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"A Comparison of Different Time Series Econometric Modeling approaches of U.S. Gasoline Demand."

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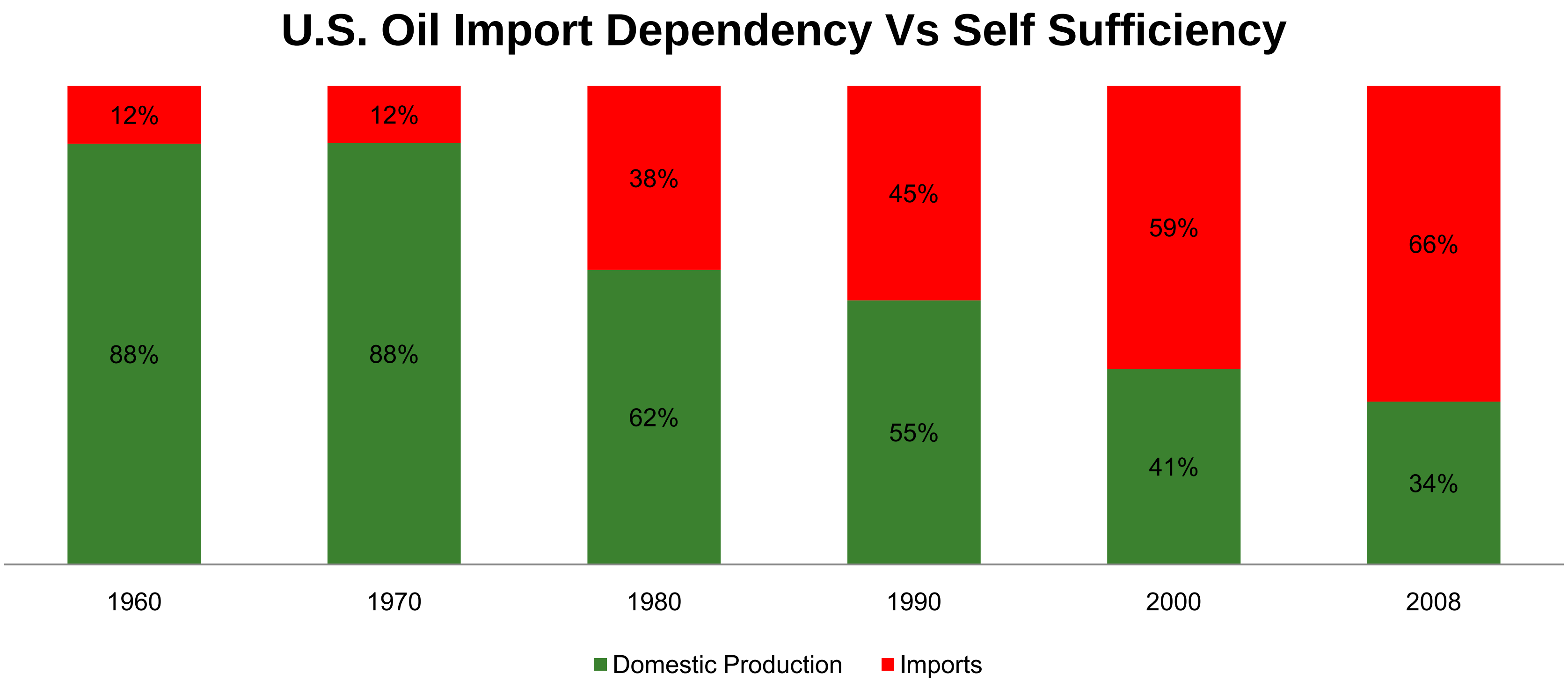
Outline

- Motivation
- Research Strategy
- Research Method and Research Data
- Estimation Results
- Summary &Conclusion
- Future Work

Motivations of the Study

- Oil Import Dependency and GHG emissions are two major problems of U.S. economy in terms of energy security and global warming respectively.



