07	0.26	0	1	0.15	0.36	0	1
Region 6	0.08	0.28	0	1	0.14	0.35	0	1	0.00	0.00	0	0
Region 7	0.10	0.31	0	1	0.07	0.26	0	1	0.15	0.36	0	1
Region 8	0.13	0.33	0	1	0.14	0.35	0	1	0.10	0.30	0	1
Region 9	0.10	0.31	0	1	0.11	0.31	0	1	0.10	0.30	0	1
State sales tax rate	4.39	1.88	0.00	7.00	4.23	1.91	0.00	7.00	4.60	1.82	0.00	6.50
Tax liability - new Honda *	816.37	845.39	0.00	3,372.00	1,444.35	597.39	627.00	3,372.00	0	0	0	0
Tax liability - used Honda *	500.80	557.61	0.00	2,443.00	886.04	456.75	444.00	2,443.00	0	0	0	0
Total miles driven per HH	12.42	2.40	7.61	23.54	12.91	2.58	9.44	23.54	11.73	1.93	7.61	15.27
Unemployment rate	4.49	0.84	2.90	6.40	4.45	0.75	3.10	5.50	4.55	0.95	2.90	6.40
Vehicle age	13	7.214109	1	25	13	7.216259	1	25	13	7.218324	1	25
Vehicle total	4,358,818	4,247,774	548,948	23,400,000	3,824,874	4,204,960	739,533	23,400,000	5,106,339	4,198,435	548,948	14,000,000
Wealth tax difference *	315.57	344.36	0.00	1,273.00	558.31	272.41	85.00	1,273.00	0	0	0	0
Wealth tax dummy	0.58	0.49	0	1	1	0	1	1	0	0	0	0
Wealth tax ratio *	1.41	0.49	1.00	3.00	1.72	0.45	1.15	3.00	1	0	1	1

Notes: A * denotes Virginia and Rhode Island were excluded from the calculations.

Table 3.4: Weighted Descriptive Statistics by Wealth Tax Status

Variable	All (N=129,266,768)				Wealth tax (N=64,707,982)				Non-wealth tax (N=64,558,786)			
	Mean	Std. Dev.	Minimum	Maximum	Mean	Std. Dev.	Minimum	Maximum	Mean	Std. Dev.	Minimum	Maximum
Ave. gas price	1.61	0.20	1.32	2.01	1.63	0.24	1.32	2.01	1.58	0.13	1.33	1.79
Ave. household size	2.59	0.14	2.39	3.13	2.61	0.16	2.39	3.13	2.57	0.10	2.41	2.74
Ave. local sales tax rate	0.92	1.09	0.00	4.32	0.83	0.88	0.00	2.65	1.00	1.26	0.00	4.32
Car total	5,426,666	3,971,991	161,788	14,500,000	5,300,898	5,060,010	161,788	14,500,000	5,552,725	2,428,015	319,091	8,067,403
College Degree	25.62	3.83	15.30	34.60	25.51	4.61	15.30	34.60	25.73	2.83	20.00	32.30
GSP per capita (in millions of \$)	0.035	0.005	0.023	0.051	0.035	0.006	0.023	0.048	0.036	0.005	0.028	0.051
Home ownership rate	68.21	6.54	53.90	77.10	69.03	6.98	58.20	77.10	67.38	5.96	53.90	76.60
I/M Programs	48.56	37.21	0.00	100.00	45.55	41.51	0.00	100.00	51.57	32.05	0.00	100.00
Income per capita	30,523.78	4,109.57	21,653.00	42,377.00	30,051.40	4,405.80	21,653.00	42,377.00	30,997.26	3,729.94	23,081.00	38,625.00
Median age	35.45	1.81	27.10	38.90	35.00	1.67	27.10	38.90	35.91	1.83	32.30	38.70
Percent black	12.23	7.72	0.30	36.34	11.49	8.80	0.30	36.34	12.98	6.38	0.42	32.49
Percent living in MSA	80.03	15.76	27.80	100.00	76.74	17.72	30.00	96.70	83.34	12.68	27.80	100.00
Percent other	11.65	9.34	1.79	33.77	13.12	11.77	1.79	33.77	10.18	5.61	2.72	31.36
Population age 15 to 21	9.93	0.73	8.51	13.69	10.07	0.63	8.69	13.69	9.80	0.79	8.51	11.84
Population over 65	23.10	2.66	17.32	30.02	22.17	1.81	17.32	26.91	24.02	3.02	19.94	30.02
Public transportation trips	29.26	37.99	0.37	163.54	18.09	16.98	0.37	61.45	40.45	48.48	1.27	163.54
Region 1	0.07	0.25	0	1	0.13	0.34	0	1	0.00	0.07	0	1
Region 2	0.17	0.37	0	1	0.00	0.00	0	0	0.34	0.47	0	1
Region 3	0.10	0.30	0	1	0.15	0.36	0	1	0.04	0.20	0	1
Region 4	0.20	0.40	0	1	0.13	0.34	0	1	0.27	0.45	0	1
Region 5	0.18	0.38	0	1	0.13	0.33	0	1	0.23	0.42	0	1
Region 6	0.05	0.22	0	1	0.10	0.30	0	1	0.00	0.00	0	0
Region 7	0.04	0.20	0	1	0.05	0.21	0	1	0.03	0.18	0	1
Region 8	0.03	0.18	0	1	0.05	0.21	0	1	0.02	0.13	0	1
Region 9	0.16	0.37	0	1	0.26	0.44	0	1	0.06	0.24	0	1
State sales tax rate	5.02	1.40	0.00	7.00	4.72	1.46	0.00	7.00	5.32	1.27	0.00	6.50
Tax liability - new Honda *	604.41	755.14	0.00	3,372.00	1,249.02	610.95	627.00	3,372.00	0	0	0	0
Tax liability - used Honda *	386.23	501.82	0.00	2,443.00	798.14	437.75	444.00	2,443.00	0	0	0	0
Total miles driven per HH	11.74	2.07	7.61	23.54	12.52	1.39	9.44	23.54	10.96	2.32	7.61	15.27
Unemployment rate	4.71	0.72	2.90	6.40	4.66	0.78	3.10	5.50	4.76	0.65	2.90	6.40
Vehicle age	9.58	6.01	1	25	9.71	6.06	1	25	9.46	5.96	1	25
Vehicle total	8,607,522	6,389,017	548,948	23,400,000	8,580,621	8,190,296	739,533	23,400,000	8,634,486	3,807,359	548,948	14,000,000
Wealth tax difference *	218.18	295.53	0.00	1,273.00	450.87	274.89	85.00	1,273.00	0	0	0	0
Wealth tax Dummy	0.50	0.50	0	1	1	0	1	1	0	0	0	0
Wealth tax ratio *	1.30	0.43	1.00	3.00	1.62	0.42	1.15	3.00	1	0	1	1

Notes: A * denotes Virginia and Rhode Island were excluded from the calculations.
The number of observations for these variables is 60,534,007.

Table 3.5: Multinomial Logit Model Coefficients (Base Category is New Car)

Vehicle age	Wealth tax dummy	GSP per capita	Income per capita	Unemployment rate	State sales tax rate	Ave. local sales tax rate
2	-0.036	-12.864	0.00004	0.036	-0.032	0.035
3	-0.019	-14.185	0.00004	0.057	-0.034	0.037
4	-0.008	-20.525	0.00005	0.046	-0.035	0.014
5	-0.038	-26.889	0.00006	0.020	-0.030	0.011
6	-0.031	-30.158	0.00007	0.010	-0.024	0.016
7	-0.041	-30.729	0.00007	0.019	-0.031	0.022
8	-0.028	-34.030	0.00008	0.020	-0.028	0.014
9	-0.026	-39.710	0.00009	0.035	-0.037	0.024
10	-0.003	-38.471	0.00010	0.053	-0.031	0.037
11	-0.010	-37.893	0.00010	0.065	-0.031	0.042
12	0.017	-37.274	0.00010	0.063	-0.026	0.042
13	0.039	-35.331	0.00009	0.062	-0.038	0.046
14	0.031	-37.856	0.00011	0.068	-0.045	0.058
15	0.044	-41.316	0.00012	0.061	-0.053	0.065
16	0.032	-36.879	0.00012	0.080	-0.055	0.079
17	-0.061	-29.268	0.00012	0.121	-0.069	0.084
18	-0.113	-31.209	0.00013	0.140	-0.075	0.102
19	-0.149	-28.523	0.00013	0.155	-0.079	0.109
20	-0.200	-26.401	0.00014	0.160	-0.082	0.136
21	-0.208	-29.018	0.00014	0.175	-0.092	0.140
22	-0.194	-39.837	0.00017	0.181	-0.102	0.146
23	-0.147	-39.389	0.00015	0.152	-0.090	0.135
24	-0.181	-46.431	0.00016	0.159	-0.102	0.138
25	-0.206	-63.585	0.00020	0.037	-0.124	0.103

Notes: Coefficients that appear in bold are **not** statistically significant at the 10 percent level or better.

A ** indicates the coefficient is only statistically significant at the 5 percent level.

A * indicates the coefficient is only statistically significant at the 10 percent level.

Table 3.5: Continued

Vehicle age	Percent black	Percent other	College degree	Median age	HH age 65	Age 15 to 21
2	0.001	0.005	-0.001	-0.074	0.046	0.090
3	0.001**	0.002	-0.004	-0.091	0.047	0.081
4	0.002	0.003	0.002	-0.054	0.041	0.173
5	0.005	0.003	-0.001	-0.084	0.043	0.217
6	0.007	0.004	-0.004	-0.074	0.036	0.231
7	0.009	0.005	-0.008	-0.066	0.032	0.230
8	0.010	0.003	-0.012	-0.049	0.029	0.255
9	0.006	0.002	-0.016	-0.032	0.028	0.287
10	0.006	0.003	-0.018	-0.020	0.027	0.338
11	0.004	0.005	-0.017	0.024	0.013	0.388
12	0.006	0.005	-0.019	0.061	0.009	0.429
13	0.007	0.003	-0.025	0.087	0.015	0.428
14	0.008	0.002	-0.028	0.112	0.016	0.449
15	0.010	0.003	-0.033	0.132	0.019	0.454
16	0.008	0.007	-0.035	0.112	0.024	0.433
17	0.005	0.010	-0.039	0.031	0.030	0.327
18	0.005	0.013	-0.045	0.017	0.029	0.325
19	0.006	0.015	-0.046	0.005	0.031	0.288
20	0.003	0.024	-0.047	0.010**	0.024	0.317
21	0.004	0.020	-0.058	0.002	0.020	0.288
22	0.003	0.014	-0.059	-0.030	0.032	0.271
23	0.005	0.014	-0.053	-0.067	0.038	0.251
24	0.004	0.016	-0.057	-0.102	0.041	0.236
25	0.007	0.020	-0.070	-0.174	0.033	0.248

Notes: Coefficients that appear in bold are **not** statistically significant at the 10 percent level or better.

A ** indicates the coefficient is only statistically significant at the 5 percent level.

A * indicates the coefficient is only statistically significant at the 10 percent level.

Table 3.5: Continued

Vehicle age	Average HH size	MSA	Home ownership rate	Average gas price	Public trans. trips	Miles traveled per HH
2	-0.484	-0.007	0.005	-0.263	-0.001	0.005
3	-0.600	-0.008	0.003	-0.275	-0.001	0.009
4	-0.484	-0.008	0.001	-0.549	-0.001	0.004
5	-0.855	-0.009	0.005	-0.492	-0.001	0.001
6	-0.879	-0.009	0.004	-0.519	-0.001	-0.004
7	-0.842	-0.009	0.006	-0.528	0.000	0.000
8	-0.829	-0.008	0.003	-0.546	0.000	0.009
9	-0.851	-0.008	0.003	-0.571	0.000	0.013
10	-0.959	-0.010	0.000	-0.582	0.000*	0.013
11	-0.730	-0.010	0.001**	-0.494	0.000	0.011
12	-0.534	-0.009	-0.001	-0.595	0.000	0.012
13	-0.217	-0.007	-0.002	-0.528	0.000	0.017
14	0.096	-0.007	-0.002	-0.616	0.000	0.015
15	0.271	-0.007	-0.002	-0.693	0.000	0.017
16	0.178	-0.007	0.002	-0.800	0.000	0.023
17	-0.312	-0.009	0.010	-0.915	0.001	0.030
18	-0.332	-0.011	0.014	-0.918	0.000	0.028
19	-0.315	-0.014	0.012	-1.005	-0.001	0.029
20	-0.208	-0.016	0.011	-1.123	-0.003	0.022
21	-0.344	-0.015	0.009	-1.245	-0.003	0.032
22	-0.653	-0.017	0.007	-1.322	-0.004	0.033
23	-1.111	-0.018	0.006	-1.331	-0.004	0.040
24	-1.483	-0.018	0.010	-1.357	-0.004	0.043
25	-2.494	-0.014	0.009	-1.105	-0.003	0.010

Notes: Coefficients that appear in bold are **not** statistically significant at the 10 percent level or better.

A ** indicates the coefficient is only statistically significant at the 5 percent level.

