The Distributional Effects of Motor Vehicle Excise Taxes: Who Pays at the Pump?

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Motivation

- What are the distributional effects of excise taxes on motor vehicles?
- Do motor vehicle taxes affect urban form decisions?
  - If so, how does a model with endogenous neighborhood choice change current estimates?

- Motor vehicle taxes are interesting for a number reasons
- They are responsible for addressing costly externalities, including pollution, traffic congestion, accidents, and highway damage
  - Automobiles were estimated to produce 28 % of all local pollutants in 2003 (EPA 2004)
  - The annual time and fuel spent in traffic was valued at $121 billion in 2013
- Motor vehicle taxes have a high public profile
  - 77 percent of voters reported rising gas prices as an 'important factor' in their voting decision during the 2012 presidential primary

- These taxes raise a large amount of revenue - $90 billion across all governments in 2012 (Tax Policy Center 2013)
- However, such funds have proven insufficient in financing highway expenditures
  - At the federal level, outlays from the Highway Trust Fund have exceeded revenues in 13 out of the last 14 years (CBO 2014)
- Auto tax revenues have also proven inadequate in covering the social costs of driving
  - Parry and Small (2002) estimated that fully paying for the externalities imposed by driving would require a 50 cent to $1 increase in the tax per gallon on gasoline (current effective tax rate is 48 cents per gallon)
- Legislative proposals to change motor vehicle tax policy include the UPDATE Act of 2013 (which would increase fuel taxes by 15 cents per gallon) and The American Clean Energy Security Act of 2009 (which would levy a carbon tax on oil producers)
- Identifying the real distributional outcomes of tax and spending programs serves as the basis for potential improvements in the welfare activities of government

- The primary obstacle to consistently identifying the incidence of motor vehicle taxes is accurately capturing all of the markets that they impact
  - These include markets for motor fuel, new and used vehicles, and public transportation
- The nature of such effects depends on what is implicitly being taxed and how the taxed is applied
  - In the market for new vehicles, an increase in the tax on gasoline will both reduce total demand (as the cost of driving increases) and lead to more purchases of vehicles with high fuel-efficiency (as their relative cost decreases)
  - An increase in the sales tax on all vehicle purchases would also decrease total demand for new vehicles but would not be expected to change relative demand for vehicles with high and low fuel-efficiency

- Several studies examined the welfare effects of taxes on motor fuel in the context of a larger debate over the proper way to measure household ability to pay (Poterba 1991, Metcalf 1993, Chernick 1997)
- West (2004) developed welfare estimates of a number of transportation taxes through a model that estimated policy effects on VMT and new vehicles
- Bento et. al. (2009) estimated the distributional effect of a 25 cent gas tax increase, accounting for the motor fuel and new and used vehicle markets

- There are four main ways that new studies could improve the current state of knowledge on the incidence of motor vehicle taxes
  - Increased coverage of policies
    - This includes policies currently in use (gas guzzler taxes, toll roads, etc.) and those proposed or implemented in other countries (carbon taxes, VMT tax)
  - Account for policy effects outside of the fuel market
  - Increase the dimensions of distributional analysis beyond measures of household wealth
  - Use data that captures recent shifts in transportation pricing
    - The most recent data used was from 2001, when the average price of a gallon of gasoline was $1.46

Contribution

- This analysis estimates the distributional impact of taxes on motor fuels, new vehicles, and gas guzzlers, as well as public toll roads
- My model covers the effect of auto taxes on the markets for fuel, new vehicles, and urban form decisions
  - Based on current estimates, a 50 cent increase in the tax on gasoline would result in the average household paying roughly $500 in additional fuel taxes per year; this increase could alter housing decisions in an effort to reduce commuting costs
- The data used measured household behavior after the large increase in fuel prices in 2006-2008

- The primary dataset for this study is the 2009 National Household Transportation Survey (NHTS)
  - The NHTS provides detailed information on household wealth, demographics, vehicle miles travelled, gasoline prices, and the vehicle stock
  - It also offers a number of measures of urbanization, including population density, the form of the surrounding community, and the availability of rail and bus transportation
- The cleaned dataset has a sample of just over 128,000 households

