# Modelling Gasoline Demand in the United States: A Flexible Semiparametric Approach

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# Introduction

- Do gasoline demand elasticities vary?
  - How do income and gas price affect elasticities of gasoline demand?
  - Are elasticities changing over time?
  - What factors may cause the heterogeneity?

- Substantial heterogeneity is observed in both price and income elasticities.
  - Income and price have substantial impacts on demand elasticities.
  - Gasoline demand elasticities have been changing over time. The fluctuation of gasoline price is the driving force.
  - State-level attributes contribute to the variation across states.

# Methodology

General Model $\quad Y_{it} = \boldsymbol{X}'_{it}\boldsymbol{g}(\boldsymbol{Z}_{it}) + \epsilon_{it}$

Gasoline Demand Function

$$\begin{aligned}\ln G_{it} = {} & \beta_0(\boldsymbol{Z}_{it}) + \beta_P(\boldsymbol{Z}_{it})\ln P_{it} + \beta_Y(\boldsymbol{Z}_{it})\ln Y_{it} + \beta_{PP}(\boldsymbol{Z}_{it})(\ln P_{it})^2 \\ & + \beta_{YY}(\boldsymbol{Z}_{it})(\ln Y_{it})^2 + \beta_{PY}(\boldsymbol{Z}_{it})\ln P_{it}\ln Y_{it} + \beta_1(\boldsymbol{Z}_{it})Q1_{it} \\ & + \beta_2(\boldsymbol{Z}_{it})Q2_{it} + \beta_3(Z_{it})Q3_{it} + \beta_4(\boldsymbol{Z}_{it})NE_i \\ & + \beta_5(\boldsymbol{Z}_{it})MW_i + \beta_6(\boldsymbol{Z}_{it})S_i + \epsilon_{it} \qquad (1)\end{aligned}$$

Price Elasticity and Income Elasticity

$$\begin{aligned} pe_{it} &= \frac{\partial \ln G_{it}}{\partial \ln P_{it}} = \beta_P(\boldsymbol{Z}_{it}) + \beta_{PY}(\boldsymbol{Z}_{it})\ln Y_{it} + 2\beta_{PP}(\boldsymbol{Z}_{it})\ln P_{it} \\ ie_{it} &= \frac{\partial \ln G_{it}}{\partial \ln Y_{it}} = \beta_Y(\boldsymbol{Z}_{it}) + \beta_{PY}(\boldsymbol{Z}_{it})\ln P_{it} + 2\beta_{YY}(\boldsymbol{Z}_{it})\ln Y_{it} \qquad (2)\end{aligned}$$

# Model Estimation

Estimation

- Estimator: NPGMM (Cai and Li, 2008)
- Bandwidth selection: Least-Square Cross Validation.

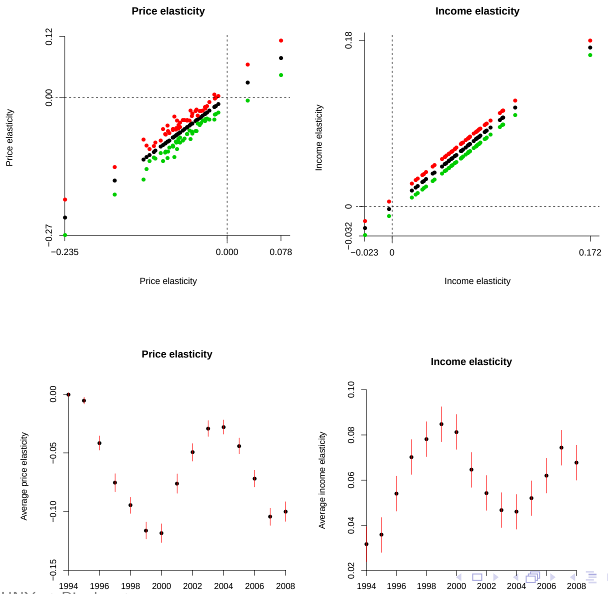
Endogeneity and IV Selection

- Prices of other petroleum products such as kerosene and residual fuel oil. (Rasche and Allen, 1975; Dahl, 1979)
- Regional dummies. (Yachew and No, 2001; Manzan and Zerom, 2010)
- Crude oil production disruptions. (Hughes, Knittel and Sperling, 2008)
- Average price of all other non adjoining states.

# Summary of Income and Price Effect

- In terms of magnitude, gasoline price has a stronger impact on price elasticity, while income has a stronger impact on income elasticity.
- As income increases, both income elasticity and price elasticity (absolute value) increase, i.e., the demand for gasoline becomes more sensitive to income and price changes.
- The variation of absolute elasticities displays a “U” shaped pattern as gasoline price rises.
- The price effect is asymmetric: demand reacts immediately to price cuts, but adjusts slowly to price increases.

# Heterogeneity Across States and Over Time



# Summary of Elasticity Heterogeneity

- Gasoline demand elasticities vary across states.
  - States with higher average income tend to have more sensitive gasoline demand.
  - High truck ratio (i.e. low average fuel efficiency) is associated with small price elasticity and large income elasticity.
  - Better public transportation system yields smaller price and income elasticities.

- Gasoline demand elasticities change over time.
  - The fluctuation of gasoline price is the driving force.
  - The demand of gasoline is more sensitive to abrupt and dramatic price shocks than gradual fluctuation.

# Conclusion

Policy Implications

- Gasoline demand in the U.S. is overall inelastic, hence a tax would need to be sufficiently large in order to control the gasoline consumption and the induced carbon emissions.
- With the rapid increase of gasoline price, gasoline tax could become a powerful instrument in the foreseeable future.
- Gasoline tax or any pricing policy is particularly effective in the areas with relatively large price elasticities.

# Estimator

NPGMM Estimator (Cai and Li (2008))

$$\hat{\beta} = [E(\pi(V_{it})\pi(V_{it})^{'}|Z_{it} = z]^{-1}E(\pi(V_{it})Y_{it}|Z_{it} = z)$$

$$V_{it} = (W_{it}, Z_{it}), \pi(V_{it}) = E(X_{it}|V_{it})$$

where $W$ is a matrix of instruments
Moment Condition

$$E(Q(V_{it})\epsilon_{it}|V_{it}) = E[Q(V_{it})(Y_{it} - X_{it}^{'}g(Z_{it}))|V_{it}] = 0$$

Locally Weighted Moment Condition

$$\sum_{i=1}^{N}\sum_{t=1}^{T} Q(V_{it})(Y_{it} - U_{it}^{'}\alpha)K_h(Z_{it} - z) = 0$$