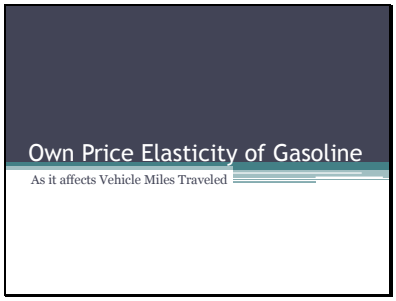
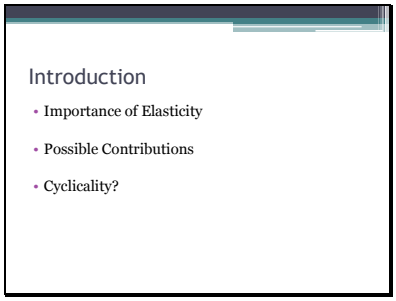
Slide 1



Slide 2



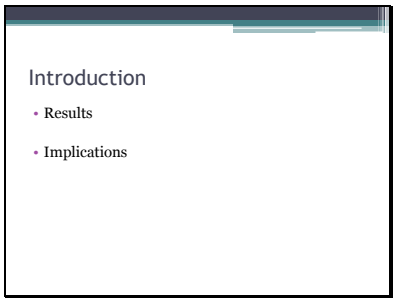
Importance to policy makers:

- Set optimal tax rates for infrastructure
- Limiting green house emission goals (regulations vs gas prices)
- Reduce driving in order to reduce traffic congestion

Cyclicality

- Do we see differences based on economic cycle

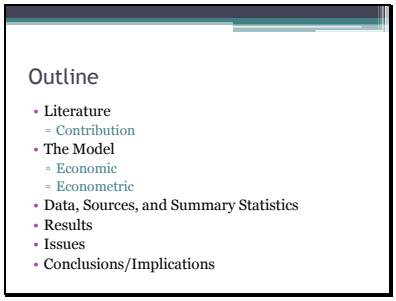
Slide 3



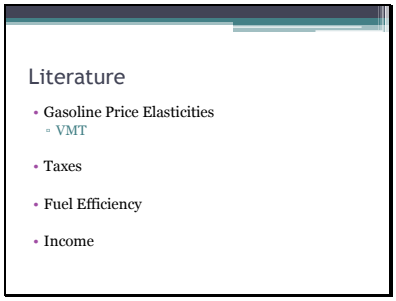
What we found was that there is a very low gasoline price elasticity for VMT, and there is some evidence that elasticity could move along with GDP.

This means that policy-makers should not rely on gasoline taxes to reduce driving, but gasoline taxes could be a good source of revenue. We also see that policy makers should take into account the changes in the economy when considering the elasticity of gasoline.

Slide 4



Slide 5



Broadly:

- Gas price and consumer demand elasticities are low (e.g. around -0.26)
- Conflicting findings on the magnitude and the direction of the effect in the longer term.

Cyclicality

- Greater inelasticity weekdays than weekends
- Rebound effect: after reduced use due to shock, resumption of higher use

Taxes:

- US study: 5-cent tax increase reduces gasoline consumption by 1.3%
- Other countries different numbers, e.g. 10.6% in B.C.
- Taxes have disproportional effect on gas demand relative to other causes of price change

Fuel Efficiency

- Most studies find 0 or a small positive effect between fuel efficiency and consumption
- Feedback loop, higher prices lead to demand for more fuel efficient vehicles (more so in the US)
- Gallagher and Muehlegger (2011) find that in the US between 2000 and 2006 tax incentives, rising gasoline prices, and social preferences accounted for 6%, 27%, and 36% of high economy hybrid sales respectively.

Income:

- Positive relationship

Broadly

Dahl, Carol, and Thomas Sterner. "Analysing gasoline demand elasticities: a survey." Energy economics 13.3 (1991): 203-210.

