Overreaction to Excise Taxes: the Case of Gasoline

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Motivation

- There is growing evidence that agents respond differently to tax changes and to price changes...

  and that consumers overreact to gasoline tax changes as compared to gasoline price changes.

- The implication for Pigouvian taxes is that their effectiveness may be underestimated if price elasticities are considered instead of tax elasticities.

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Literature

- Growing literature questioning the Public Finance assumption that agents respond to tax changes as they respond to price changes (Chetty, 2009; Finkelstein, 2009; Chetty *et al.* 2009).
- Empirical evidence that consumers overreact to gasoline tax changes as compared to gasoline price changes (Davis and Kilian, 2011; Li *et al.* 2012; Rivers and Schaufele, 2013).
- Different explanations for such differences:
  - Rational behavior (Davis and Kilian, 2011; Li *et al.* 2012)
  - Tax Aversion (McCaffery and Baron, 2006; Kalbekken *et al.* 2010 and 2011; Blaufus and Mohlmann, 2012)
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Our contribution

- We compute gasoline price elasticities and gasoline excise tax elasticities by estimating a complete system of demands for U.S. consumers between 2007 and 2009.
- We compare reactions to gasoline retail (tax inclusive) prices and reactions to information on gasoline excise taxes.
- We find that consumers overreact to tax changes as compared to price changes: the reaction to a tax change is around 8 times larger than the reaction to a price change of the same amount.
- We compute the degree of tax overreaction for a number of demographics accounting for household heterogeneity in the U.S..

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The Model

Data and Estimation

Conclusions

Implications

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QAIDS Share Equations

Quadratic Almost Ideal (Banks *et al.* 1997) expenditure share equations are:

$$w_i^h = \alpha_i + \sum_i \sum_k \alpha_{ik} d_k^h + \sum_j c_{ij}\ ln\ p_j + \beta_i\ ln\left[\frac{y^h}{A(p)}\right] + \left[\frac{\lambda_i}{B(p)}\right]\left[ln\left(\frac{y^h}{A(p)}\right)\right]^2 \quad (1)$$

- y^h total expenditure of household h
- $c_{ij} = \frac{1}{2}(c_{ij}^* + c_{ji}^*) = c_{ji}$
- α_{ik} coefficients of the translating intercepts $d^h = d_1^h ... d_k^h$ (households' types, households' location)
- $lnA(p)$ translog and linear homogeneous price index
- $B(p)$ homogeneous of degree zero in p Cobb-Douglas price index
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Incorporating Information on Taxes into the Demand Functions

- We include excise taxes on gasoline among the explanatory variables of the share equations using the translating technique (Pollak and Wales, 1992; Lewbel, 1985)
- This technique has often been used to analyze the effect of information (Jensen *et al.*, 1992; Chern *et al.*, 1995), innovation (Moro *et al.*, 1996) and advertising (Duffy, 1995; Brown and Lee, 1997), in demand systems.

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Tax Overreaction

Given the retail price of gasoline $q = p + t^e$

the degree of overreaction θ is measured by the ratio of the compensated (Hicksian) elasticities of demand to t^e and q, each multiplied by the respective percentage change

$$\theta = \frac{\left(\frac{\delta X}{\delta t^e} \times \frac{t^e}{X}\right) \times \frac{\Delta t^e}{t^e}}{\left(\frac{\delta X}{\delta q} \times \frac{q}{X}\right) \times \frac{\Delta q}{q}} = \frac{\varepsilon_{x,t^e} \times \frac{\Delta t^e}{t^e}}{\varepsilon_{x,q} \times \frac{\Delta q}{q}} \qquad (2)$$

A given value of θ suggests how strongly consumers react to a given tax change compared to a price change **of the same amount.**

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Data sources

Expenditure data

- U.S. Consumer Expenditure Survey (CEX) waves 2007, 2008 and 2009 supplied by the Bureau of Labour Statistics (BLS).
- The sample spans 39 months, from January 2007 to March 2010, and 20 Metropolitan Statistical Areas (MSA).
- Our system of demands considers current expenditures (ignoring durables and occasional purchases) on:
  1. Home food
  2. Electricity
  3. Natural Gas
  4. Other Home Fuels
  5. Motor Fuels (gasoline)
  6. Public Transports
  7. All Other Expenditures

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  5. Motor Fuels (gasoline)
  6. Public Transports
  7. All Other Expenditures