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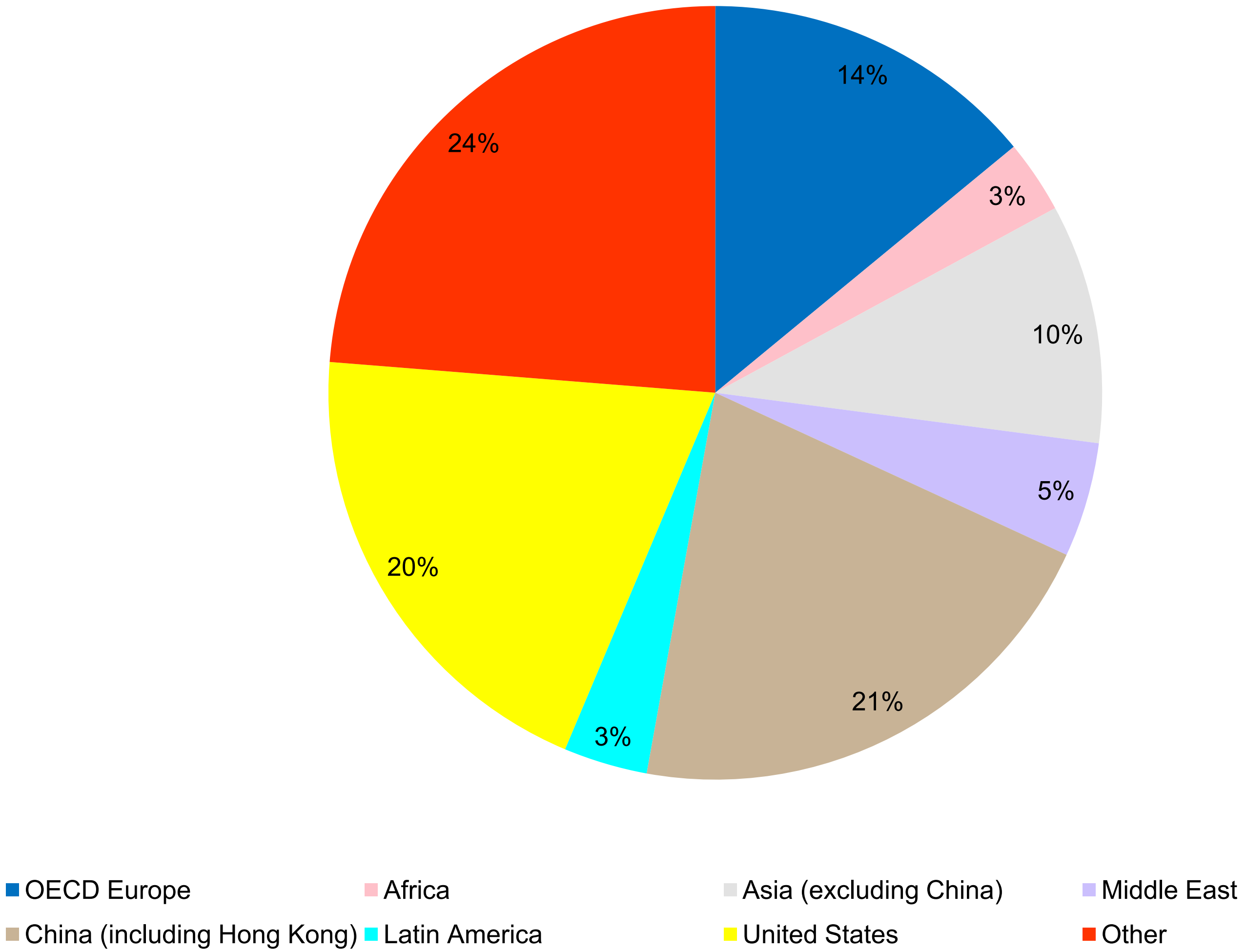
CO_2 Emissions by Region 2007