Cyclicality

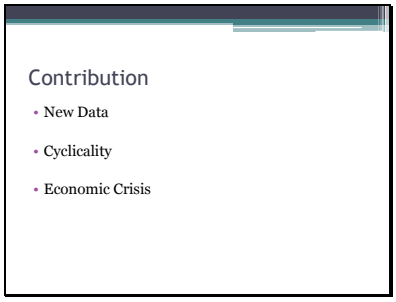
Yang, Dujuan, and Harry Timmermans. "Effects of energy price fluctuation on car-based individual activity-travel behavior." Procedia-Social and Behavioral Sciences 20 (2011): 547-557.

Hymel, K. M., Small, K. A., & Van Dender, K. Induced demand and rebound effects in road transport. Transportation Research Part B: Methodological, (2010): 44(10), 1220-1241.

Taxes

Li, Shanjun, Joshua Linn, and Erich Muehlegger. Gasoline taxes and consumer behavior. No. w17891. National Bureau of Economic Research, (2012)
Rivers, Nicholas, and Brandon Schaufele. "Carbon tax salience and gasoline demand." Sustainable Prosperity: Ottawa, ON, Canada 23.6 (2012): 35-45.
Fuel
Gallagher, Kelly Sims, and Erich Muehlegger. "Giving green to get green? Incentives and consumer adoption of hybrid vehicle technology." Journal of Environmental Economics and Management 61.1 (2011).

Slide 6



2 contributions

- Per capita monthly VMT, very recent data
- Determine whether historical trends are continuing or changing

We will:

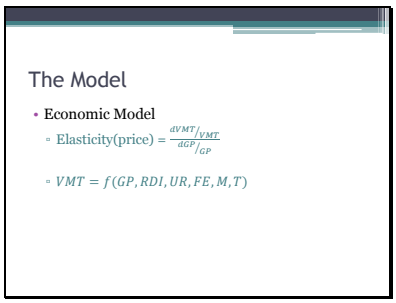
- Consider cyclical trends
- Consider effect of economic cycles

a. Expansionary period (2000 – 2007)

b. Contractionary period (2007q4-2009q2,)

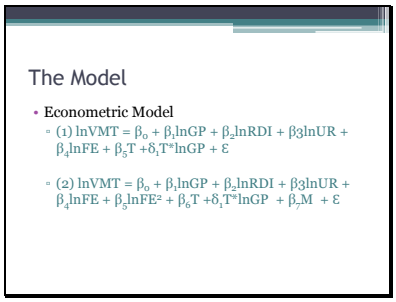
c. Recovery period (2009q3-2013.)

Slide 7



Log-log model
VMT: per capita vehicle miles driven
GP: monthly gasoline prices
RDI: real disposable income per capita
UR: monthly unemployment rate
FE: fuel efficiency: average miles per gallon for passenger cars
M: Month
T: Time period

Slide 8



Most studies use the double log function.
Particularly relevant to our study, Steven and Greening (1999) use the log transformation for gasoline prices, vehicle miles driven, and miles per gallon
Greene and Hu (1986) found that the log transformation closely fit the optimal Box-Cox transformation. [[The Box-Cox method applies the maximum likelihood theory to estimate a simple power transformation, e.g. y' = ln(y), for the dependent variable.]]

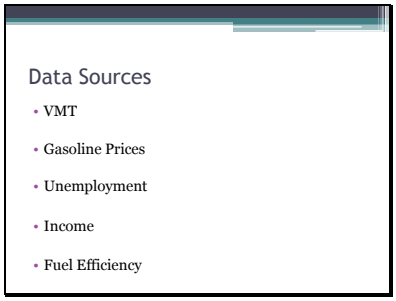
Advantage of log-log model: easily interpret the elasticities

Puller, Steven L., and Lorna A. Greening. "Household adjustment to gasoline price change: an analysis using 9 years of US survey data." Energy Economics 21.1 (1999): 37-52.