A * indicates the coefficient is only statistically significant at the 10 percent level.

Table 3.5: Continued

Vehicle age	I/M programs	Region								Constant
		1	2	3	4	6	7	8	9	
2	0.001	0.113	0.076	0.037	-0.026	-0.051	0.091	-0.153	-0.027	1.912
3	0.001	0.052	-0.003	-0.054	-0.131	-0.059	0.153	-0.245	-0.157	3.105
4	0.002	0.106	0.066	0.063	-0.019	-0.023	0.180	-0.120	0.037	1.154
5	0.002	0.207	0.056	0.151	0.029	0.070	0.208	0.000	0.179	2.333
6	0.002	0.218	0.049	0.175	0.051	0.089	0.231	0.053	0.166	2.221
7	0.002	0.254	0.035	0.183	0.032	0.076	0.265	0.005	0.145	1.956
8	0.001	0.222	-0.005	0.178	-0.028	0.051	0.281	0.043	0.155	1.022
9	0.002	0.163	0.001	0.201	0.006*	0.015	0.284	0.055	0.150	0.114
10	0.001	0.089	0.016	0.146	-0.057	-0.055	0.234	0.015**	0.078	-0.679
11	0.002	0.023	0.003	0.133	-0.068	-0.032	0.252	0.014*	0.156	-3.205
12	0.002	0.080	0.044	0.164	-0.093	-0.075	0.290	0.080	0.174	-5.282
13	0.002	0.061	-0.054	0.138	-0.185	-0.143	0.315	0.002	0.110	-7.067
14	0.002	0.128	-0.023	0.193	-0.190	-0.135	0.352	0.085	0.179	-9.149
15	0.002	0.162	0.033	0.270	-0.162	-0.141	0.381	0.199	0.332	-10.740
16	0.001	0.145	0.027	0.209	-0.208	-0.155	0.308	0.205	0.319	-10.028
17	0.000	0.312	0.103	0.206	-0.095	-0.036	0.327	0.292	0.411	-5.730
18	0.000	0.357	0.173	0.259	-0.050	0.030	0.377	0.342	0.511	-5.746
19	-0.001	0.447	0.219	0.299	0.021	0.133	0.479	0.489	0.649	-5.309
20	-0.002	0.615	0.410	0.359	0.129	0.235	0.459	0.570	0.799	-6.141
21	-0.002	0.610	0.392	0.287	0.048	0.195	0.578	0.641	0.871	-4.917
22	-0.001	0.523	0.440	0.326	0.133	0.208	0.649	0.757	1.034	-3.272
23	0.000	0.313	0.322	0.213	0.009	0.116	0.632	0.582	0.919	0.070
24	0.000	0.322	0.342	0.254	0.040	0.166	0.639	0.632	1.016	1.752
25	-0.001	0.321	0.317	0.299	0.066	0.354	0.722	0.939	1.251	8.948

Notes: Coefficients that appear in bold are **not** statistically significant at the 10 percent level or better.

A ** indicates the coefficient is only statistically significant at the 5 percent level.

A * indicates the coefficient is only statistically significant at the 10 percent level.

Table 3.6: Relative Risk Ratios (Base Category is New Car)

Vehicle age	Wealth tax dummy	GSP per capita	Income per capita	Unemployment rate	State sales tax rate	Ave. local sales tax rate
2	0.96	0.00	1.00	1.04	0.97	1.04
3	0.98	0.00	1.00	1.06	0.97	1.04
4	0.99	0.00	1.00	1.05	0.97	1.01
5	0.96	0.00	1.00	1.02	0.97	1.01
6	0.97	0.00	1.00	1.01	0.98	1.02
7	0.96	0.00	1.00	1.02	0.97	1.02
8	0.97	0.00	1.00	1.02	0.97	1.01
9	0.97	0.00	1.00	1.04	0.96	1.02
10	1.00	0.00	1.00	1.05	0.97	1.04
11	0.99	0.00	1.00	1.07	0.97	1.04
12	1.02	0.00	1.00	1.07	0.97	1.04
13	1.04	0.00	1.00	1.06	0.96	1.05
14	1.03	0.00	1.00	1.07	0.96	1.06
15	1.05	0.00	1.00	1.06	0.95	1.07
16	1.03	0.00	1.00	1.08	0.95	1.08
17	0.94	0.00	1.00	1.13	0.93	1.09
18	0.89	0.00	1.00	1.15	0.93	1.11
19	0.86	0.00	1.00	1.17	0.92	1.12
20	0.82	0.00	1.00	1.17	0.92	1.15
21	0.81	0.00	1.00	1.19	0.91	1.15
22	0.82	0.00	1.00	1.20	0.90	1.16
23	0.86	0.00	1.00	1.16	0.91	1.14
24	0.83	0.00	1.00	1.17	0.90	1.15
25	0.81	0.00	1.00	1.04	0.88	1.11

Table 3.6: Continued

Vehicle age	Percent black	Percent other	College degree	Median age	HH age 65	Age 15 to 21
2	1.00	1.01	1.00	0.93	1.05	1.09
3	1.00	1.00	1.00	0.91	1.05	1.08
4	1.00	1.00	1.00	0.95	1.04	1.19
5	1.01	1.00	1.00	0.92	1.04	1.24
6	1.01	1.00	1.00	0.93	1.04	1.26
7	1.01	1.01	0.99	0.94	1.03	1.26
8	1.01	1.00	0.99	0.95	1.03	1.29
9	1.01	1.00	0.98	0.97	1.03	1.33
10	1.01	1.00	0.98	0.98	1.03	1.40
11	1.00	1.00	0.98	1.02	1.01	1.47
12	1.01	1.01	0.98	1.06	1.01	1.54
13	1.01	1.00	0.98	1.09	1.02	1.53
14	1.01	1.00	0.97	1.12	1.02	1.57
15	1.01	1.00	0.97	1.14	1.02	1.57
16	1.01	1.01	0.97	1.12	1.02	1.54
17	1.01	1.01	0.96	1.03	1.03	1.39
18	1.00	1.01	0.96	1.02	1.03	1.38
19	1.01	1.02	0.96	1.01	1.03	1.33
20	1.00	1.02	0.95	1.01	1.02	1.37
21	1.00	1.02	0.94	1.00	1.02	1.33
22	1.00	1.01	0.94	0.97	1.03	1.31
23	1.00	1.01	0.95	0.94	1.04	1.29
24	1.00	1.02	0.94	0.90	1.04	1.27
25	1.01	1.02	0.93	0.84	1.03	1.28

Table 3.6: Continued

Vehicle age	Average HH size	MSA	Home ownership rate	Average gas price	Public trans. trips	Miles traveled per HH
2	0.62	0.99	1.01	0.77	1.00	1.01
3	0.55	0.99	1.00	0.76	1.00	1.01
4	0.62	0.99	1.00	0.58	1.00	1.00
5	0.43	0.99	1.00	0.61	1.00	1.00
6	0.42	0.99	1.00	0.60	1.00	1.00
7	0.43	0.99	1.01	0.59	1.00	1.00
8	0.44	0.99	1.00	0.58	1.00	1.01
9	0.43	0.99	1.00	0.56	1.00	1.01
10	0.38	0.99	1.00	0.56	1.00	1.01
11	0.48	0.99	1.00	0.61	1.00	1.01
12	0.59	0.99	1.00	0.55	1.00	1.01
13	0.80	0.99	1.00	0.59	1.00	1.02
14	1.10	0.99	1.00	0.54	1.00	1.02
15	1.31	0.99	1.00	0.50	1.00	1.02
16	1.19	0.99	1.00	0.45	1.00	1.02
17	0.73	0.99	1.01	0.40	1.00	1.03
18	0.72	0.99	1.01	0.40	1.00	1.03
19	0.73	0.99	1.01	0.37	1.00	1.03
20	0.81	0.98	1.01	0.33	1.00	1.02
21	0.71	0.98	1.01	0.29	1.00	1.03
22	0.52	0.98	1.01	0.27	1.00	1.03
23	0.33	0.98	1.01	0.26	1.00	1.04
24	0.23	0.98	1.01	0.26	1.00	1.04
24	0.08	0.99	1.01	0.33	1.00	1.01

Table 3.6: Continued

Vehicle age	Average HH size	MSA	Home ownership rate	Average gas price	Public trans. trips	Miles traveled per HH
2	0.62	0.99	1.01	0.77	1.00	1.01
3	0.55	0.99	1.00	0.76	1.00	1.01
4	0.62	0.99	1.00	0.58	1.00	1.00
5	0.43	0.99	1.00	0.61	1.00	1.00
6	0.42	0.99	1.00	0.60	1.00	1.00
7	0.43	0.99	1.01	0.59	1.00	1.00
8	0.44	0.99	1.00	0.58	1.00	1.01
9	0.43	0.99	1.00	0.56	1.00	1.01
10	0.38	0.99	1.00	0.56	1.00	1.01
11	0.48	0.99	1.00	0.61	1.00	1.01
12	0.59	0.99	1.00	0.55	1.00	1.01
13	0.80	0.99	1.00	0.59	1.00	1.02
14	1.10	0.99	1.00	0.54	1.00	1.02
15	1.31	0.99	1.00	0.50	1.00	1.02
16	1.19	0.99	1.00	0.45	1.00	1.02
17	0.73	0.99	1.01	0.40	1.00	1.03
18	0.72	0.99	1.01	0.40	1.00	1.03
19	0.73	0.99	1.01	0.37	1.00	1.03
20	0.81	0.98	1.01	0.33	1.00	1.02
21	0.71	0.98	1.01	0.29	1.00	1.03
22	0.52	0.98	1.01	0.27	1.00	1.03
23	0.33	0.98	1.01	0.26	1.00	1.04
24	0.23	0.98	1.01	0.26	1.00	1.04
24	0.08	0.99	1.01	0.33	1.00	1.01

Table 3.7: Discrete Change in Predicted Probabilities

Vehicle age	Wealth Tax Dummy	Dummy Variables							
		Region							
		1	2	3	4	6	7	8	9
1	0.0011	-0.0065	-0.0023	-0.0059	0.0019	-0.0001	-0.0103	-0.0042	-0.0092
2	-0.0005	-0.0035	0.0012	-0.0072	0.0013	-0.0033	-0.0114	-0.0150	-0.0158
3	0.0005	-0.0067	-0.0035	-0.0116	-0.0050	-0.0036	-0.0074	-0.0186	-0.0208
4	0.0011	-0.0035	0.0005	-0.0051	0.0015	-0.0014	-0.0057	-0.0119	-0.0111
5	-0.0006	0.0023	0.0000	-0.0003	0.0047	0.0042	-0.0045	-0.0063	-0.0041
6	-0.0002	0.0028	-0.0005	0.0012	0.0058	0.0052	-0.0030	-0.0030	-0.0046
7	-0.0009	0.0058	-0.0015	0.0019	0.0054	0.0051	-0.0012	-0.0065	-0.0067
8	0.0000	0.0031	-0.0036	0.0013	0.0010	0.0029	-0.0001	-0.0037	-0.0053
9	0.0001	-0.0004	-0.0032	0.0027	0.0031	0.0008	0.0000	-0.0030	-0.0056
10	0.0014	-0.0042	-0.0022	-0.0005	-0.0006	-0.0030	-0.0027	-0.0048	-0.0087
11	0.0010	-0.0076	-0.0029	-0.0012	-0.0012	-0.0019	-0.0017	-0.0049	-0.0049
12	0.0024	-0.0046	-0.0007	0.0005	-0.0025	-0.0040	0.0003	-0.0014	-0.0039
13	0.0035	-0.0055	-0.0056	-0.0009	-0.0071	-0.0073	0.0017	-0.0054	-0.0070
14	0.0028	-0.0020	-0.0038	0.0019	-0.0066	-0.0063	0.0034	-0.0010	-0.0033
15	0.0029	-0.0003	-0.0010	0.0049	-0.0045	-0.0055	0.0041	0.0039	0.0035
16	0.0021	-0.0008	-0.0010	0.0019	-0.0054	-0.0052	0.0009	0.0036	0.0025
17	-0.0009	0.0042	0.0013	0.0015	-0.0014	-0.0011	0.0013	0.0056	0.0048
18	-0.0019	0.0044	0.0026	0.0024	-0.0001	0.0006	0.0021	0.0056	0.0063
19	-0.0016	0.0041	0.0023	0.0020	0.0009	0.0018	0.0028	0.0058	0.0062
20	-0.0015	0.0046	0.0035	0.0019	0.0016	0.0022	0.0016	0.0048	0.0060
21	-0.0013	0.0038	0.0028	0.0010	0.0007	0.0015	0.0024	0.0048	0.0059
22	-0.0010	0.0025	0.0027	0.0011	0.0012	0.0014	0.0026	0.0051	0.0067
23	-0.0009	0.0011	0.0022	0.0004	0.0004	0.0009	0.0031	0.0043	0.0067
24	-0.0009	0.0010	0.0019	0.0006	0.0005	0.0010	0.0025	0.0038	0.0063
25	-0.0066	0.0058	0.0105	0.0055	0.0042	0.0148	0.0191	0.0423	0.0560
Average Change	0.0015	0.0037	0.0025	0.0026	0.0027	0.0034	0.0038	0.0072	0.0089