Expenditure and demographic data

Table 1 – Summary statistics of budget shares

Variable	Obs.(#)	Mean	Standard deviation	Coeff. of variation	Min	Max	Zeros
Food at home	43,457	22.8%	13.7%	0.60	0.0%	100.0%	0.9%
Electricity	43,457	5.8%	5.3%	0.92	0.0%	100.0%	8.5%
Natural gas	43,457	2.9%	4.3%	1.50	0.0%	63.4%	38.5%
Other home fuels	43,457	0.7%	3.1%	4.59	0.0%	72.8%	91.2%
Motor fuels	43,457	9.1%	7.7%	0.84	0.0%	100.0%	12.9%
Public transport	43,457	2.0%	5.4%	2.63	0.0%	81.4%	73.4%
All other expenditures	43,457	56.7%	17.5%	0.31	0.0%	100.0%	0.1%

Table 2 – Summary statistics of socio-demographics and total current expenditure

Variable	Obs.(#)	Mean	Standard deviation	Min	Max
Single	43,457	0.28	0.45	0	1
H&W	43,457	0.19	0.40	0	1
H&W, child(ren) <6	43,457	0.05	0.21	0	1
H&W, child(ren)<18	43,457	0.14	0.34	0	1
H&W,child(ren) >17	43,457	0.08	0.27	0	1
Other households	43,457	0.26	0.44	0	1
Northeast	43,457	0.31	0.46	0	1
Midwest	43,457	0.20	0.40	0	1
South	43,457	0.24	0.43	0	1
West	43,457	0.26	0.44	0	1
Composition income earners	43,457	0.23	0.42	0	1
*Education reference person**	43,457	13.41	1.98	0	17
Number of cars	43,457	0.91	0.89	0	15
Total current expenditure, $	43,457	7,178.8	7,298.6	35.0	321,316.0

* 0 "Never attended school", 10 "1st through 8th grade", 11 "9th through 12th grade", 12 "High school graduate", 13 "Some college, less than college graduate", 14 "Associate's degree", 15 "Bachelor's degree", 16 "Master's degree", 17 "Professional/Doctorate degree".

Data sources

Price and Tax data

- We use monthly price indices varying by MSA, supplied by the Bureau of Labour Statistics (BLS).
- Three layers of taxes apply to U.S. consumption of gasoline and auto diesel: federal taxes, State taxes and local taxes.
- The federal tax rate on gasoline is 18.4 cents per gallon and has not changed since 2006.
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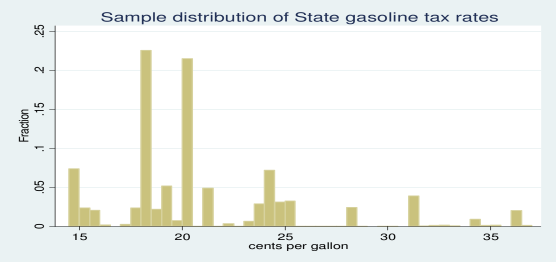
Price and Tax data

Table A3 – Price indices (1982-84 = 100)

Index	Obs.(#)	Mean	St. deviation	Min	Max
Food at home	43,457	208.40	24.61	124.23	236.79
Electricity	43,457	195.16	42.81	102.03	311.82
Natural gas	43,457	214.95	38.67	112.18	371.55
Other home fuels	43,457	273.30	44.96	228.03	384.30
Motor fuels	43,457	233.48	49.92	143.60	453.11
Public transport	43,457	237.77	10.85	219.86	267.72
All other expenditures	43,457	177.12	17.11	123.00	222.55

Note: All indices are Laspeyres price indices, for all urban consumers, not seasonally adjusted.

Figure A2 – Distribution of gasoline taxes



Two-Step Estimation

Two-step estimator (Shonkwiler and Yen, 1999):

1) probit estimation in the first step
2) a selectivity-augmented equation system estimated with maximum likelihood in the second step.

The dependent variable in the first-step probits is the binary outcome defined by the expenditure in each good.

Exogenous variables used in the first-step probits are:

- total expenditure
- dummies indicating household location and household type
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- a dummy for the presence of two income earners in the household

Since the proportion of consuming households for Food exceeds 95%, probit is estimated only for the remaining commodities.