Equation 1 doesn't include month

Equation 2 adds month and the quadratic specification of fuel efficiency

Slide 9



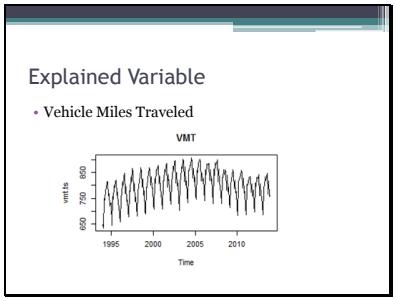
US Department of Transportation
Federal Highway Administration

- Per capita VMT
- Monthly gasoline prices
- Passenger Car Fuel Efficiency (FE)

St. Louis Federal Reserve

- Real Disposable Income per Capita (RDI)
- Monthly Unemployment Rate (UR)

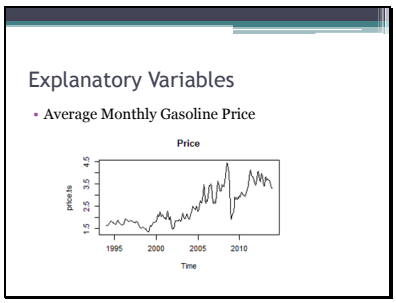
Slide 10



Non-stationary:

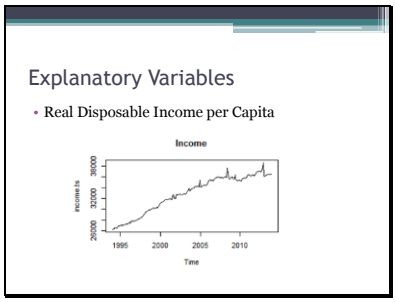
- Some trend
- Seasonal (important because probably source of some of our non-normality later)

Slide 11



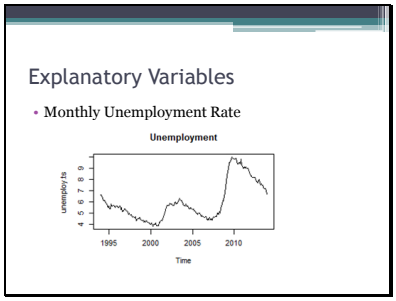
Note: sharp change in gasoline price and compare to later slides change in unemployment and fuel efficiency

Slide 12



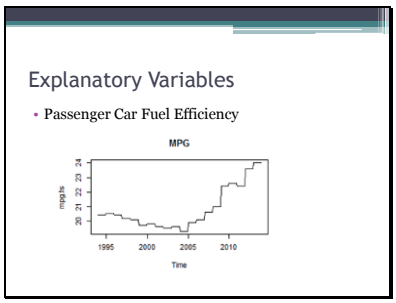
Generally upward trend, but decline during the recession

Slide 13



Lagging indicator

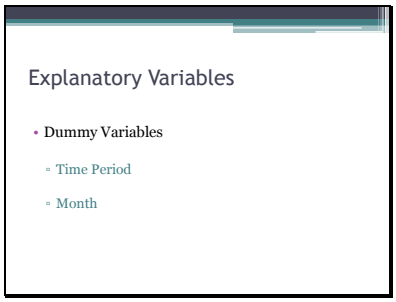
Slide 14



Notice passenger car fuel efficiency declined during the economy expansion periods, then increased sharply during the recession
This is important to remember for our final results!

But economy not only factor in determining fuel efficiency.