Table 3.7: Continued

Vehicle age	One-Unit Change					
	Median age	avehhsz00	rate01	localave01	avegasprice	unmprate01
1	0.0006	0.0242	0.0017	-0.0017	0.0235	-0.0021
2	-0.0037	0.0076	0.0006	-0.0005	0.0198	-0.0010
3	-0.0046	0.0004	0.0004	-0.0003	0.0179	0.0003
4	-0.0022	0.0068	0.0003	-0.0016	0.0015	-0.0003
5	-0.0042	-0.0147	0.0007	-0.0019	0.0051	-0.0020
6	-0.0034	-0.0152	0.0009	-0.0016	0.0032	-0.0024
7	-0.0034	-0.0152	0.0007	-0.0014	0.0031	-0.0022
8	-0.0020	-0.0127	0.0008	-0.0017	0.0017	-0.0019
9	-0.0010	-0.0139	0.0002	-0.0011	0.0002	-0.0010
10	-0.0002	-0.0186	0.0005	-0.0003	-0.0004	0.0001
11	0.0022	-0.0065	0.0006	0.0000	0.0044	0.0007
12	0.0041	0.0038	0.0008	0.0000	-0.0010	0.0006
13	0.0054	0.0201	0.0001	0.0002	0.0025	0.0005
14	0.0062	0.0336	-0.0002	0.0007	-0.0020	0.0008
15	0.0060	0.0356	-0.0005	0.0009	-0.0048	0.0004
16	0.0045	0.0274	-0.0005	0.0013	-0.0079	0.0010
17	0.0013	0.0080	-0.0008	0.0012	-0.0095	0.0020
18	0.0007	0.0058	-0.0008	0.0013	-0.0074	0.0019
19	0.0003	0.0038	-0.0005	0.0009	-0.0057	0.0014
20	0.0002	0.0034	-0.0004	0.0008	-0.0048	0.0009
21	0.0001	0.0019	-0.0004	0.0007	-0.0049	0.0009
22	-0.0001	-0.0003	-0.0004	0.0006	-0.0046	0.0008
23	-0.0004	-0.0037	-0.0004	0.0007	-0.0058	0.0008
24	-0.0005	-0.0052	-0.0004	0.0006	-0.0047	0.0006
25	-0.0058	-0.0763	-0.0030	0.0022	-0.0193	-0.0005
Average Change	0.00252	0.01459	0.00065	0.00097	0.00663	0.00108

Table 3.7: Continued

One-Standard Deviation Change							
Vehicle age		Percent black	Percent other	College degree	HH age 65	Age 15 to 21	Home ownership rate
	1	-0.0021	-0.0014	0.0032	-0.0026	-0.0102	-0.0006
	2	-0.0029	0.0001	0.0047	0.0026	-0.0107	0.0007
	3	-0.0028	-0.0012	0.0036	0.0026	-0.0106	0.0001
	4	-0.0018	-0.0010	0.0050	0.0016	-0.0052	-0.0007
	5	-0.0002	-0.0011	0.0044	0.0020	-0.0032	0.0005
	6	0.0009	-0.0005	0.0034	0.0009	-0.0023	0.0002
	7	0.0020	0.0001	0.0029	0.0005	-0.0027	0.0009
	8	0.0024	-0.0008	0.0014	0.0002	-0.0010	0.0001
	9	0.0003	-0.0014	0.0004	0.0000	0.0007	-0.0001
	10	0.0001	-0.0007	0.0001	-0.0001	0.0032	-0.0007
	11	-0.0006	-0.0001	0.0002	-0.0019	0.0057	-0.0006
	12	0.0004	0.0000	-0.0002	-0.0023	0.0075	-0.0012
	13	0.0009	-0.0007	-0.0015	-0.0016	0.0075	-0.0012
	14	0.0011	-0.0010	-0.0021	-0.0014	0.0077	-0.0012
	15	0.0016	-0.0005	-0.0027	-0.0009	0.0067	-0.0010
	16	0.0009	0.0004	-0.0026	-0.0004	0.0051	-0.0003
	17	-0.0001	0.0009	-0.0026	0.0001	0.0014	0.0010
	18	-0.0002	0.0011	-0.0025	0.0000	0.0010	0.0012
	19	0.0001	0.0009	-0.0016	0.0001	0.0002	0.0006
	20	-0.0002	0.0011	-0.0011	-0.0001	0.0003	0.0003
	21	-0.0001	0.0008	-0.0013	-0.0001	0.0001	0.0002
	22	-0.0001	0.0004	-0.0011	0.0001	0.0000	0.0001
	23	0.0000	0.0004	-0.0011	0.0002	-0.0002	0.0001
	24	-0.0001	0.0004	-0.0010	0.0002	-0.0002	0.0002
	25	0.0004	0.0037	-0.0081	0.0004	-0.0009	0.0010
Average Change		0.00089	0.00083	0.00236	0.00091	0.00376	0.00059

Table 3.7: Continued

Vehicle age	One-Standard Deviation Change					
	MSA	Public trans. trips	Miles traveled per HH	I/M programs	GSP per capita	Income per capita
1	0.0071	0.0005	-0.0010	-0.0018	0.0074	-0.0157
2	0.0026	-0.0014	-0.0008	-0.0011	0.0068	-0.0126
3	0.0011	-0.0013	-0.0002	-0.0004	0.0059	-0.0117
4	0.0003	-0.0008	-0.0009	0.0013	0.0035	-0.0094
5	-0.0006	-0.0002	-0.0014	0.0010	0.0015	-0.0060
6	-0.0010	-0.0002	-0.0020	0.0007	0.0003	-0.0045
7	-0.0009	0.0001	-0.0018	0.0011	0.0001	-0.0048
8	0.0007	0.0009	-0.0003	0.0002	-0.0011	-0.0025
9	0.0004	0.0013	0.0003	0.0012	-0.0031	0.0011
10	-0.0012	0.0006	0.0003	0.0005	-0.0024	0.0028
11	-0.0013	0.0004	0.0000	0.0007	-0.0023	0.0027
12	0.0000	0.0010	0.0002	0.0012	-0.0020	0.0030
13	0.0013	0.0013	0.0008	0.0019	-0.0014	0.0020
14	0.0014	0.0011	0.0006	0.0011	-0.0020	0.0046
15	0.0017	0.0009	0.0007	0.0016	-0.0025	0.0064
16	0.0015	0.0005	0.0010	0.0000	-0.0012	0.0050
17	-0.0001	0.0008	0.0013	-0.0015	0.0003	0.0037
18	-0.0012	0.0001	0.0009	-0.0014	0.0000	0.0041
19	-0.0015	-0.0002	0.0006	-0.0010	0.0002	0.0027
20	-0.0013	-0.0006	0.0002	-0.0010	0.0002	0.0019
21	-0.0010	-0.0005	0.0004	-0.0008	0.0001	0.0018
22	-0.0011	-0.0005	0.0003	-0.0004	-0.0003	0.0022
23	-0.0015	-0.0006	0.0005	-0.0005	-0.0004	0.0022
24	-0.0012	-0.0005	0.0005	-0.0003	-0.0005	0.0021
25	-0.0042	-0.0027	-0.0001	-0.0025	-0.0070	0.0189
Average Change 	0.00145	0.00076	0.00068	0.00101	0.00210	0.00538

Table 3.8: MNLM Coefficients for the Wealth Tax Measure Across Specifications

Vehicle age	Wealth Tax Specification		
	Wealth tax dummy	Wealth tax ratio	Wealth tax difference
2	-0.0358	0.0177	-0.000008**
3	-0.0186	0.0245	0.000001
4	-0.0076	0.0336	0.000028
5	-0.0380	0.0120	-0.000009
6	-0.0308	0.0117	-0.000007**
7	-0.0406	0.0076	-0.000025
8	-0.0282	-0.0021	-0.000043
9	-0.0260	-0.0125	-0.000058
10	-0.0026	-0.0026	-0.000041
11	-0.0096	0.0090	-0.000025
12	0.0169	0.0066	-0.000008**
13	0.0390	0.0183	0.000005
14	0.0305	0.0142	-0.000007*
15	0.0445	0.0098	-0.000006
16	0.0323	-0.0086	-0.000039
17	-0.0610	-0.0591	-0.000139
18	-0.1132	-0.0784	-0.000174
19	-0.1487	-0.0911	-0.000205
20	-0.1999	-0.1149	-0.000253
21	-0.2084	-0.1333	-0.000277
22	-0.1945	-0.1347	-0.000272
23	-0.1467	-0.0963	-0.000209
24	-0.1805	-0.1318	-0.000273
25	-0.2062	-0.2238	-0.000345

Notes: Coefficients that appear in bold are **not** statistically significant at the 10 percent level or better.

A ** indicates the coefficient is only statistically significant at the 5 percent level.

A * indicates the coefficient is only statistically significant at the 10 percent level.

Table 4.1: MOBILE6 Emission Factors (g/mile)

Pollutant	National		
	Actual	Predicted	Percent error
Hydrocarbons -VOCs	2.00	2.12	6.11
Carbon monoxide	20.55	21.58	5.01
Nitrogen oxide	1.41	1.47	3.75
	Wealth Tax		
	Actual	Predicted	Percent error
Hydrocarbons -VOCs	2.05	2.12	3.71
Carbon monoxide	20.97	21.62	3.10
Nitrogen oxide	1.44	1.47	2.37
	Non-Wealth-Tax		
	Actual	Predicted	Percent error
Hydrocarbons -VOCs	1.95	2.11	8.53
Carbon monoxide	20.14	21.53	6.90
Nitrogen oxide	1.39	1.46	5.03
	Wealth Tax Versus Non-Wealth Tax		
	Actual Dif.		Predicted dif.
Hydrocarbons -VOCs	0.10		0.01
Carbon monoxide	0.83		0.09
Nitrogen oxide	0.04		0.007
	Uniform National Policy		
	Wealth Tax	Non-Wealth-Tax	Difference
Hydrocarbons -VOCs	2.08	2.18	-0.10
Carbon monoxide	21.27	22.10	-0.83
Nitrogen oxide	1.46	1.49	-0.03

Note: Percent error equals (Predicted-Actual)/Actual * 100

Table 4.2: MOBILE6 Emission Factors (g/mile) by State

	Actual	Predicted	Percent error	Change in policy	Difference as percent of predicted
Tennessee (NWT)					
Hydrocarbons -VOCs	2.24	2.07	-7.85	1.99	-3.82
Carbon monoxide	22.54	21.18	-6.03	20.50	-3.21
Nitrogen oxide	1.52	1.45	-4.72	1.43	-1.72
California (WT)					
Hydrocarbons -VOCs	2.13	2.13	0.00	2.24	5.15
Carbon monoxide	21.52	21.53	0.05	22.47	4.37
Nitrogen oxide	1.46	1.46	0.00	1.49	2.47
Connecticut (WT)					
Hydrocarbons -VOCs	1.99	1.88	-5.82	1.95	3.57
Carbon monoxide	20.32	19.46	-4.23	20.04	2.98
Nitrogen oxide	1.41	1.37	-3.47	1.39	1.47
Georgia (WT)					
Hydrocarbons -VOCs	1.97	1.98	0.81	2.08	4.74
Carbon monoxide	20.53	20.63	0.49	21.43	3.88
Nitrogen oxide	1.40	1.41	0.79	1.44	2.13
Maryland (NWT)					
Hydrocarbons -VOCs	1.73	1.87	8.08	1.81	-3.37
Carbon monoxide	18.54	19.58	5.61	19.04	-2.76
Nitrogen oxide	1.30	1.36	4.39	1.34	-1.40
Massachusetts (WT)					
Hydrocarbons -VOCs	1.73	1.74	0.52	1.79	2.76
Carbon monoxide	18.54	18.44	-0.54	18.85	2.22
Nitrogen oxide	1.30	1.32	1.31	1.33	1.06
New Jersey (NWT)					
Hydrocarbons -VOCs	1.93	1.81	-5.77	1.76	-2.98
Carbon monoxide	19.80	18.96	-4.24	18.49	-2.48
Nitrogen oxide	1.37	1.33	-3.21	1.31	-1.21
Rhode Island (WT)					
Hydrocarbons -VOCs	1.81	1.68	-6.98	1.71	1.91
Carbon monoxide	18.87	17.96	-4.82	18.24	1.56
Nitrogen oxide	1.36	1.31	-3.62	1.31	0.54

Notes: State's status quo wealth tax policy appears in parentheses.