Summary Statistics

Table 1: Summary Statistics by Number of Vehicles					
	Number of Vehicles				
Household Characteristics	0	1	2	3+	All
Number of households	94	36,021	55,858	36,278	128,256
Annual income	44,202	37,101	68,457	78,129	62,368
Number of drivers	1.51	1.21	1.93	2.43	1.87
Number of workers	0.71	0.44	1.02	1.50	0.99
Age of household head	53.8	63.6	54.9	50.0	55.9
% of households that are white	70.2	84.8	87.6	88.2	87.0
% of household heads with education > high school	51.1	62.1	75.5	74.8	71.6
% of households in an urban area	81.9	78.4	70.8	60.7	70.1
% Households in Northeast	9.6	15.1	13.1	11.3	13.2
% Households in Midwest	7.4	9.4	10.3	10.3	10.5
% Households in South	64.9	53.8	55.7	55.7	18.3
% Households in West	18.1	21.7	20.8	20.8	21.0
% Home owners	74.5	77.9	92.2	96.1	89.3

SOURCE: 2009 NHTS. All reported figures are mean values unless stated otherwise. Annual income is measured in 2009 dollars. Household heads are identified as: (a) if the household has at least one worker, the workers with the most total education; (b) if no workers are present, the oldest individual. Households must exclusively identify as white to be treated as such in this table. Northeast, Midwest, South and West regions are consistent with those identified by the U.S. Census Bureau.

- In the auto transportation market, households choose both (a) what type of vehicle bundles to consume (number, age, and size), and (b) how much they want to drive
- Vehicle bundle choices are discrete: given a number of cars n and bundle type b, consumers maximize the conditional indirect utility function:

$$V_{nb} = f(b, y_{nb}, p_{nb}, c_{nb}, h, \epsilon_{nb}, \eta)$$

  - y represents income net of vehicle expenses, p is the cost per mile of driving, c represents the observable attributes of the vehicle bundle, h the observed household characteristics, and ϵ and η the unobservables of the vehicles and household respectively
- By Roy's identity, household vehicle miles travelled is thus

$$VMT_{nb} = \frac{\delta V_{nb}/\delta p_{nb}}{\delta V_{nb}/\delta y_{nb}}$$

- The vehicle bundle decision can be decomposed into choices over the number of vehicles to own and the bundle (age and size); if one assumes the error terms in each equation are jointly distributed GEV, nested logit is appropriate
- The functional form for the conditional indirect utility equation is modified from work by Dubin and McFadden, and is

$$V_{nb} = (\alpha_0^{nb} + \alpha_1/\beta + \alpha_1 p_{nb} + h'\gamma + \beta y_{nb} + \eta)e^{-\beta p_{nb}} + \epsilon_{nb}$$

- Application of Roy's Identity as in the previous yields the appropriate VMT equation:

$$VMT_{nb} = q_{nb} + \alpha_0^{nb} + \alpha_1 p_{nb} + h'\gamma + \beta y_{nb} + \eta$$

- If we believed that the error terms in each equation to be independent, these equations could be accurately estimated via OLS
- However, because this is implausible (households with longer commutes may prefer more fuel-efficient vehicles, etc.), the conditional expectation correction method must be use to eliminate bias

Table 2: Summary Statistics by Income Category						
	Household Income					
Household Characteristics	<$25K	$25K-$50K	$50K-$75K	$75K-$100K	>100K	All
Number of households	25,617	35,618	23,580	18,078	25,363	128,256
Number of drivers	1.44	1.74	1.97	2.1	2.19	1.87
Number of workers	0.43	0.76	1.12	1.36	1.47	0.99
Average age of household head	62.1	59.1	54	51.3	50.8	56.0
% of households that are white	80.4	87	88.9	89.4	89.6	87.0
% of household heads with education > high school	41.6	63.9	79.3	86.4	92.8	71.5
% of households in an urban area	68	68.9	68.9	70.2	74.6	70.1
% Households in Northeast	11.4	12.8	13.7	14.1	14.3	13.2
% Households in Midwest	10.2	11.6	11.9	10.6	8.0	10.0
% Households in South	60	56.1	54.1	53.9	51.7	55.2
% Households in West	18.4	19.5	20.2	21.5	25.9	21.1
% Home owners	76.6	87.6	92.6	94.7	96.7	89.3
Annual miles driven, all vehicles	10,311	16,424	22,186	26,197	29,058	20,444
% of total income spent on motor fuel	18.7	8.2	6.2	5.1	3.8	8.35
% of Households that use at least 2 vehicles	38.9	64.1	80.6	89.0	93.4	71.8
% of Households that use at least 3 vehicles	10.8	21.6	32	38.6	43.3	28.3