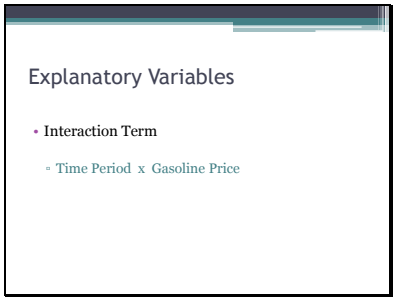
Slide 15



Two sets of dummy variables:

- Three time periods considered (2000 – 2007), (2007q4-2009q2,), (2009q3-2013) + base line (1994 – 2000)
- Months (January, February, … , December)

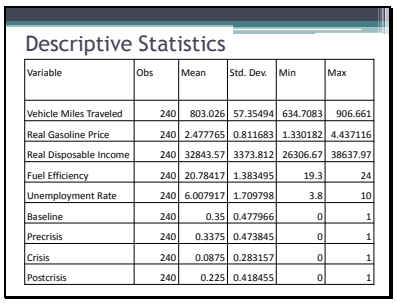
Slide 16



Interaction term:

- allows us to measure the difference of elasticities in 4 different time periods
- Time period is the dummy variable value
- Use natural log of gasoline price

Slide 17



Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Vehicle Miles Traveled	240	803.026	57.35494	634.7083	906.661
Real Gasoline Price	240	2.477765	0.811683	1.330182	4.437116
Real Disposable Income	240	32843.57	3373.812	26306.67	38637.97
Fuel Efficiency	240	20.78417	1.383495	19.3	24
Unemployment Rate	240	6.007917	1.709798	3.8	10
Baseline	240	0.35	0.477966	0	1
Precrisis	240	0.3375	0.473845	0	1
Crisis	240	0.0875	0.283157	0	1
Postcrisis	240	0.225	0.418455	0	1

240 observations
These are the untransformed values
VMT:

- 800 miles / month ~ 9,600 miles / yr
- Min of 635 = non-discretionary uses (e.g. travel to job), highly inelastic

Gas:

- Std. Dev. = 0.81, highly volatile

Income

- Steady upward trend, mean is meaningless

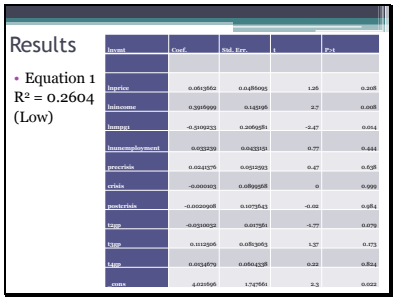
Fuel Efficiency
1. Very small range, could be causing problems in the regressions as seen later
Unemployment

- Fluctuation up and down, some periods of rapid change (e.g. financial crisis)

Baseline, Precrisis, Crisis, and Postcrisis

- Dummy variables
- Mean just represents the proportion of time in each period

Slide 18



Results

- Equation 1 $R^2 = 0.2604$ (Low)

lnumt	Coef.	Std. Err.	t	P>|t|
lnprice	0.0613662	0.0486095	1.26	0.208
lnincome	0.3916999	0.145196	2.7	0.008
lnmpg1	-0.5109233	0.2069581	-2.47	0.014
lnunemployment	0.0533239	0.0433151	0.77	0.444
precrisis	0.0214376	0.0512593	0.42	0.638
crisis	-0.000103	0.0895368	0	0.999
postcrisis	-0.0020908	0.1073643	-0.02	0.984
tspp	-0.0510032	0.037561	-1.77	0.079
tspp	0.1112506	0.0813063	1.37	0.173
tspp	0.0234679	0.0561338	0.22	0.824
cons	4.021696	1.747661	2.3	0.022

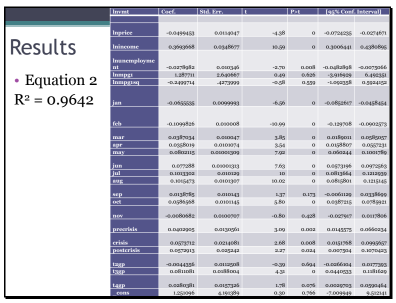
In the first specification, only a few of our variables are significant, and we get an Adjusted R squared of 0.2604. This is very low compared to similar studies in the literature. Most gasoline price elasticity studies report an R squared in the upper 0.90's.