Percent error equals (Predicted-Actual)/Actual * 100

Difference as percent of predicted equals (Change in policy - Predicted)/Predicted*100

Appendix C: The Independence of Irrelevant Alternatives Assumption of the Multinomial Logit Model

The multinomial logit model makes the assumption known as the independence of irrelevant alternatives (IIA). This assumption requires that the odds of two alternatives be independent of the alternatives included in the choice set. Therefore, if a new alternative becomes available then all probabilities for the original outcomes must adjust in precisely the amount necessary to retain the original odds among all pairs of outcomes. For example, assume that a household has a choice of two vacation destinations: a beach resort that is chosen with a probability of 0.5 and a lake resort that is chosen with a probability of 0.5. The implied odds of taking a beach vacation versus a lake vacation are equal to one ($0.5/0.5$). Now suppose that a ski resort vacation becomes available. The IIA assumption requires that the household adjusts its probabilities of choosing each vacation destination in such a way that the relative odds of the beach and lake resorts remain the same. Thus if the household chooses the ski resort with a probability of 0.4, the probability that the beach and lake resorts are chosen must be 0.3 for each alternative. The IIA assumption generally fails to hold when a sub-set of the alternatives have similar characteristics. Suppose that a second lake resort that is nearly identical to the first is added to the household's choice set instead of the ski resort. Given the similarities in the lake resorts, it would be unrealistic to assume that the household would adjust its selection such that the odds of the beach resort and the original lake resort vacations remain the same. Realistically, the original probability of a lake resort vacation would be split between the two lake destinations. The new probabilities might be $\text{Pr}(\text{beach})=0.5$, $\text{Pr}(\text{lake1})=0.25$ and $\text{Pr}(\text{lake2})=0.25$. Such a model fails the IIA assumption as the odds of a beach vacation versus the original lake vacation change from one to two.

The independence of irrelevant alternatives is an important assumption of the multinomial logit model. If the IIA property fails to hold, the parameter estimates obtained from the model will be inconsistent. Fortunately, there are two tests of the IIA assumption. The first is a Hausman-type test developed by Hausman and McFadden (1984). This test is based on the assumption that if an alternative of the choice set is truly irrelevant, omitting it from the choice set will not change the parameter estimates systematically. The test statistic is

$$\chi^2 = (\hat{\beta}_R - \hat{\beta}_F)' [\hat{V}_R - \hat{V}_F]^{-1} (\hat{\beta}_R - \hat{\beta}_F)$$

where $\hat{\beta}_F$ are parameter estimates obtained from fitting the full model, $\hat{\beta}_R$ are the parameter estimates obtained from fitting a restricted model where one or more of the alternatives have been omitted, and $\hat{V}_F$ and $\hat{V}_R$ are the respective estimates of the asymptotic covariance matrices. The test statistic is asymptotically distributed as chi-square with degrees of freedom equal to the rows in $\hat{\beta}_R$. The second test of the IIA assumption was developed by Small and Hsiao (1985). This test is computed by dividing the sample randomly into two sub-samples of roughly equal size. The full MNLM is estimated for each of these samples and a weighted average of the coefficients is computed as

$$\hat{\beta}_u^{S_1 S_2} = \left(\frac{1}{\sqrt{2}}\right) \hat{\beta}_u^{S_1} + \left[1 - \left(\frac{1}{\sqrt{2}}\right)\right] \hat{\beta}_u^{S_2}$$

Parameters from a restricted model ($\hat{\beta}_R^{S_2}$) are estimated from the second sub-sample after eliminating one of the alternatives. The Small-Hsiao test is a likelihood ratio test where the test statistic is

$$SH = -2[L(\hat{\beta}_u^{S_1 S_2}) - L(\hat{\beta}_R^{S_2})]$$

which has a chi-squared distribution with K+1 degrees of freedom where K equals the number of independent variables. Zhang and Hoffman (1993) present a good exposition on these methods and provide details on applying each test with statistical software.

Each of these tests were conducted for the multinomial logit model of vehicle age estimated by this analysis. Small-Hsiao tests of the IIA assumption were estimated in Stata. Twenty-four separate test statistics were estimated using different vehicle ages as the omitted alternative. The p-values of the chi-squared test statistics were all equal to one indicating a failure to reject the null hypothesis that the model meets the IIA assumption.¹⁶ These results suggest that the parameter estimates of the MNLM reported in Table 3.5 are consistent and that the odds of two vehicle age outcomes are independent of the age outcomes used in the model. Unfortunately, results of the Hausman test of the IIA assumption are unavailable for comparison purposes. For unknown reasons, the Hausman tests of IIA assumption failed to converge in Stata. Different tests were attempted using various vehicle ages as the omitted alternative; however, none of these tests converged to a test statistic. If the Hausman test had converged, the results may or may not have supported the conclusions of the Small-Hsiao test. Long and Freese (2003) suggest that the Hausman and Small-Hsiao tests often provide inconsistent results and little guidance to violations of the IIA assumption.

Kennedy (2003, p. 270) offers several alternative estimation procedures to circumvent any IIA problems. Although the results of the Small-Hsiao test suggest that

¹⁶ A complete set of results is available upon request.

the IIA assumption holds for the vehicle age model, this analysis included an attempt at several of these alternatives in hopes of generating vehicle age distributions that could be compared to those generated by the multinomial logit model. The first alternative estimation procedure attempted was the multinomial probit model (MNPM). This model is derived by assuming that the errors in the discrete choice model are normally distributed. Its primary advantage over the MNLM is that the errors can be correlated across choices, which eliminates the IIA restriction. However, the computational cost of the MNPM can be quite restrictive as multiple (one less than the number of categories) integrals must be calculated. Therefore, it was no surprise that attempts to estimate the MNPM in Limdep ultimately failed.¹⁷ Other alternatives including the nested logit model, heteroskedastic extreme value model and the random parameters logit model were also explored using Limdep. However, these attempts also failed. Each of these models required that each independent variable vary across vehicle age outcomes, which would require an interaction with an alternative specific constant given the nature of the data. Given the number of independent variables used in the model, this would result in the estimation of well over 650 parameters, and unfortunately each of these models is limited to 100 parameters in Limdep. Finally, Kennedy notes that IIA problems are often ignored in hopes that the MNLM are not too misleading. Unfortunately, there would be no way to characterize the inconsistency that would result from a failure of the model to meet the independence of irrelevant alternatives assumption. Absent a computationally

¹⁷ Limdep was used in the attempt to estimate a MNPM as Stata currently has no program capable of this estimation. As it turns out, Limdep's MNPM capabilities are limited to models with four or fewer outcomes.

feasible alternative, the MNLM results are the only results available. However, the results of the Small-Hsiao test suggest that the IIA assumption may not be a concern for this analysis and that the parameters used to calculate the predicted probabilities are consistent.

Appendix D: MOBILE6 Input File

MOBILE6 INPUT FILE :

RUN DATA

MIN/MAX TEMP : 64. 92.
REG DIST : anation.d

SCENARIO REC : Scenario Title Text - Actual National
CALENDAR YEAR : 2001
FUEL RVP : 7.0

END OF RUN

MIN/MAX TEMP : 64. 92.
EVALUATION MONTH : 7
REG DIST : prednat.d
FUEL RVP : 7.0

SCENARIO REC : Scenario Title Text - Predicted National
CALENDAR YEAR : 2001

END OF RUN

MIN/MAX TEMP : 64. 92.
EVALUATION MONTH : 7
REG DIST : actwt.d
FUEL RVP : 7.0

SCENARIO REC : Scenario Title Text - Actual Wealth Tax
CALENDAR YEAR : 2001

END OF RUN

MIN/MAX TEMP : 64. 92.
EVALUATION MONTH : 7
REG DIST : predwt.d
FUEL RVP : 7.0

SCENARIO REC : Scenario Title Text - Predicted Wealth Tax
CALENDAR YEAR : 2001

END OF RUN

MIN/MAX TEMP : 64. 92.
EVALUATION MONTH : 7
REG DIST : actnwt.d
FUEL RVP : 7.0

SCENARIO REC : Scenario Title Text - Actual Non Wealth Tax
CALENDAR YEAR : 2001

END OF RUN

MIN/MAX TEMP : 64. 92.
EVALUATION MONTH : 7
REG DIST : prednwt.d
FUEL RVP : 7.0

SCENARIO REC : Scenario Title Text - Predicted Non Wealth Tax
CALENDAR YEAR : 2001

END OF RUN

MIN/MAX TEMP : 64. 92.
EVALUATION MONTH : 7
REG DIST : predawt.d
FUEL RVP : 7.0

SCENARIO REC : Scenario Title Text - Predicted ALL Wealth Tax
CALENDAR YEAR : 2001

END OF RUN

MIN/MAX TEMP : 64. 92.
EVALUATION MONTH : 7
REG DIST : predanwt.d
FUEL RVP : 7.0

SCENARIO REC : Scenario Title Text - Predicted All Non Wealth Tax
CALENDAR YEAR : 2001

END OF RUN

MIN/MAX TEMP : 64. 92.
EVALUATION MONTH : 7
REG DIST : tna.d
FUEL RVP : 7.0

SCENARIO REC : Scenario Title Text - Tennessee Actual

CALENDAR YEAR : 2001

END OF RUN

MIN/MAX TEMP : 64. 92.

EVALUATION MONTH : 7

REG DIST : tnsq.d

FUEL RVP : 7.0

SCENARIO REC : Scenario Title Text - Tennessee Status Quo

CALENDAR YEAR : 2001

END OF RUN

MIN/MAX TEMP : 64. 92.

EVALUATION MONTH : 7

REG DIST : tnc.d

FUEL RVP : 7.0

SCENARIO REC : Scenario Title Text - Tennessee Change

CALENDAR YEAR : 2001

END OF RUN

MIN/MAX TEMP : 64. 92.

EVALUATION MONTH : 7

REG DIST : caa.d

FUEL RVP : 7.0

SCENARIO REC : Scenario Title Text - California Actual

CALENDAR YEAR : 2001

END OF RUN

MIN/MAX TEMP : 64. 92.

EVALUATION MONTH : 7

REG DIST : casq.d

FUEL RVP : 7.0

SCENARIO REC : Scenario Title Text - California Status Quo

CALENDAR YEAR : 2001

END OF RUN

MIN/MAX TEMP : 64. 92.

EVALUATION MONTH : 7
REG DIST : cac.d
FUEL RVP : 7.0

SCENARIO REC : Scenario Title Text - California Change
CALENDAR YEAR : 2001

END OF RUN

MIN/MAX TEMP : 64. 92.
EVALUATION MONTH : 7
REG DIST : gaa.d
FUEL RVP : 7.0

SCENARIO REC : Scenario Title Text - Georgia Actual
CALENDAR YEAR : 2001

END OF RUN

MIN/MAX TEMP : 64. 92.
EVALUATION MONTH : 7
REG DIST : gasq.d
FUEL RVP : 7.0

SCENARIO REC : Scenario Title Text - Georgia Status Quo
CALENDAR YEAR : 2001

END OF RUN

MIN/MAX TEMP : 64. 92.
EVALUATION MONTH : 7
REG DIST : gac.d
FUEL RVP : 7.0

SCENARIO REC : Scenario Title Text - Georgia Change
CALENDAR YEAR : 2001

END OF RUN

MIN/MAX TEMP : 64. 92.
EVALUATION MONTH : 7
REG DIST : nja.d
FUEL RVP : 7.0

SCENARIO REC : Scenario Title Text - New Jersey Actual

CALENDAR YEAR : 2001

END OF RUN

MIN/MAX TEMP : 64. 92.

EVALUATION MONTH : 7

REG DIST : njsq.d

FUEL RVP : 7.0

SCENARIO REC : Scenario Title Text - New Jersey Status Quo

CALENDAR YEAR : 2001

END OF RUN

MIN/MAX TEMP : 64. 92.

EVALUATION MONTH : 7

REG DIST : njc.d

FUEL RVP : 7.0

SCENARIO REC : Scenario Title Text - New Jersey Change

CALENDAR YEAR : 2001

END OF RUN

MIN/MAX TEMP : 64. 92.

EVALUATION MONTH : 7

REG DIST : mda.d

FUEL RVP : 7.0

SCENARIO REC : Scenario Title Text - Maryland Actual

CALENDAR YEAR : 2001

END OF RUN

MIN/MAX TEMP : 64. 92.

EVALUATION MONTH : 7

REG DIST : mdsq.d

FUEL RVP : 7.0

SCENARIO REC : Scenario Title Text - Maryland Status Quo

CALENDAR YEAR : 2001

END OF RUN

MIN/MAX TEMP : 64. 92.

EVALUATION MONTH : 7
REG DIST : mdc.d
FUEL RVP : 7.0

SCENARIO REC : Scenario Title Text - Maryland Change
CALENDAR YEAR : 2001

END OF RUN

MIN/MAX TEMP : 64. 92.
EVALUATION MONTH : 7
REG DIST : maa.d
FUEL RVP : 7.0

SCENARIO REC : Scenario Title Text - Mass Actual
CALENDAR YEAR : 2001

END OF RUN

MIN/MAX TEMP : 64. 92.
EVALUATION MONTH : 7
REG DIST : masq.d
FUEL RVP : 7.0

SCENARIO REC : Scenario Title Text - Mass Status Quo
CALENDAR YEAR : 2001

END OF RUN

MIN/MAX TEMP : 64. 92.
EVALUATION MONTH : 7
REG DIST : mac.d
FUEL RVP : 7.0

SCENARIO REC : Scenario Title Text - Mass Change
CALENDAR YEAR : 2001

END OF RUN

MIN/MAX TEMP : 64. 92.
EVALUATION MONTH : 7
REG DIST : ria.d
FUEL RVP : 7.0

SCENARIO REC : Scenario Title Text - Rhode Island Actual

CALENDAR YEAR : 2001

END OF RUN

MIN/MAX TEMP : 64. 92.