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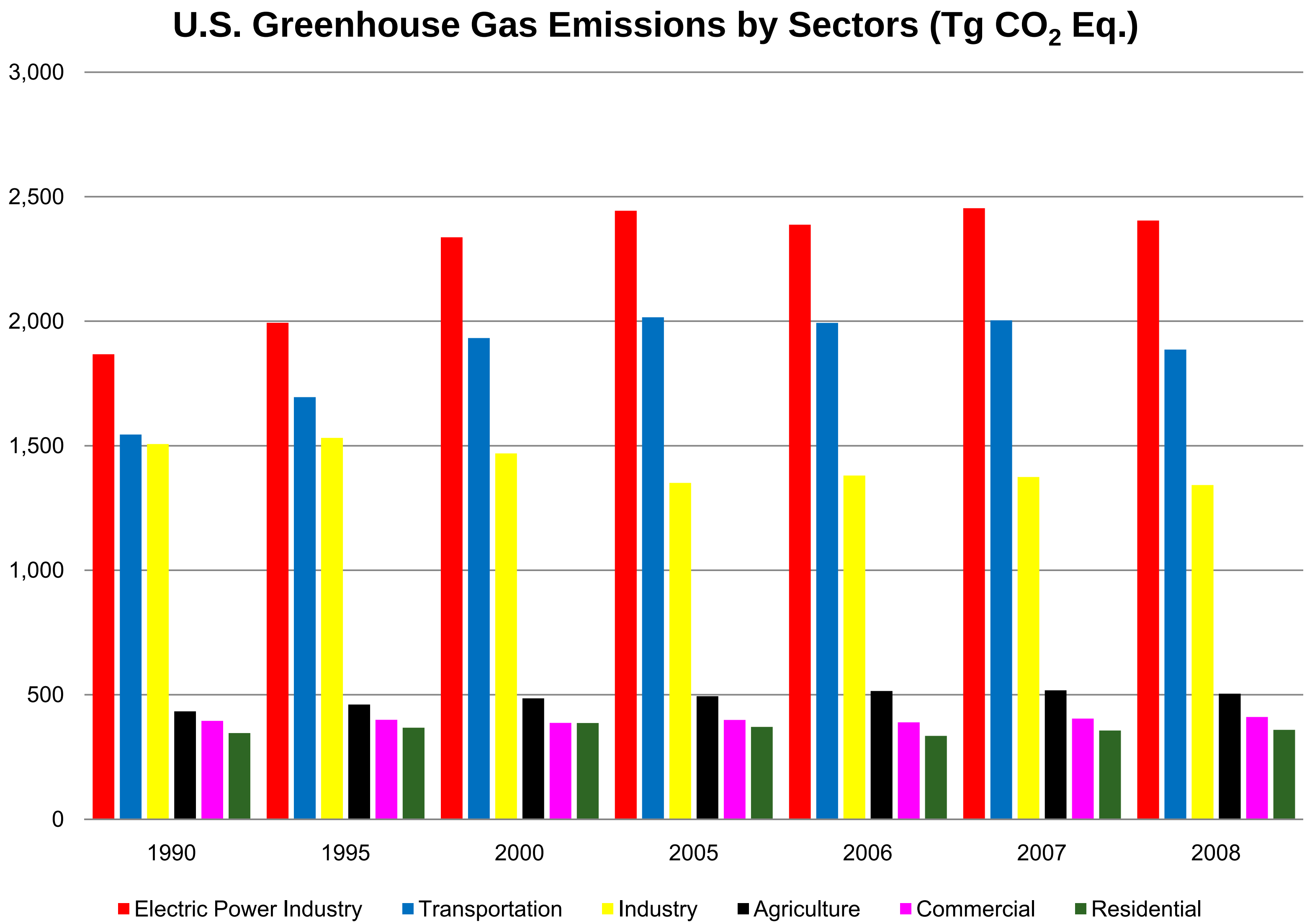

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Motivations of the Study

- Therefore it is important to determine the main drivers of U.S. gasoline consumption such as income , price and other exogenous factors. (Income -Price Elasticities and Underlying Energy Demand Trend).

  - There is a significant number of studies focus on demand elasticities of U.S. Gasoline consumption.

  - The findings of these researches are summarized in surveys including;

    Taylor (1977), Bohi (1981), Kouris (1983), Bohi and Zimmerman (1984), Dahl (1986), Dahl and Sterner (1991), Goodwin (1992), Dahl (1993), Espey (1998)

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Motivations of the Study

- These studies employs a wide range of estimation techniques along with different model specifications. These Researches suggest a wide range of income and price elasticities.

- Therefore it is important to explore what determines these differences.

- As far as known no study attempt to compare different methodologies for U.S. Gasoline consumption. Therefore this study attempt to compare different modelling approaches by incorporating some major dimensions in the literature.