Besides most variables being insignificant, the sign on lnmpg1 is not what we would expect…

Lnincome is what we would expect

Add month and lnmpg1 squared in the second equation

Slide 19



lnvmt	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]	
lnprice	-0.0499453	0.0114047	-4.38	0	-0.0724235	-0.0274671
lnincome	0.3693668	0.0348677	10.59	0	0.3006441	0.4380895
lnunemployment	-0.0278982	0.010346	-2.70	0.008	-0.0482898	-0.0075066
lnmpg1	1.287711	2.640667	0.49	0.626	-3.916929	6.492351
lnmpg1sq	-0.2499714	.4273999	-0.58	0.559	-1.092358	0.5924152
jan	-0.0655535	0.0099993	-6.56	0	-0.0852617	-0.0458454
feb	-0.1099826	0.010008	-10.99	0	-0.129708	-0.0902573
mar	0.0387034	0.010047	3.85	0	0.0189011	0.0585057
apr	0.0358019	0.0101074	3.54	0	0.0158807	0.0557231
may	0.0802115	0.01001309	7.92	0	0.060244	0.1001789
jun	0.077288	0.01001313	7.63	0	0.0573196	0.0972563
jul	0.1013302	0.010129	10	0	0.0813664	0.1212939
aug	0.1015473	0.0101307	10.02	0	0.0815801	0.1215145
sep	0.0138785	0.010143	1.37	0.173	-0.0061129	0.0338699
oct	0.0586568	0.0101145	5.80	0	0.0387215	0.0785921
nov	-0.0080682	0.0100707	-0.80	0.428	-0.027917	0.0117806
precrisis	0.0402905	0.0130561	3.09	0.002	0.0145575	0.0660234
crisis	0.0573712	0.0214081	2.68	0.008	0.0151768	0.0995657
postcrisis	0.0572913	0.025242	2.27	0.024	0.007504	0.1070423
t2gp	-0.0044356	0.0112508	-0.39	0.694	-0.0266104	0.0177393
t3gp	0.0811081	0.0188004	4.31	0	0.0440533	0.1181629
t4gp	0.0280381	0.0157326	1.78	0.076	0.0029703	0.0590464
_cons	1.251096	4.191389	0.30	0.766	-7.009949	9.512141

The results of this specification are much better, and closer to what we would expect. Our R squared is a much nicer 0.9642 and most of the variables are now significant.

Talk about coefficients…

If gas price doubled, VMT would fall by 5%, very small

Lnincome is what we would expect, VMT rises with income

Lnmpg1 and lnmpg1 squared makes more sense, but now insignificant. Perhaps because there is such a small range of values. Other studies looked at a larger range, by comparing regular vehicles with Hybrids.

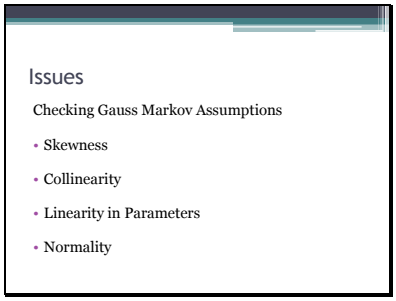
Lnunemployment what we would expect, VMT falls as unemployment rises

Month makes sense – People drive more during summer months

T2gp not significant

T3gp shows that we have a higher elasticity during the financial crisis than during the baseline, and t4gp also shows a higher elasticity than during the baseline, but lower than during the crisis.

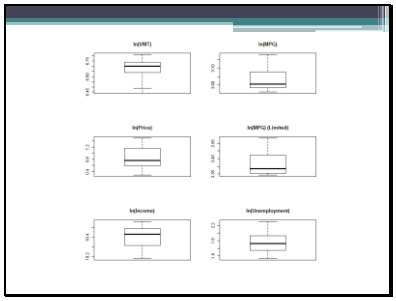
Slide 20



Met BLUE assumptions, but not the normality assumptions.