EVALUATION MONTH : 7

REG DIST : risq.d

FUEL RVP : 7.0

SCENARIO REC : Scenario Title Text - Rhode Island Status Quo

CALENDAR YEAR : 2001

END OF RUN

MIN/MAX TEMP : 64. 92.

EVALUATION MONTH : 7

REG DIST : ric.d

FUEL RVP : 7.0

SCENARIO REC : Scenario Title Text - Rhode Island Change

CALENDAR YEAR : 2001

END OF RUN

MIN/MAX TEMP : 64. 92.

EVALUATION MONTH : 7

REG DIST : cta.d

FUEL RVP : 7.0

SCENARIO REC : Scenario Title Text - Conn Actual

CALENDAR YEAR : 2001

END OF RUN

MIN/MAX TEMP : 64. 92.

EVALUATION MONTH : 7

REG DIST : ctsq.d

FUEL RVP : 7.0

SCENARIO REC : Scenario Title Text - Conn Status Quo

CALENDAR YEAR : 2001

END OF RUN

MIN/MAX TEMP : 64. 92.

EVALUATION MONTH : 7
REG DIST : ctc.d
FUEL RVP : 7.0

SCENARIO REC : Scenario Title Text - Conn Change
CALENDAR YEAR : 2001

END OF RUN

Appendix E: MOBILE6 Output File

 * MOBILE6.2.03 (24-Sep-2003)
 * Input file: EMISS1.IN (file 1, run 1).

* Reading Registration Distributions from the following external
 * data file: ANATION.D

* #####
 * Scenario Title Text - Actual National
 * File 1, Run 1, Scenario 1.
 * #####
 M 48 Warning: there are no sales for vehicle class HDGV8b

Calendar Year: 2001
 Month: July
 Altitude: Low
 Minimum Temperature: 64.0 (F)
 Maximum Temperature: 92.0 (F)
 Absolute Humidity: 75. grains/lb
 Nominal Fuel RVP: 7.0 psi
 Weathered RVP: 6.7 psi
 Fuel Sulfur Content: 299. ppm

Exhaust I/M Program: No
 Evap I/M Program: No
 ATP Program: No
 Reformulated Gas: No

Vehicle Type:	LDGV	LDGT12	LDGT34	LDGT	HDGV	LDDV
	LDDT	HDDV	MC	All Veh		
GVWR:	<6000	>6000	(All)			

VMT Distribution:	0.4596	0.3055	0.1051	0.0367	0.0010	0.0016
	0.0843	0.0063	1.0000			

 Composite Emission Factors (g/mi):
 Composite VOC : 1.996 1.868 2.876 2.126 2.378 0.862 0.871 0.736
 2.14 1.955
 Composite CO : 20.55 22.21 33.93 25.21 29.26 1.882 1.521 3.821
 16.31 21.297
 Composite NOX : 1.414 1.427 1.772 1.515 5.191 1.786 1.633 16.685
 1.19 2.880

 * MOBILE6.2.03 (24-Sep-2003)
 * Input file: EMISS1.IN (file 1, run 2).

* Reading Registration Distributions from the following external
 * data file: PREDNAT.D

* #####
 * Scenario Title Text - Predicted National
 * File 1, Run 2, Scenario 1.
 * #####
 M 48 Warning: there are no sales for vehicle class HDGV8b

Calendar Year: 2001
 Month: July
 Altitude: Low
 Minimum Temperature: 64.0 (F)
 Maximum Temperature: 92.0 (F)
 Absolute Humidity: 75. grains/lb
 Nominal Fuel RVP: 7.0 psi
 Weathered RVP: 6.7 psi
 Fuel Sulfur Content: 299. ppm

Exhaust I/M Program: No
 Evap I/M Program: No
 ATP Program: No
 Reformulated Gas: No

Vehicle Type:	LDGV	LDGT12	LDGT34	LDGT	HDGV	LDDV
	LDDT	HDDV	MC	All Veh		
GVWR:	<6000	>6000	(All)			
VMT Distribution:	0.4562	0.3073	0.1057	0.0369	0.0011	0.0017
	0.0848	0.0063	1.0000			

 Composite Emission Factors (g/mi):
 Composite VOC : 2.118 1.868 2.876 2.126 2.378 0.896 0.871 0.736
 2.14 2.011
 Composite CO : 21.58 22.21 33.93 25.21 29.26 1.928 1.521 3.821
 16.31 21.770
 Composite NOX : 1.467 1.427 1.772 1.515 5.191 1.825 1.633 16.685
 1.19 2.914

 * MOBILE6.2.03 (24-Sep-2003)
 * Input file: EMISS1.IN (file 1, run 3).

* Reading Registration Distributions from the following external
 * data file: ACTWT.D

* #####
 * Scenario Title Text - Actual Wealth Tax
 * File 1, Run 3, Scenario 1.
 * #####
 M 48 Warning: there are no sales for vehicle class HDGV8b

Calendar Year: 2001
 Month: July
 Altitude: Low
 Minimum Temperature: 64.0 (F)
 Maximum Temperature: 92.0 (F)
 Absolute Humidity: 75. grains/lb
 Nominal Fuel RVP: 7.0 psi
 Weathered RVP: 6.7 psi
 Fuel Sulfur Content: 299. ppm

Exhaust I/M Program: No
 Evap I/M Program: No
 ATP Program: No
 Reformulated Gas: No

Vehicle Type:	LDGV	LDGT12	LDGT34	LDGT	HDGV	LDDV
	LDDT	HDDV	MC	All Veh		
GVWR:	<6000	>6000	(All)			
VMT Distribution:	0.4582	0.3062	0.1053	0.0368	0.0010	0.0017
	0.0845	0.0063	1.0000			

 Composite Emission Factors (g/mi):
 Composite VOC : 2.046 1.868 2.876 2.126 2.378 0.876 0.871 0.736
 2.14 1.978
 Composite CO : 20.97 22.21 33.93 25.21 29.26 1.901 1.521 3.821
 16.31 21.491
 Composite NOX : 1.436 1.427 1.772 1.515 5.191 1.800 1.633 16.685
 1.19 2.894

 * MOBILE6.2.03 (24-Sep-2003)
 * Input file: EMISS1.IN (file 1, run 4).

* Reading Registration Distributions from the following external
 * data file: PREDWT.D

* #####
 * Scenario Title Text - Predicted Wealth Tax
 * File 1, Run 4, Scenario 1.
 * #####
 M 48 Warning: there are no sales for vehicle class HDGV8b

Calendar Year: 2001
 Month: July
 Altitude: Low
 Minimum Temperature: 64.0 (F)
 Maximum Temperature: 92.0 (F)
 Absolute Humidity: 75. grains/lb
 Nominal Fuel RVP: 7.0 psi
 Weathered RVP: 6.7 psi
 Fuel Sulfur Content: 299. ppm

Exhaust I/M Program: No
 Evap I/M Program: No
 ATP Program: No
 Reformulated Gas: No

Vehicle Type:	LDGV	LDGT12	LDGT34	LDGT	HDGV	LDDV
	LDDT	HDDV	MC	All Veh		
GVWR:	<6000	>6000	(All)			
-----	-----	-----	-----	-----	-----	-----
VMT Distribution:	0.4560	0.3074	0.1058		0.0369	0.0011 0.0017
	0.0848	0.0063	1.0000			

 Composite Emission Factors (g/mi):
 Composite VOC : 2.122 1.868 2.876 2.126 2.378 0.897 0.871 0.736
 2.14 2.012
 Composite CO : 21.62 22.21 33.93 25.21 29.26 1.929 1.521 3.821
 16.31 21.789
 Composite NOX : 1.470 1.427 1.772 1.515 5.191 1.824 1.633 16.685
 1.19 2.916

* MOBILE6.2.03 (24-Sep-2003)

* Input file: EMISS1.IN (file 1, run 5).

* Reading Registration Distributions from the following external

* data file: ACTNWT.D

* #####

* Scenario Title Text - Actual Non Wealth Tax

* File 1, Run 5, Scenario 1.

* #####

M 48 Warning: there are no sales for vehicle class HDGV8b

Calendar Year: 2001

Month: July

Altitude: Low

Minimum Temperature: 64.0 (F)

Maximum Temperature: 92.0 (F)

Absolute Humidity: 75. grains/lb

Nominal Fuel RVP: 7.0 psi

Weathered RVP: 6.7 psi

Fuel Sulfur Content: 299. ppm

Exhaust I/M Program: No

Evap I/M Program: No

ATP Program: No

Reformulated Gas: No

Vehicle Type:	LDGV	LDGT12	LDGT34	LDGT	HDGV	LDDV
	LDDT	HDDV	MC	All Veh		
GVWR:	<6000	>6000	(All)			

VMT Distribution:	0.4609	0.3047	0.1048	0.0366	0.0010	0.0016
	0.0841	0.0062	1.0000			

Composite Emission Factors (g/mi):

Composite VOC :	1.946	1.868	2.876	2.126	2.378	0.848	0.871	0.736
	2.14	1.932						

Composite CO :	20.14	22.21	33.93	25.21	29.26	1.862	1.521	3.821
	16.31	21.104						

Composite NOX :	1.393	1.427	1.772	1.515	5.191	1.772	1.633	16.685
	1.19	2.867						

 * MOBILE6.2.03 (24-Sep-2003)
 * Input file: EMISS1.IN (file 1, run 6).

* Reading Registration Distributions from the following external
 * data file: PREDNWT.D

* #####
 * Scenario Title Text - Predicted Non Wealth Tax
 * File 1, Run 6, Scenario 1.
 * #####
 M 48 Warning: there are no sales for vehicle class HDGV8b

Calendar Year: 2001
 Month: July
 Altitude: Low
 Minimum Temperature: 64.0 (F)
 Maximum Temperature: 92.0 (F)
 Absolute Humidity: 75. grains/lb
 Nominal Fuel RVP: 7.0 psi
 Weathered RVP: 6.7 psi
 Fuel Sulfur Content: 299. ppm

Exhaust I/M Program: No
 Evap I/M Program: No
 ATP Program: No
 Reformulated Gas: No

Vehicle Type:	LDGV	LDGT12	LDGT34	LDGT	HDGV	LDDV
	LDDT	HDDV	MC	All Veh		
GVWR:	<6000	>6000	(All)			
-----	-----	-----	-----	-----	-----	-----
VMT Distribution:	0.4565	0.3072	0.1057		0.0369	0.0011
	0.0848	0.0063	1.0000			0.0017

 Composite Emission Factors (g/mi):
 Composite VOC : 2.112 1.868 2.876 2.126 2.378 0.894 0.871 0.736
 2.14 2.008
 Composite CO : 21.53 22.21 33.93 25.21 29.26 1.927 1.521 3.821
 16.31 21.744
 Composite NOX : 1.463 1.427 1.772 1.515 5.191 1.826 1.633 16.685
 1.19 2.911

 * MOBILE6.2.03 (24-Sep-2003)
 * Input file: EMISS1.IN (file 1, run 7).

* Reading Registration Distributions from the following external
 * data file: PREDAWT.D

* #####
 * Scenario Title Text - Predicted ALL Wealth Tax
 * File 1, Run 7, Scenario 1.
 * #####
 M 48 Warning: there are no sales for vehicle class HDGV8b

Calendar Year: 2001
 Month: July
 Altitude: Low
 Minimum Temperature: 64.0 (F)
 Maximum Temperature: 92.0 (F)
 Absolute Humidity: 75. grains/lb
 Nominal Fuel RVP: 7.0 psi
 Weathered RVP: 6.7 psi
 Fuel Sulfur Content: 299. ppm

Exhaust I/M Program: No
 Evap I/M Program: No
 ATP Program: No
 Reformulated Gas: No

Vehicle Type:	LDGV	LDGT12	LDGT34	LDGT	HDGV	LDDV
	LDDT	HDDV	MC	All Veh		
GVWR:	<6000	>6000	(All)			
VMT Distribution:	0.4568	0.3070	0.1056		0.0369	0.0010
	0.0847	0.0063	1.0000			0.0017

 Composite Emission Factors (g/mi):
 Composite VOC : 2.082 1.868 2.876 2.126 2.378 0.885 0.871 0.736
 2.14 1.994
 Composite CO : 21.27 22.21 33.93 25.21 29.26 1.912 1.521 3.821
 16.31 21.629

 Composite NOX : 1.456 1.427 1.772 1.515 5.191 1.809 1.633 16.685
 1.19 2.907

* MOBILE6.2.03 (24-Sep-2003)

* Input file: EMISS1.IN (file 1, run 8).

* Reading Registration Distributions from the following external

* data file: PREDANWT.D

* #####

* Scenario Title Text - Predicted All Non Wealth Tax

* File 1, Run 8, Scenario 1.