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Second-step QAID estimates

Table 3 - Second-step QAID estimates

Coefficient	i=1 Food	i=2 Electricity	i=3 Nat. Gas	i=4 Oth. F.	i=5 Gasoline	i=6 Pb. Tr.
α_i	**0.200**	**0.054**	**0.036**	**0.647**	**0.106**	**0.119**
	0.001	*0.001*	*0.006*	*0.031*	*0.002*	*0.025*
β_i	**-0.109**	**-0.029**	**-0.019**	**-0.044**	**-0.039**	**0.032**
	0.001	*0.001*	*0.001*	*0.001*	*0.001*	*0.006*
λ_i	**-0.003**	**0.001**	**-0.004**	**-0.041**	**-0.013**	**-0.007**
	0.001	*0.000*	*0.000*	*0.002*	*0.001*	*0.001*
$\alpha_{i,NE}$	**0.030**	**0.012**	**-0.006**	**-0.083**	**0.009**	**-0.033**
	0.002	*0.001*	*0.004*	*0.015*	*0.001*	*0.005*
$\alpha_{i,SO}$	**0.017**	**0.039**	**-0.027**	**-0.021**	**0.013**	**0.012**
	0.002	*0.001*	*0.005*	*0.008*	*0.001*	*0.004*
$\alpha_{i,WE}$	**0.041**	**-0.005**	**-0.038**	**-0.002**	**0.018**	**-0.013**
	0.002	*0.001*	*0.001*	*0.009*	*0.001*	*0.004*
$\alpha_{i,NCAR}$	**-0.011**	**0.001**	**0.001**	**0.008**	**0.011**	**-0.007**
	0.001	*0.000*	*0.000*	*0.001*	*0.001*	*0.001*
$\alpha_{i,TWOE}$	**-0.001**	**-0.001**	**-0.002**	**-0.021**	**0.011**	**0.002**
	0.001	*0.000*	*0.001*	*0.003*	*0.001*	*0.003*
$\alpha_{i,N1}$	**-0.056**	**-0.009**	0.001	**0.107**	**0.003**	**-0.030**
	0.002	*0.001*	*0.002*	*0.007*	*0.001*	*0.005*
$\alpha_{i,N3}$	**0.028**	-0.001	-0.002	0.035	0.011	**-0.014**
	0.003	*0.001*	*0.001*	*0.006*	*0.002*	*0.004*
$\alpha_{i,N4}$	**0.053**	**0.007**	0.001	**0.024**	**0.018**	**0.002**
	0.002	*0.001*	*0.001*	*0.004*	*0.001*	*0.004*
$\alpha_{i,N5}$	**0.048**	**0.008**	-0.000	**0.022**	**0.022**	-0.011
	0.002	*0.001*	*0.001*	*0.001*	*0.001*	*0.004*
$\alpha_{i,N6}$	**0.024**	**0.003**	0.001	**0.039**	**0.016**	-0.026
	0.001	0.001	0.001	0.001	0.001	0.004
$\alpha_{i,EDUC}$	**-0.005**	**-0.002**	**-0.001**	**-0.001**	**-0.004**	**0.001**
	0.000	*0.000*	*0.000*	*0.001*	*0.000*	*0.001*
$\alpha_{i,TAX}$	**-0.030**	**0.017**	**-0.013**	**0.144**	**-0.061**	**0.029**
	0.005	*0.002*	*0.003*	*0.009*	*0.004*	*0.007*
LogLikelihood	392.200					
R^2	0.34	0.18	0.11	0.07	0.15	0.04
N obs	43,256					

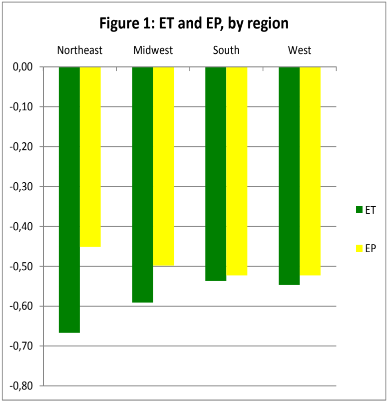
Estimated Budget Shares, Expenditure and Hicksian Elasticities

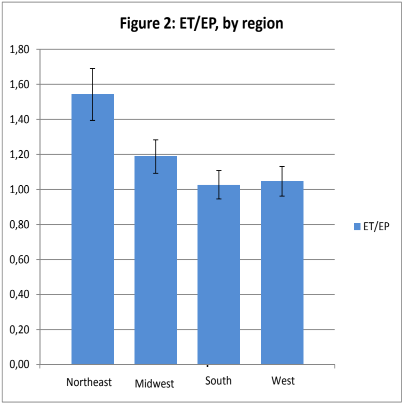
Table 4 - Estimated Budget Shares, Expenditure and Compensated Elasticities