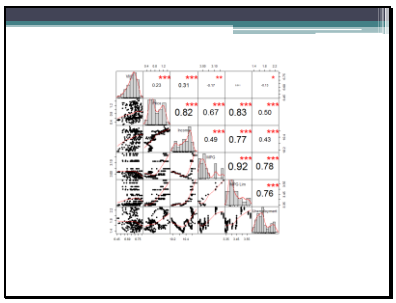
- Linear in Parameters
- Random sampling
- No perfect collinearity
- Zero conditional Mean
- Homoscedasticity – constant variance
- Normality – Not met, but central limit theorem: 240 obs is large enough not to worry

Slide 21



Boxplots:
1. Show skewness in the data in both the original and transformed data – suggesting issues with normality.

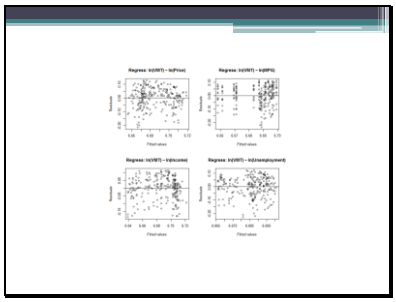
Slide 22



Multicollinearity:

- collinearity, up to 0.82
- No perfect multicollinearity
- price, mpg and unemployment data appear to be right skewed while the income data appears to be left skewed.

Slide 23

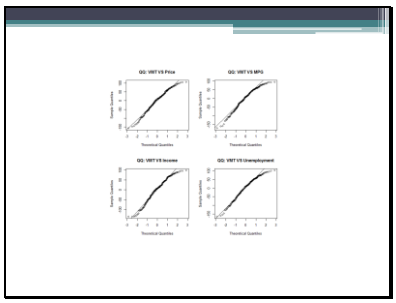


Residuals:

- residuals on the vertical axis and the independent variable on the horizontal axis.
- Fairly randomly distributed

3. Appears to have constant variance
4. Appears to be independent

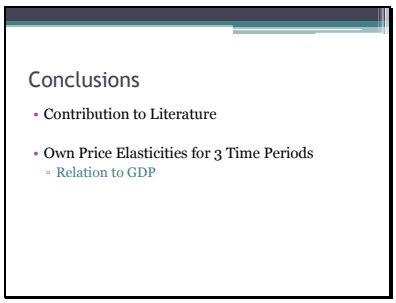
Slide 24



QQ plots:

- Non-normal distribution at the ends
- Probably due to nonstationary (e.g. seasonal) nature of the data

Slide 25



Contributed Recent VMT study with latest data and an economics crises Focused specifically on the economic crisis

Found different elasticities during different time periods

Slide 26

Elasticity Dark blue line, GDP light blue line

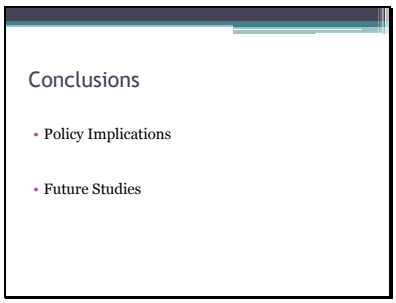
No obvious cyclicality, but some evidence of a trend,

Starts out, and then falls as GDP continues to steadily rise

Jumps up during the economic crisis, the falls again after, but still higher than original

Perhaps because consumers have not regained full confidence in the market during the slow recovery

Slide 27



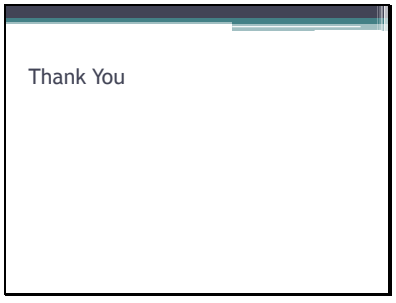
VMT very low, tax not reliable to reduce driving

Is more reliable for income from taxes

Evidence of some trend with economic cycles

Future work should continue to look at this possible relationship

Slide 28



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