* #####

M 48 Warning: there are no sales for vehicle class HDGV8b

Calendar Year: 2001

Month: July

Altitude: Low

Minimum Temperature: 64.0 (F)

Maximum Temperature: 92.0 (F)

Absolute Humidity: 75. grains/lb

Nominal Fuel RVP: 7.0 psi

Weathered RVP: 6.7 psi

Fuel Sulfur Content: 299. ppm

Exhaust I/M Program: No

Evap I/M Program: No

ATP Program: No

Reformulated Gas: No

Vehicle Type: LDGV LDGT12 LDGT34 LDGT HDGV LDDV

LDDT HDDV MC All Veh

GVWR: <6000 >6000 (All)

VMT Distribution: 0.4553 0.3078 0.1059 0.0370 0.0011 0.0017
0.0849 0.0063 1.0000

Composite Emission Factors (g/mi):

Composite VOC : 2.179 1.868 2.876 2.126 2.378 0.913 0.871 0.736
2.14 2.038

Composite CO : 22.10 22.21 33.93 25.21 29.26 1.953 1.521 3.821
16.31 22.005

Composite NOX : 1.487 1.427 1.772 1.515 5.191 1.848 1.633 16.685
1.19 2.925

 * MOBILE6.2.03 (24-Sep-2003)
 * Input file: EMISS1.IN (file 1, run 9).

* Reading Registration Distributions from the following external
 * data file: TNA.D

* #####
 * Scenario Title Text - Tennessee Actual
 * File 1, Run 9, Scenario 1.
 * #####
 M 48 Warning: there are no sales for vehicle class HDGV8b

Calendar Year: 2001
 Month: July
 Altitude: Low
 Minimum Temperature: 64.0 (F)
 Maximum Temperature: 92.0 (F)
 Absolute Humidity: 75. grains/lb
 Nominal Fuel RVP: 7.0 psi
 Weathered RVP: 6.7 psi
 Fuel Sulfur Content: 299. ppm

Exhaust I/M Program: No
 Evap I/M Program: No
 ATP Program: No
 Reformulated Gas: No

Vehicle Type:	LDGV	LDGT12	LDGT34	LDGT	HDGV	LDDV
	LDDT	HDDV	MC	All Veh		
GVWR:	<6000	>6000	(All)			
-----	-----	-----	-----	-----	-----	-----
VMT Distribution:	0.4520	0.3096	0.1065		0.0372	0.0012
	0.0854	0.0064	1.0000			0.0017

 Composite Emission Factors (g/mi):
 Composite VOC : 2.243 1.868 2.876 2.126 2.378 0.918 0.871 0.736
 2.14 2.066
 Composite CO : 22.54 22.21 33.93 25.21 29.26 1.960 1.521 3.821
 16.31 22.200
 Composite NOX : 1.524 1.427 1.772 1.515 5.191 1.862 1.633 16.685
 1.19 2.950

 * MOBILE6.2.03 (24-Sep-2003)
 * Input file: EMISS1.IN (file 1, run 10).

* Reading Registration Distributions from the following external
 * data file: TNSQ.D

* #####
 * Scenario Title Text - Tennessee Status Quo
 * File 1, Run 10, Scenario 1.
 * #####
 M 48 Warning: there are no sales for vehicle class HDGV8b

Calendar Year: 2001
 Month: July
 Altitude: Low
 Minimum Temperature: 64.0 (F)
 Maximum Temperature: 92.0 (F)
 Absolute Humidity: 75. grains/lb
 Nominal Fuel RVP: 7.0 psi
 Weathered RVP: 6.7 psi
 Fuel Sulfur Content: 299. ppm

Exhaust I/M Program: No
 Evap I/M Program: No
 ATP Program: No
 Reformulated Gas: No

Vehicle Type:	LDGV	LDGT12	LDGT34	LDGT	HDGV	LDDV
	LDDT	HDDV	MC	All Veh		
GVWR:	<6000	>6000	(All)			
VMT Distribution:	0.4570	0.3069	0.1056		0.0368	0.0010
	0.0847	0.0063	1.0000			0.0017

 Composite Emission Factors (g/mi):
 Composite VOC : 2.067 1.868 2.876 2.126 2.378 0.883 0.871 0.736
 2.14 1.987
 Composite CO : 21.18 22.21 33.93 25.21 29.26 1.910 1.521 3.821
 16.31 21.585
 Composite NOX : 1.452 1.427 1.772 1.515 5.191 1.815 1.633 16.685
 1.19 2.904

 * MOBILE6.2.03 (24-Sep-2003)
 * Input file: EMISS1.IN (file 1, run 11).

* Reading Registration Distributions from the following external
 * data file: TNC.D

* #####
 * Scenario Title Text - Tennessee Change
 * File 1, Run 11, Scenario 1.
 * #####
 M 48 Warning: there are no sales for vehicle class HDGV8b

Calendar Year: 2001
 Month: July
 Altitude: Low
 Minimum Temperature: 64.0 (F)
 Maximum Temperature: 92.0 (F)
 Absolute Humidity: 75. grains/lb
 Nominal Fuel RVP: 7.0 psi
 Weathered RVP: 6.7 psi
 Fuel Sulfur Content: 299. ppm

Exhaust I/M Program: No
 Evap I/M Program: No
 ATP Program: No
 Reformulated Gas: No

Vehicle Type:	LDGV	LDGT12	LDGT34	LDGT	HDGV	LDDV
	LDDT	HDDV	MC	All Veh		
GVWR:	<6000	>6000	(All)			
VMT Distribution:	0.4582	0.3063	0.1054		0.0368	0.0010
	0.0845	0.0063	1.0000			0.0017

 Composite Emission Factors (g/mi):
 Composite VOC : 1.988 1.868 2.876 2.126 2.378 0.855 0.871 0.736
 2.14 1.951
 Composite CO : 20.50 22.21 33.93 25.21 29.26 1.869 1.521 3.821
 16.31 21.274
 Composite NOX : 1.427 1.427 1.772 1.515 5.191 1.775 1.633 16.685
 1.19 2.890

 * MOBILE6.2.03 (24-Sep-2003)
 * Input file: EMISS1.IN (file 1, run 12).

* Reading Registration Distributions from the following external
 * data file: CAA.D

* #####
 * Scenario Title Text - California Actual
 * File 1, Run 12, Scenario 1.
 * #####
 M 48 Warning: there are no sales for vehicle class HDGV8b

Calendar Year: 2001
 Month: July
 Altitude: Low
 Minimum Temperature: 64.0 (F)
 Maximum Temperature: 92.0 (F)
 Absolute Humidity: 75. grains/lb
 Nominal Fuel RVP: 7.0 psi
 Weathered RVP: 6.7 psi
 Fuel Sulfur Content: 299. ppm

Exhaust I/M Program: No
 Evap I/M Program: No
 ATP Program: No
 Reformulated Gas: No

Vehicle Type:	LDGV	LDGT12	LDGT34	LDGT	HDGV	LDDV
	LDDT	HDDV	MC	All Veh		
GVWR:	<6000	>6000	(All)			
	-----	-----	-----	-----	-----	-----
VMT Distribution:	0.4567	0.3070	0.1056		0.0369	0.0011 0.0017
	0.0847	0.0063	1.0000			

 Composite Emission Factors (g/mi):
 Composite VOC : 2.132 1.868 2.876 2.126 2.378 0.889 0.871 0.736
 2.14 2.017
 Composite CO : 21.52 22.21 33.93 25.21 29.26 1.922 1.521 3.821
 16.31 21.740
 Composite NOX : 1.457 1.427 1.772 1.515 5.191 1.821 1.633 16.685
 1.19 2.908

```
*****
* MOBILE6.2.03 (24-Sep-2003)
* Input file: EMISS1.IN (file 1, run 13).
*****
```

```
* Reading Registration Distributions from the following external
* data file: CASQ.D
```

```
* #####
* Scenario Title Text - California Status Quo
* File 1, Run 13, Scenario 1.
* #####
M 48 Warning: there are no sales for vehicle class HDGV8b
```

```
Calendar Year: 2001
Month: July
Altitude: Low
Minimum Temperature: 64.0 (F)
Maximum Temperature: 92.0 (F)
Absolute Humidity: 75. grains/lb
Nominal Fuel RVP: 7.0 psi
Weathered RVP: 6.7 psi
Fuel Sulfur Content: 299. ppm
```

```
Exhaust I/M Program: No
Evap I/M Program: No
ATP Program: No
Reformulated Gas: No
```

Vehicle Type:	LDGV	LDGT12	LDGT34	LDGT	HDGV	LDDV
	LDDT	HDDV	MC	All Veh		
GVWR:	<6000	>6000	(All)			
VMT Distribution:	0.4567	0.3070	0.1056		0.0369	0.0011
	0.0847	0.0063	1.0000			0.0017

```
-----
Composite Emission Factors (g/mi):
Composite VOC : 2.134 1.868 2.876 2.126 2.378 0.890 0.871 0.736
                2.14 2.018
Composite CO : 21.53 22.21 33.93 25.21 29.26 1.923 1.521 3.821
               16.31 21.745
Composite NOX : 1.457 1.427 1.772 1.515 5.191 1.823 1.633 16.685
               1.19 2.908
```

 * MOBILE6.2.03 (24-Sep-2003)
 * Input file: EMISS1.IN (file 1, run 14).

* Reading Registration Distributions from the following external
 * data file: CAC.D

* #####
 * Scenario Title Text - California Change
 * File 1, Run 14, Scenario 1.
 * #####
 M 48 Warning: there are no sales for vehicle class HDGV8b

Calendar Year: 2001
 Month: July
 Altitude: Low
 Minimum Temperature: 64.0 (F)
 Maximum Temperature: 92.0 (F)
 Absolute Humidity: 75. grains/lb
 Nominal Fuel RVP: 7.0 psi
 Weathered RVP: 6.7 psi
 Fuel Sulfur Content: 299. ppm

Exhaust I/M Program: No
 Evap I/M Program: No
 ATP Program: No
 Reformulated Gas: No

Vehicle Type:	LDGV	LDGT12	LDGT34	LDGT	HDGV	LDDV
	LDDT	HDDV	MC	All Veh		
GVWR:	<6000	>6000	(All)			
	-----	-----	-----	-----	-----	-----
VMT Distribution:	0.4549	0.3080	0.1059		0.0370	0.0012 0.0017
	0.0850	0.0063	1.0000			

 Composite Emission Factors (g/mi):
 Composite VOC : 2.244 1.868 2.876 2.126 2.378 0.918 0.871 0.736
 2.14 2.067
 Composite CO : 22.47 22.21 33.93 25.21 29.26 1.964 1.521 3.821
 16.31 22.170
 Composite NOX : 1.493 1.427 1.772 1.515 5.191 1.862 1.633 16.685
 1.19 2.929

 * MOBILE6.2.03 (24-Sep-2003)
 * Input file: EMISS1.IN (file 1, run 15).

* Reading Registration Distributions from the following external
 * data file: GAA.D

* #####
 * Scenario Title Text - Georgia Actual
 * File 1, Run 15, Scenario 1.
 * #####
 M 48 Warning: there are no sales for vehicle class HDGV8b

Calendar Year: 2001
 Month: July
 Altitude: Low
 Minimum Temperature: 64.0 (F)
 Maximum Temperature: 92.0 (F)
 Absolute Humidity: 75. grains/lb
 Nominal Fuel RVP: 7.0 psi
 Weathered RVP: 6.7 psi
 Fuel Sulfur Content: 299. ppm

Exhaust I/M Program: No
 Evap I/M Program: No
 ATP Program: No
 Reformulated Gas: No

Vehicle Type:	LDGV	LDGT12	LDGT34	LDGT	HDGV	LDDV
	LDDT	HDDV	MC	All Veh		
GVWR:	<6000	>6000	(All)			
VMT Distribution:	0.4619	0.3042	0.1046		0.0365	0.0010
	0.0839	0.0062	1.0000			0.0016

 Composite Emission Factors (g/mi):
 Composite VOC : 1.968 1.868 2.876 2.126 2.378 0.876 0.871 0.736
 2.14 1.942
 Composite CO : 20.53 22.21 33.93 25.21 29.26 1.897 1.521 3.821
 16.31 21.286
 Composite NOX : 1.397 1.427 1.772 1.515 5.191 1.784 1.633 16.685
 1.19 2.866

 * MOBILE6.2.03 (24-Sep-2003)
 * Input file: EMISS1.IN (file 1, run 16).