NOTE: All reported figures are mean values unless stated otherwise. Annual income is measured in 2009 dollars. Household heads are identified as: (a) if the household has at least one worker, the workers with the most total education; (b) if no workers are present, the oldest individual. Households must exclusively identify as white to be treated as such in this table. Northeast, Midwest, South and West regions are consistent with those identified by the U.S. Census Bureau.

Table 3: VMT Regressions on vehicle-owning households Dependent variable = (VMT-typical miles driven): standard errors in parentheses				
Variable	OLS		CEC	
Operating cost per mile	-69213.4	*(10611.1)*	-64970.5	*(19437.1)*
Income-total operating cost	-0.0078	*(0.041)*	0.031	*(0.043)*
Operating costs*net income	0.097	*(0.25)*	-0.064	*(0.25)*
Vehicle capital cost	0.27	*(0.028)*	0.74	*(0.14)*
Midwest	2820.4	*(857.9)*	2307.1	*(863.3)*
South	4412.6	*(916.1)*	3974.5	*(844.2)*
West	1364.9	*(799.1)*	1009.3	*(813.6)*
Head's education>high school	282.3	*(796.7)*	-57.4	*(902.4)*
White household	1598.3	*(747.1)*	643.5	*(458.7)*
Number of income earners	2740.5	*(701.3)*	1843.7	*(898.9)*
Family size	806.1	*(298.3)*	337.1	*(302.1)*
Number of drivers	3320.6	*(720.3)*	1245.5	*(733.4)*
Head age 25-44	-1127.9	*(1822.5)*	-1145.4	*(1847.8)*
Head age 45-64	-677.0	*(1824.8)*	-632.3	*(1921.4)*
Head age 65+	-3255.0	*(1741.8)*	-2644.8	*(1954.5)*
Home in Town & Country	4311.9	*(983.2)*	4632.9	*(1028.3)*
Home in Suburbs	-139.0	*(892.3)*	225.7	*(904.3)*
Home in Small City	1601.6	*(1029.0)*	1023.4	*(1125.7)*
Bias	-	-	-25.41	*(4.60)*
Constant	8131.35	*(644.05)*	-	-
R-squared	0.314		0.396	
Observations	128,256		128,256	
NOTE: Standard errors were calculated using the Huber-White sandwich estimator.				

Table 4: Distributional Effects Using Conditional Expectation Correction (CEC) Estimates *Demand elasticities are allowed to vary across deciles*		
Decile	Elasticity of Demand for VMT with respect to…	
	Operating Costs	Income
1	-1.89	1.23
2	-1.34	1.14
3	-1.32	1.08
4	-1.24	1.02
5	-1.10	0.98
6	-1.05	0.98
7	-0.99	0.94
8	-0.96	0.84
9	-0.91	0.73
10	-0.88	0.54
Suits Index:	-0.346	
NOTE: Elasticities calculated assuming a gas tax increase of 25 cents per gallon. Miles after tax are calculated using estimated elasticities and miles before tax. Demand elasticities are obtained at the mean operating cost per mile, miles driven, and income levels within a given decile.		