	j=1 Food	j=2 Electricity	j=3 Nat. Gas	j=4 Oth. Fuels	j=5 Gasoline	j=6 Public Transport	j=7 Other Goods
w_j	0.228	0.058	0.029	0.007	0.090	0.021	0.567
e_j	**0.871**	**1.260**	**0.712**	**2.882**	**0.405**	**1.389**	**1.098**
	0.021	*0.033*	*0.060*	*0.151*	*0.032*	*0.117*	*0.010*
e^C_{1j}	**-0.844**	**-0.050**	**0.104**	0.005	-0.019	**0.512**	**0.629**
	0.040	*0.013*	*0.013*	*0.025*	*0.018*	*0.034*	*0.050*
e^C_{2j}	-0.072	**-0.855**	-0.019	0.054	**-0.147**	-0.026	**1.798**
	0.047	*0.027*	*0.021*	*0.042*	*0.029*	*0.065*	*0.075*
e^C_{3j}	**0.528**	-0.041	**-0.296**	**0.367**	**-0.289**	**0.647**	**-0.848**
	0.067	*0.029*	*0.040*	*0.056*	*0.036*	*0.088*	*0.099*
e^C_{4j}	0.155	0.063	**0.224**	**-0.734**	0.131	**0.248**	**2.037**
	0.098	*0.038*	*0.035*	*0.142*	*0.049*	*0.115*	*0.251*
e^C_{5j}	**-0.167**	**-0.149**	**-0.151**	-0.008	**-0.502**	-0.032	**0.717**
	-0.041	*0.018*	*0.017*	*0.033*	*0.027*	*0.044*	*0.067*
e^C_{6j}	**1.545**	-0.026	**0.388**	**0.269**	0.018	**-0.331**	**-1.175**
	0.105	*0.054*	*0.056*	*0.111*	*0.058*	*0.212*	*0.194*
e^C_{7j}	**0.291**	**0.134**	**-0.018**	**-0.029**	**0.115**	**-0.223**	**-0.393**
	0.018	*0.007*	*0.007*	*0.013*	*0.011*	*0.017*	*0.011*

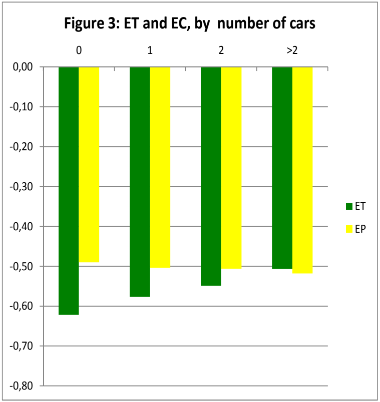
Note: Standard Errors in Italics below coefficients. Bold entries correspond to rejection of $H_0 : e = 0$ at the 5% significance level for a two tailed test.

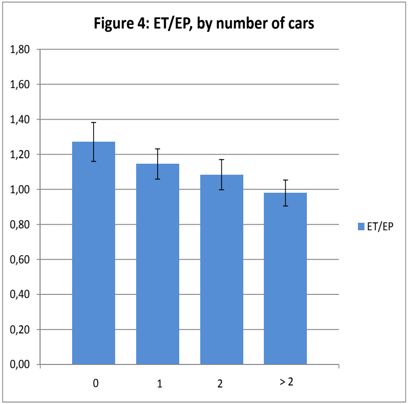
Ratio of Elasticities by region





Ratio of Elasticities by number of cars





Degree of Overreaction

Degree of overreaction by region

Regions	Theta
Sample mean	8.0
Northeast	10.0
Northwest	8.0
South	7.2
West	7.5

$\theta = 8$ means that a 13.5 cents increase in gasoline excise taxes is eight times more effective at reducing gasoline demand than a 13.5 cents increase in gasoline final price.

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Conclusions

- We compare reactions to gasoline price changes and to excise taxes' changes.
- Households overreact to gasoline taxes as compared to gasoline prices ($\theta = 8$ at the sample mean).
  - The Northeast exhibits the lowest price elasticity, the highest tax elasticity and the highest degree of overreaction among U.S. regions.
  - The ratio of elasticities appears to be negatively related to the number of cars: the more the cars owned by the household, the lower the tax elasticity relative to the price elasticity.

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Implications

- Responsiveness to tax and price changes can be very different.
- This has implications for the carbon tax debate in the U.S..
- The carbon tax rate that would reduce carbon emissions to any targeted level could be set lower than predicted by the current literature.
- A lower carbon tax rate would also probably be perceived as more acceptable than a correspondingly higher tax rate, thus improving the effectiveness-acceptability trade-off.

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