* Reading Registration Distributions from the following external
 * data file: GASQ.D

* #####
 * Scenario Title Text - Georgia Status Quo
 * File 1, Run 16, Scenario 1.
 * #####
 M 48 Warning: there are no sales for vehicle class HDGV8b

Calendar Year: 2001
 Month: July
 Altitude: Low
 Minimum Temperature: 64.0 (F)
 Maximum Temperature: 92.0 (F)
 Absolute Humidity: 75. grains/lb
 Nominal Fuel RVP: 7.0 psi
 Weathered RVP: 6.7 psi
 Fuel Sulfur Content: 299. ppm

Exhaust I/M Program: No
 Evap I/M Program: No
 ATP Program: No
 Reformulated Gas: No

Vehicle Type:	LDGV	LDGT12	LDGT34	LDGT	HDGV	LDDV
	LDDT	HDDV	MC	All Veh		
GVWR:	<6000	>6000	(All)			
VMT Distribution:	0.4608	0.3048	0.1049		0.0366	0.0010
	0.0841	0.0063	1.0000			0.0016

 Composite Emission Factors (g/mi):
 Composite VOC : 1.984 1.868 2.876 2.126 2.378 0.876 0.871 0.736
 2.14 1.950
 Composite CO : 20.63 22.21 33.93 25.21 29.26 1.900 1.521 3.821
 16.31 21.329
 Composite NOX : 1.408 1.427 1.772 1.515 5.191 1.799 1.633 16.685
 1.19 2.874

 * MOBILE6.2.03 (24-Sep-2003)
 * Input file: EMISS1.IN (file 1, run 17).

* Reading Registration Distributions from the following external
 * data file: GAC.D

* #####
 * Scenario Title Text - Georgia Change
 * File 1, Run 17, Scenario 1.
 * #####
 M 48 Warning: there are no sales for vehicle class HDGV8b

Calendar Year: 2001
 Month: July
 Altitude: Low
 Minimum Temperature: 64.0 (F)
 Maximum Temperature: 92.0 (F)
 Absolute Humidity: 75. grains/lb
 Nominal Fuel RVP: 7.0 psi
 Weathered RVP: 6.7 psi
 Fuel Sulfur Content: 299. ppm

Exhaust I/M Program: No
 Evap I/M Program: No
 ATP Program: No
 Reformulated Gas: No

Vehicle Type:	LDGV	LDGT12	LDGT34	LDGT	HDGV	LDDV
	LDDT	HDDV	MC	All Veh		
GVWR:	<6000	>6000	(All)			
	-----	-----	-----	-----	-----	-----
VMT Distribution:	0.4592	0.3056	0.1051		0.0367	0.0011 0.0017
	0.0843	0.0063	1.0000			

 Composite Emission Factors (g/mi):
 Composite VOC : 2.078 1.868 2.876 2.126 2.378 0.905 0.871 0.736
 2.14 1.993
 Composite CO : 21.43 22.21 33.93 25.21 29.26 1.942 1.521 3.821
 16.31 21.700
 Composite NOX : 1.438 1.427 1.772 1.515 5.191 1.838 1.633 16.685
 1.19 2.892

 * MOBILE6.2.03 (24-Sep-2003)
 * Input file: EMISS1.IN (file 1, run 18).

* Reading Registration Distributions from the following external
 * data file: NJA.D

* #####
 * Scenario Title Text - New Jersey Actual
 * File 1, Run 18, Scenario 1.
 * #####
 M 48 Warning: there are no sales for vehicle class HDGV8b

Calendar Year: 2001
 Month: July
 Altitude: Low
 Minimum Temperature: 64.0 (F)
 Maximum Temperature: 92.0 (F)
 Absolute Humidity: 75. grains/lb
 Nominal Fuel RVP: 7.0 psi
 Weathered RVP: 6.7 psi
 Fuel Sulfur Content: 299. ppm

Exhaust I/M Program: No
 Evap I/M Program: No
 ATP Program: No
 Reformulated Gas: No

Vehicle Type:	LDGV	LDGT12	LDGT34	LDGT	HDGV	LDDV
	LDDT	HDDV	MC	All Veh		
GVWR:	<6000	>6000	(All)			
VMT Distribution:	0.4622	0.3040	0.1046		0.0365	0.0011
	0.0839	0.0062	1.0000			0.0016

 Composite Emission Factors (g/mi):
 Composite VOC : 1.925 1.868 2.876 2.126 2.378 0.838 0.871 0.736
 2.14 1.922
 Composite CO : 19.80 22.21 33.93 25.21 29.26 1.853 1.521 3.821
 16.31 20.944
 Composite NOX : 1.369 1.427 1.772 1.515 5.191 1.779 1.633 16.685
 1.19 2.853

```
*****
* MOBILE6.2.03 (24-Sep-2003)
* Input file: EMISS1.IN (file 1, run 19).
*****
```

```
* Reading Registration Distributions from the following external
* data file: NJSQ.D
```

```
* #####
* Scenario Title Text - New Jersey Status Quo
* File 1, Run 19, Scenario 1.
* #####
M 48 Warning: there are no sales for vehicle class HDGV8b
```

```
Calendar Year: 2001
Month: July
Altitude: Low
Minimum Temperature: 64.0 (F)
Maximum Temperature: 92.0 (F)
Absolute Humidity: 75. grains/lb
Nominal Fuel RVP: 7.0 psi
Weathered RVP: 6.7 psi
Fuel Sulfur Content: 299. ppm
```

```
Exhaust I/M Program: No
Evap I/M Program: No
ATP Program: No
Reformulated Gas: No
```

Vehicle Type:	LDGV	LDGT12	LDGT34	LDGT	HDGV	LDDV
	LDDT	HDDV	MC	All Veh		
GVWR:	<6000	>6000	(All)			
VMT Distribution:	0.4655	0.3021	0.1039		0.0363	0.0010
	0.0834	0.0062	1.0000			0.0016

```
-----
Composite Emission Factors (g/mi):
Composite VOC : 1.814 1.868 2.876 2.126 2.378 0.806 0.871 0.736
                2.14 1.871
Composite CO : 18.96 22.21 33.93 25.21 29.26 1.805 1.521 3.821
                16.31 20.548
Composite NOX : 1.325 1.427 1.772 1.515 5.191 1.726 1.633 16.685
                1.19 2.823
```

 * MOBILE6.2.03 (24-Sep-2003)
 * Input file: EMISS1.IN (file 1, run 20).

* Reading Registration Distributions from the following external
 * data file: NJC.D

* #####
 * Scenario Title Text - New Jersey Change
 * File 1, Run 20, Scenario 1.
 * #####
 M 48 Warning: there are no sales for vehicle class HDGV8b

Calendar Year: 2001
 Month: July
 Altitude: Low
 Minimum Temperature: 64.0 (F)
 Maximum Temperature: 92.0 (F)
 Absolute Humidity: 75. grains/lb
 Nominal Fuel RVP: 7.0 psi
 Weathered RVP: 6.7 psi
 Fuel Sulfur Content: 299. ppm

Exhaust I/M Program: No
 Evap I/M Program: No
 ATP Program: No
 Reformulated Gas: No

Vehicle Type:	LDGV	LDGT12	LDGT34	LDGT	HDGV	LDDV
	LDDT	HDDV	MC	All Veh		
GVWR:	<6000	>6000	(All)			
-----	-----	-----	-----	-----	-----	-----
VMT Distribution:	0.4663	0.3017	0.1038		0.0362	0.0009 0.0016
	0.0833	0.0062	1.0000			

 Composite Emission Factors (g/mi):
 Composite VOC : 1.760 1.868 2.876 2.126 2.378 0.779 0.871 0.736
 2.14 1.846
 Composite CO : 18.49 22.21 33.93 25.21 29.26 1.764 1.521 3.821
 16.31 20.328
 Composite NOX : 1.309 1.427 1.772 1.515 5.191 1.685 1.633 16.685
 1.19 2.813

 * MOBILE6.2.03 (24-Sep-2003)
 * Input file: EMISS1.IN (file 1, run 21).

* Reading Registration Distributions from the following external
 * data file: MDA.D

* #####
 * Scenario Title Text - Maryland Actual
 * File 1, Run 21, Scenario 1.
 * #####
 M 48 Warning: there are no sales for vehicle class HDGV8b

Calendar Year: 2001
 Month: July
 Altitude: Low
 Minimum Temperature: 64.0 (F)
 Maximum Temperature: 92.0 (F)
 Absolute Humidity: 75. grains/lb
 Nominal Fuel RVP: 7.0 psi
 Weathered RVP: 6.7 psi
 Fuel Sulfur Content: 299. ppm

Exhaust I/M Program: No
 Evap I/M Program: No
 ATP Program: No
 Reformulated Gas: No

Vehicle Type:	LDGV	LDGT12	LDGT34	LDGT	HDGV	LDDV
	LDDT	HDDV	MC	All Veh		
GVWR:	<6000	>6000	(All)			
VMT Distribution:	0.4683	0.3006	0.1034	0.0361	0.0008	0.0016
	0.0830	0.0062	1.0000			

 Composite Emission Factors (g/mi):
 Composite VOC : 1.732 1.868 2.876 2.126 2.378 0.784 0.871 0.736
 2.14 1.832
 Composite CO : 18.54 22.21 33.93 25.21 29.26 1.766 1.521 3.821
 16.31 20.348
 Composite NOX : 1.299 1.427 1.772 1.515 5.191 1.664 1.633 16.685
 1.19 2.803

 * MOBILE6.2.03 (24-Sep-2003)
 * Input file: EMISS1.IN (file 1, run 22).

* Reading Registration Distributions from the following external
 * data file: MDSQ.D

* #####
 * Scenario Title Text - Maryland Status Quo
 * File 1, Run 22, Scenario 1.
 * #####
 M 48 Warning: there are no sales for vehicle class HDGV8b

Calendar Year: 2001
 Month: July
 Altitude: Low
 Minimum Temperature: 64.0 (F)
 Maximum Temperature: 92.0 (F)
 Absolute Humidity: 75. grains/lb
 Nominal Fuel RVP: 7.0 psi
 Weathered RVP: 6.7 psi
 Fuel Sulfur Content: 299. ppm

Exhaust I/M Program: No
 Evap I/M Program: No
 ATP Program: No
 Reformulated Gas: No

Vehicle Type:	LDGV	LDGT12	LDGT34	LDGT	HDGV	LDDV
	LDDT	HDDV	MC	All Veh		
GVWR:	<6000	>6000	(All)			
	-----	-----	-----	-----	-----	-----
VMT Distribution:	0.4638	0.3031	0.1043		0.0364	0.0009
	0.0836	0.0062	1.0000			0.0016

 Composite Emission Factors (g/mi):
 Composite VOC : 1.872 1.868 2.876 2.126 2.378 0.831 0.871 0.736
 2.14 1.898
 Composite CO : 19.58 22.21 33.93 25.21 29.26 1.837 1.521 3.821
 16.31 20.842
 Composite NOX : 1.356 1.427 1.772 1.515 5.191 1.744 1.633 16.685
 1.19 2.842

 * MOBILE6.2.03 (24-Sep-2003)
 * Input file: EMISS1.IN (file 1, run 23).

* Reading Registration Distributions from the following external
 * data file: MDC.D

* #####
 * Scenario Title Text - Maryland Change
 * File 1, Run 23, Scenario 1.
 * #####
 M 48 Warning: there are no sales for vehicle class HDGV8b

Calendar Year: 2001
 Month: July
 Altitude: Low
 Minimum Temperature: 64.0 (F)
 Maximum Temperature: 92.0 (F)
 Absolute Humidity: 75. grains/lb
 Nominal Fuel RVP: 7.0 psi
 Weathered RVP: 6.7 psi
 Fuel Sulfur Content: 299. ppm

Exhaust I/M Program: No
 Evap I/M Program: No
 ATP Program: No
 Reformulated Gas: No

Vehicle Type:	LDGV	LDGT12	LDGT34	LDGT	HDGV	LDDV
	LDDT	HDDV	MC	All Veh		
GVWR:	<6000	>6000	(All)			
	-----	-----	-----	-----	-----	-----
VMT Distribution:	0.4647	0.3026	0.1041		0.0363	0.0009
	0.0835	0.0062	1.0000			0.0016

 Composite Emission Factors (g/mi):
 Composite VOC : 1.809 1.868 2.876 2.126 2.378 0.802 0.871 0.736
 2.14 1.869
 Composite CO : 19.04 22.21 33.93 25.21 29.26 1.794 1.521 3.821
 16.31 20.587
 Composite NOX : 1.337 1.427 1.772 1.515 5.191 1.703 1.633 16.685
 1.19 2.831

* MOBILE6.2.03 (24-Sep-2003)

* Input file: EMISS1.IN (file 1, run 24).

* Reading Registration Distributions from the following external

* data file: MAA.D

* #####

* Scenario Title Text - Mass Actual

* File 1, Run 24, Scenario 1.

* #####

M 48 Warning: there are no sales for vehicle class HDGV8b

Calendar Year: 2001

Month: July

Altitude: Low

Minimum Temperature: 64.0 (F)

Maximum Temperature: 92.0 (F)

Absolute Humidity: 75. grains/lb

Nominal Fuel RVP: 7.0 psi

Weathered RVP: 6.7 psi

Fuel Sulfur Content: 299. ppm

Exhaust I/M Program: No

Evap I/M Program: No

ATP Program: No

Reformulated Gas: No

Vehicle Type:	LDGV	LDGT12	LDGT34	LDGT	HDGV	LDDV
	LDDT	HDDV	MC	All Veh		
GVWR:	<6000	>6000	(All)			

VMT Distribution:	0.4683	0.3006	0.1034		0.0361	0.0008	0.0016
	0.0830	0.0062	1.0000				

Composite Emission Factors (g/mi):

Composite VOC :	1.732	1.868	2.876	2.126	2.378	0.784	0.871	0.736
	2.14	1.832						

Composite CO :	18.54	22.21	33.93	25.21	29.26	1.766	1.521	3.821
	16.31	20.348						

Composite NOX :	1.299	1.427	1.772	1.515	5.191	1.664	1.633	16.685
	1.19	2.803						

* MOBILE6.2.03 (24-Sep-2003)

* Input file: EMISS1.IN (file 1, run 25).