- The available evidence suggests that taxes on motor fuels are more regressive than indicated in previous studies
- A 25 cent increase on the tax on gasoline would be expected to produce a 8 percent reduction in total vehicle miles traveled
- Increases in the regressivity of the motor fuels tax and in consumer responsiveness may be a function of rising fuel prices and of the availability of more fuel-efficient vehicles
- Low-income households have more elastic price demand for VMT than wealthier households

- Raising taxes on automobiles increases the cost of driving, which increases the relative utility of residences that reduce commuting times and distances, have less traffic, and have more attractive transportation alternatives to driving
  - Bento et. al. (2005) showed that both the quantity and type of driving demanded (VMT and average distance driven) varies significantly across measures of urban form
  - Devereux, Lockwood and Redondo (2007) provide evidence that differences in fuel tax rates induces interstate mobility

Table 5: Summary Statistics by Urban Form Category					
	Urban Category				
Household Characteristics	Urban	Second City	Suburban	Town & Country	All
Number of households	62,112	30,176	22,764	13,204	128,256
Annual income	61,052	58,968	72,066	59,182	62,368
Number of drivers	1.79	1.8	1.9	1.9	1.87
Number of workers	0.98	0.97	1.04	0.99	0.99
Age of household head	54.9	56.1	55.6	56.2	55.9
% of households that are white	73.3	83.6	85.7	91.7	87.0
% of household heads with education > high school	74.6	72.4	80.1	66.5	71.6
% Households in Northeast	12.5	7.8	11.1	16.3	13.2
% Households in Midwest	3.9	11.2	10.8	11.6	10.5
% Households in South	31.1	57.6	48.7	62.8	55.3
% Households in West	52.4	23.4	29.3	9.4	21.0
% Home owners	78.9	85.2	90.4	92.4	89.3
Annual miles driven, all vehicles	17,989	20,692	22,137	25,771	23,212
% of total income spent on motor fuel	7.33	7.75	6.37	9.93	8.44
% of Households that use at least 2 vehicles	58.7	65.4	72.3	76.8	71.8
% of Households that use at least 3 vehicles	33.7	25.7	22.7	18.4	28.3

SOURCE: 2009 NHTS. Urban categories are assigned by census block using data on population density and distance to the nearest population center. All reported figures are mean values unless stated otherwise. Annual income is measured in 2009 dollars. Household heads are identified as: (a) if the household has at least one worker, the workers with the most total education; (b) if no workers are present, the oldest individual. Households must exclusively identify as white to be treated as such in this table. Northeast, Midwest, South and West regions are consistent with those identified by the U.S. Census Bureau.

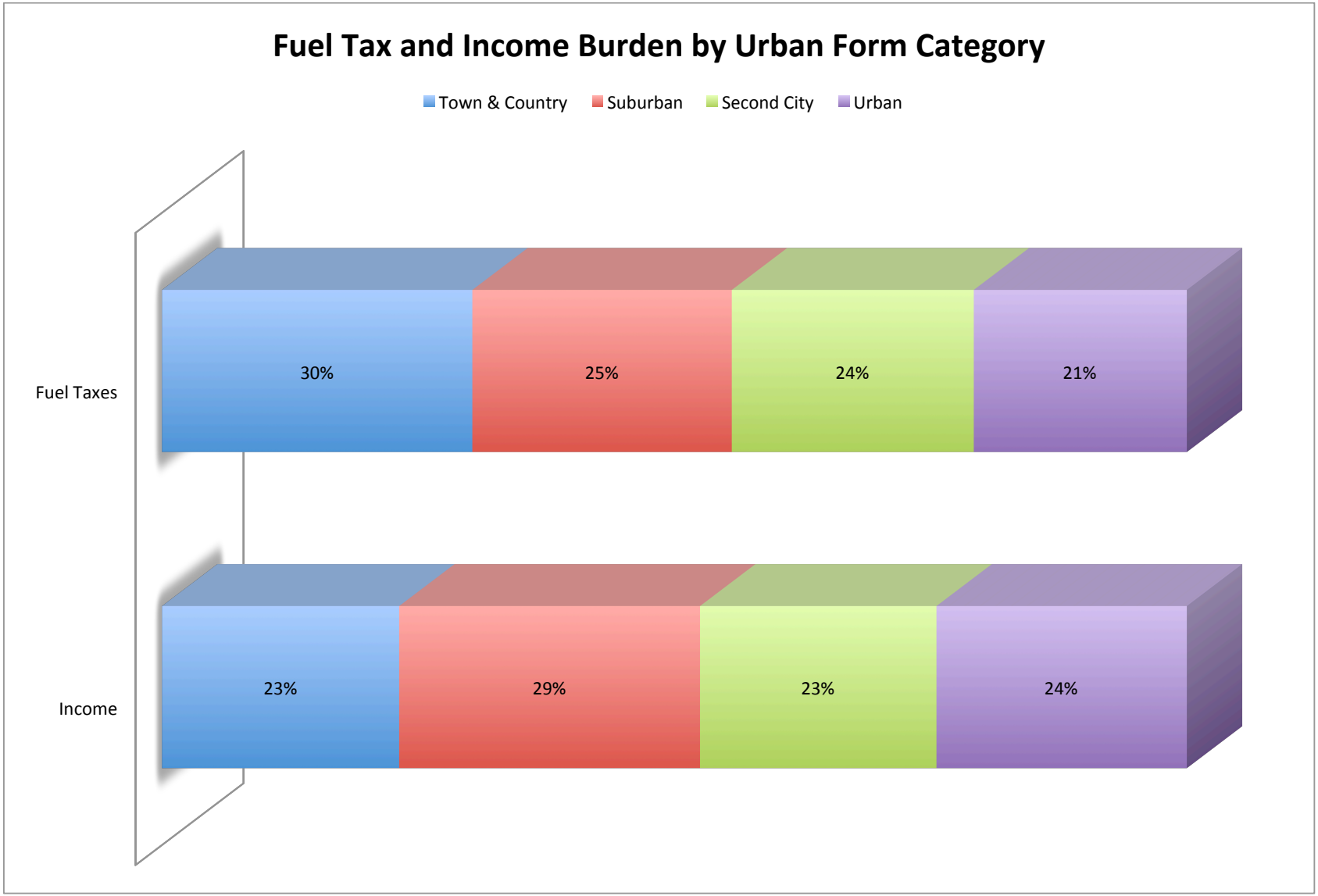
Fuel Tax and Income Burden by Urban Form Category
Town & Country
Suburban
Second City
Urban
Fuel Taxes
30%
25%
24%
21%
Income
23%
29%
23%
24%

Table 6: Within-Urban Form Income and Fuel Tax Burdens								
Urban Form Measure	Urban		Second City		Suburban		Town and Country	
Decile	*Income*	*Fuel Taxes*	*Income*	*Fuel Taxes*	*Income*	*Fuel Taxes*	*Income*	*Fuel Taxes*
1	1%	6%	1%	5%	2%	5%	1%	5%
2	3%	7%	3%	6%	3%	6%	3%	6%
3	4%	7%	4%	7%	4%	8%	4%	8%
4	5%	9%	5%	8%	6%	9%	5%	9%
5	7%	9%	7%	9%	7%	10%	7%	10%
6	8%	10%	8%	10%	9%	11%	8%	11%
7	10%	11%	10%	12%	11%	12%	10%	11%
8	13%	13%	13%	13%	12%	13%	13%	13%
9	17%	13%	17%	15%	19%	13%	17%	14%
10	31%	14%	31%	15%	28%	13%	31%	14%
	Suits Index:	0.314	Suits Index:	0.271	Suits Index:	0.269	Suits Index:	0.290
NOTE: Urban form categories are calculated through a combination of census block population densities and distance from population centers.								

Empirical Strategy

- There is increasing evidence that automobile tax policies influence household mobility decisions
- This study seeks to recognize this relationship with a model where urban form, vehicle bundle, and VMT decisions are all endogenous
- The NHTS provides information on rail transportation in urban locations, as well as average commuting distance and time to work and school
- arcGIS layers on North American Terminals and U.S. Major Roads offer additional detail on public transportation, road access, and traffic congestion
- Accurate measurement of the (likely conflicting) variables representing commuting distance and congestion will be needed to consistently estimate urban form effects: omitted variables also remains a concern

Limitations and next steps

- Lifetime income and annual consumption have been shown to be more preferable measures of household wealth than annual income, especially for households at the tails of the age spectrum
- Lower-income households are less likely to own a vehicle than the general population
  - Incidence of these taxes across expected lifetime wealth for the national population is likely more progressive than the results shown here
- Modeling that includes urban form as an endogenous variable must account for uncertainty in the timing of urban form and vehicle bundling decisions