* Reading Registration Distributions from the following external

* data file: MASQ.D

* #####

* Scenario Title Text - Mass Status Quo

* File 1, Run 25, Scenario 1.

* #####

M 48 Warning: there are no sales for vehicle class HDGV8b

Calendar Year: 2001

Month: July

Altitude: Low

Minimum Temperature: 64.0 (F)

Maximum Temperature: 92.0 (F)

Absolute Humidity: 75. grains/lb

Nominal Fuel RVP: 7.0 psi

Weathered RVP: 6.7 psi

Fuel Sulfur Content: 299. ppm

Exhaust I/M Program: No

Evap I/M Program: No

ATP Program: No

Reformulated Gas: No

Vehicle Type: LDGV LDGT12 LDGT34 LDGT HDGV LDDV

LDDT HDDV MC All Veh

GVWR: <6000 >6000 (All)

VMT Distribution: 0.4655 0.3022 0.1040 0.0363 0.0008 0.0016
0.0834 0.0062 1.0000

Composite Emission Factors (g/mi):

Composite VOC : 1.741 1.868 2.876 2.126 2.378 0.761 0.871 0.736
2.14 1.837

Composite CO : 18.44 22.21 33.93 25.21 29.26 1.738 1.521 3.821
16.31 20.306

Composite NOX : 1.316 1.427 1.772 1.515 5.191 1.660 1.633 16.685
1.19 2.819

* MOBILE6.2.03 (24-Sep-2003)

* Input file: EMISS1.IN (file 1, run 26).

* Reading Registration Distributions from the following external

* data file: MAC.D

* #####

* Scenario Title Text - Mass Change

* File 1, Run 26, Scenario 1.

* #####

M 48 Warning: there are no sales for vehicle class HDGV8b

Calendar Year: 2001

Month: July

Altitude: Low

Minimum Temperature: 64.0 (F)

Maximum Temperature: 92.0 (F)

Absolute Humidity: 75. grains/lb

Nominal Fuel RVP: 7.0 psi

Weathered RVP: 6.7 psi

Fuel Sulfur Content: 299. ppm

Exhaust I/M Program: No

Evap I/M Program: No

ATP Program: No

Reformulated Gas: No

Vehicle Type: LDGV LDGT12 LDGT34 LDGT HDGV LDDV

LDDT HDDV MC All Veh

GVWR: <6000 >6000 (All)

VMT Distribution: 0.4650 0.3025 0.1041 0.0363 0.0009 0.0016
0.0835 0.0062 1.0000

Composite Emission Factors (g/mi):

Composite VOC : 1.789 1.868 2.876 2.126 2.378 0.789 0.871 0.736
2.14 1.859

Composite CO : 18.85 22.21 33.93 25.21 29.26 1.778 1.521 3.821
16.31 20.501

Composite NOX : 1.330 1.427 1.772 1.515 5.191 1.700 1.633 16.685
1.19 2.827

* MOBILE6.2.03 (24-Sep-2003)

* Input file: EMISS1.IN (file 1, run 27).

* Reading Registration Distributions from the following external

* data file: RIA.D

* #####

* Scenario Title Text - Rhode Island Actual

* File 1, Run 27, Scenario 1.

* #####

M 48 Warning: there are no sales for vehicle class HDGV8b

Calendar Year: 2001

Month: July

Altitude: Low

Minimum Temperature: 64.0 (F)

Maximum Temperature: 92.0 (F)

Absolute Humidity: 75. grains/lb

Nominal Fuel RVP: 7.0 psi

Weathered RVP: 6.7 psi

Fuel Sulfur Content: 299. ppm

Exhaust I/M Program: No

Evap I/M Program: No

ATP Program: No

Reformulated Gas: No

Vehicle Type: LDGV LDGT12 LDGT34 LDGT HDGV LDDV

LDDT HDDV MC All Veh

GVWR: <6000 >6000 (All)

VMT Distribution:	0.4624	0.3040	0.1046	0.0365	0.0008	0.0016
	0.0839	0.0062	1.0000			

Composite Emission Factors (g/mi):

Composite VOC :	1.805	1.868	2.876	2.126	2.378	0.763	0.871	0.736
	2.14	1.867						

Composite CO :	18.87	22.21	33.93	25.21	29.26	1.736	1.521	3.821
	16.31	20.520						

Composite NOX :	1.355	1.427	1.772	1.515	5.191	1.644	1.633	16.685
	1.19	2.846						

* MOBILE6.2.03 (24-Sep-2003)

* Input file: EMISS1.IN (file 1, run 28).

* Reading Registration Distributions from the following external

* data file: RISQ.D

* #####

* Scenario Title Text - Rhode Island Status Quo

* File 1, Run 28, Scenario 1.

* #####

M 48 Warning: there are no sales for vehicle class HDGV8b

Calendar Year: 2001

Month: July

Altitude: Low

Minimum Temperature: 64.0 (F)

Maximum Temperature: 92.0 (F)

Absolute Humidity: 75. grains/lb

Nominal Fuel RVP: 7.0 psi

Weathered RVP: 6.7 psi

Fuel Sulfur Content: 299. ppm

Exhaust I/M Program: No

Evap I/M Program: No

ATP Program: No

Reformulated Gas: No

Vehicle Type:	LDGV	LDGT12	LDGT34	LDGT	HDGV	LDDV
	LDDT	HDDV	MC	All Veh		
GVWR:	<6000	>6000	(All)			

VMT Distribution:	0.4657	0.3022	0.1040	0.0363	0.0007	0.0016
	0.0834	0.0062	1.0000			

Composite Emission Factors (g/mi):

Composite VOC :	1.679	1.868	2.876	2.126	2.378	0.723	0.871	0.736
	2.14	1.808						

Composite CO :	17.96	22.21	33.93	25.21	29.26	1.683	1.521	3.821
	16.31	20.084						

Composite NOX :	1.306	1.427	1.772	1.515	5.191	1.615	1.633	16.685
	1.19	2.814						

* MOBILE6.2.03 (24-Sep-2003)

* Input file: EMISS1.IN (file 1, run 29).

* Reading Registration Distributions from the following external

* data file: RIC.D

* #####

* Scenario Title Text - Rhode Island Change

* File 1, Run 29, Scenario 1.

* #####

M 48 Warning: there are no sales for vehicle class HDGV8b

Calendar Year: 2001

Month: July

Altitude: Low

Minimum Temperature: 64.0 (F)

Maximum Temperature: 92.0 (F)

Absolute Humidity: 75. grains/lb

Nominal Fuel RVP: 7.0 psi

Weathered RVP: 6.7 psi

Fuel Sulfur Content: 299. ppm

Exhaust I/M Program: No

Evap I/M Program: No

ATP Program: No

Reformulated Gas: No

Vehicle Type:	LDGV	LDGT12	LDGT34	LDGT	HDGV	LDDV
	LDDT	HDDV	MC	All Veh		
GVWR:	<6000	>6000	(All)			

VMT Distribution:	0.4655	0.3023	0.1040	0.0363	0.0008	0.0016
	0.0834	0.0062	1.0000			

Composite Emission Factors (g/mi):

Composite VOC :	1.711	1.868	2.876	2.126	2.378	0.749	0.871	0.736
	2.14	1.823						

Composite CO :	18.24	22.21	33.93	25.21	29.26	1.721	1.521	3.821
	16.31	20.216						

Composite NOX :	1.313	1.427	1.772	1.515	5.191	1.654	1.633	16.685
	1.19	2.818						

 * MOBILE6.2.03 (24-Sep-2003)
 * Input file: EMISS1.IN (file 1, run 30).

* Reading Registration Distributions from the following external
 * data file: CTA.D

* #####
 * Scenario Title Text - Conn Actual
 * File 1, Run 30, Scenario 1.
 * #####
 M 48 Warning: there are no sales for vehicle class HDGV8b

Calendar Year: 2001
 Month: July
 Altitude: Low
 Minimum Temperature: 64.0 (F)
 Maximum Temperature: 92.0 (F)
 Absolute Humidity: 75. grains/lb
 Nominal Fuel RVP: 7.0 psi
 Weathered RVP: 6.7 psi
 Fuel Sulfur Content: 299. ppm

Exhaust I/M Program: No
 Evap I/M Program: No
 ATP Program: No
 Reformulated Gas: No

Vehicle Type:	LDGV	LDGT12	LDGT34	LDGT	HDGV	LDDV
	LDDT	HDDV	MC	All Veh		
GVWR:	<6000	>6000	(All)			
VMT Distribution:	0.4584	0.3061	0.1053	0.0367	0.0010	0.0017
	0.0845	0.0063	1.0000			

 Composite Emission Factors (g/mi):
 Composite VOC : 1.994 1.868 2.876 2.126 2.378 0.840 0.871 0.736
 2.14 1.954
 Composite CO : 20.32 22.21 33.93 25.21 29.26 1.854 1.521 3.821
 16.31 21.190
 Composite NOX : 1.414 1.427 1.772 1.515 5.191 1.779 1.633 16.685
 1.19 2.883

 * MOBILE6.2.03 (24-Sep-2003)
 * Input file: EMISS1.IN (file 1, run 31).

* Reading Registration Distributions from the following external
 * data file: CTSQ.D

* #####
 * Scenario Title Text - Conn Status Quo
 * File 1, Run 31, Scenario 1.
 * #####
 M 48 Warning: there are no sales for vehicle class HDGV8b

Calendar Year: 2001
 Month: July
 Altitude: Low
 Minimum Temperature: 64.0 (F)
 Maximum Temperature: 92.0 (F)
 Absolute Humidity: 75. grains/lb
 Nominal Fuel RVP: 7.0 psi
 Weathered RVP: 6.7 psi
 Fuel Sulfur Content: 299. ppm

Exhaust I/M Program: No
 Evap I/M Program: No
 ATP Program: No
 Reformulated Gas: No

Vehicle Type:	LDGV	LDGT12	LDGT34	LDGT	HDGV	LDDV
	LDDT	HDDV	MC	All Veh		
GVWR:	<6000	>6000	(All)			

VMT Distribution:	0.4622	0.3040	0.1046	0.0365	0.0009	0.0016
	0.0839	0.0062	1.0000			

 Composite Emission Factors (g/mi):

Composite VOC :	1.878	1.868	2.876	2.126	2.378	0.810	0.871	0.736
	2.14	1.901						
Composite CO :	19.46	22.21	33.93	25.21	29.26	1.810	1.521	3.821
	16.31	20.790						
Composite NOX :	1.365	1.427	1.772	1.515	5.191	1.731	1.633	16.685
	1.19	2.851						

 * MOBILE6.2.03 (24-Sep-2003)
 * Input file: EMISS1.IN (file 1, run 32).

* Reading Registration Distributions from the following external
 * data file: CTC.D

* #####
 * Scenario Title Text - Conn Change
 * File 1, Run 32, Scenario 1.
 * #####
 M 48 Warning: there are no sales for vehicle class HDGV8b

Calendar Year: 2001
 Month: July
 Altitude: Low
 Minimum Temperature: 64.0 (F)
 Maximum Temperature: 92.0 (F)
 Absolute Humidity: 75. grains/lb
 Nominal Fuel RVP: 7.0 psi
 Weathered RVP: 6.7 psi
 Fuel Sulfur Content: 299. ppm

Exhaust I/M Program: No
 Evap I/M Program: No
 ATP Program: No
 Reformulated Gas: No

Vehicle Type:	LDGV	LDGT12	LDGT34	LDGT	HDGV	LDDV
	LDDT	HDDV	MC	All Veh		
GVWR:		<6000	>6000	(All)		
VMT Distribution:	0.4612	0.3046	0.1048		0.0366	0.0010
	0.0840	0.0062	1.0000			0.0016

 Composite Emission Factors (g/mi):
 Composite VOC : 1.945 1.868 2.876 2.126 2.378 0.838 0.871 0.736
 2.14 1.932
 Composite CO : 20.04 22.21 33.93 25.21 29.26 1.850 1.521 3.821
 16.31 21.057
 Composite NOX : 1.385 1.427 1.772 1.515 5.191 1.771 1.633 16.685
 1.19 2.863

Vita

Karie Barbour was born in Princeton, West Virginia in 1977. In 1995, she graduated from Unioto High School in Chillicothe, OH. Karie received a B.A. with a double major in economics and political science in May of 1999 from the University of Tennessee, Knoxville. In December of 2003, she received a M.A. in Economics from the University of Tennessee. Karie received her Ph.D. in Economics from the University of Tennessee, Knoxville in August of 2004. After completing her Ph.D., Karie joined the faculty at Illinois State University in Normal, Illinois as an assistant professor in the economics department.