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Research Strategy

- Asymmetric Vs. Symmetric Price Responses

  - This study investigates whether or not demand responses differs according to different price movements such as price hikes, price recoveries and price cuts. And how these asymmetric price responses are affected form different estimation techniques and model specifications.

  - The asymmetric price responses in energy demand are addressed by a number of studies including;

    Dargay (1992), Gately (1992) , Dargay and Gately (1994 and1995), Gately and Streifel (1997) , Hans and Schipper (1998), Gately And Huntington (2002), Huntington (2006) , Griffin and Schulman (2006) , Adeyemi and Hunt (2007), Manzan and Zeron (2008) , Huntington (2010)

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Research Strategy

- Technical Progress Vs. UEDT

  - Another aim of this study is to define the appropriate way to capture other exogenous factors that affects U.S. gasoline consumption such as technical change of capital stock and other exogenous factors. (Deterministic vs. Stochastic Trend)

  - Deterministic Trend is used to capture technological progress

  Beenstock and Wilcocks (1981,1983) Vs. Kouris (1983a, 1983b)

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Research Strategy

- Technical Progress Vs. UEDT

  - Stochastic Trend is used to capture technological progress and other exogenous factors that affect Energy Demand .

    Hunt et al. (2003) introduced the concept of Underlying Energy Demand Trend which stands for exogenous factors such as ; technical progress, consumer tastes, change in regulations, economic structure, rebound effect etc.

  - This study investigates the affect of specification of exogenous factors on estimation results and estimated elastcities.

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Research Strategy

- Time Varying Parameters Vs. Fixed Parameters

  - This study investigates whether or not the elasticities change over the estimation period. Furthermore this study explores the effect of specification of parameters on estimation results such as fixed and time varying.

  - Zhao (2010) ; is the only TVP approach focus on US gasoline consumption.

    Price elasticities vary between -0.35 and -0.10

    Income elasticities vary between 0.02 and 0.10

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Research Strategy

- Different Estimation Approaches
  - This study compares the outcome of different econometric modelling approaches and invetsigates the probable reasons for the different estimation results.

Cointegration/ECM with Fixed Elasticities, Deterministic Trend and Asymmetric Price Responses (as in Huntington-2010)

Vs.

STSM with Fixed Elasticities, Stochastic Trend and Asymmetric Price Responses

Vs.

STSM with Time Varying Parameters, Stochastic Trend and Asymmetric Price Responses

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Research Strategy

- <u>SUMARY:</u>

As taking into account and firstly attempting to compare the models which incorporates the above mentioned dimensions in the literature, this study explores the strengths and weaknesses of different energy demand modeling strategies.

Research Method

- It is assumed that U.S. Gasoline Demand is characterized by;

$$E_t = f(Y_t, p_t^{max}, p_t^{rec}, p_t^{cut}, \mu_t) \quad (1)$$

e_t = Ln (gasoline consumption per capita);

y_t =Ln (GDP per capita);

p_t^{max} = cum. increase in the nat. log. of maximum historical real gasoline prices;

p_t^{rec} = cum. sub-max increase in the nat. log. of historical real gasoline prices;

p_t^{cut} = cum. decrease in the nat. log. of historical real gasoline prices;

μ_t= level of underlying energy demand trend for gasoline (UEDT) in year t;

ε_t = a random error term and ;

λy_t = B(L)/A(L)= long run income elasticity;

λp_t^{max} = C(L)/A(L)= long run price max elasticity;

λp_t^{rec} = D(L)/A(L) = long run price recovery elasticity;

λp_t^{cut} = D(L)/A(L) = long run price cut elasticity;

Research Method

i) Error Correction Model with Fixed Parameters, Deterministic Trend and Asymmetric Price Responses:

$$A(L)\Delta e_t = B(L)\,\Delta y_t + C(L)\,\Delta p_t^{max} + D(L)\,\Delta p_t^{rec} + E(L)\,\Delta p_t^{cut} + \mu_t + EC_{t-1} + \varepsilon_t \qquad (2)$$

$$\mu_t = a + \beta t \qquad (3)$$

ii) Structural Time Series Modelling with Fixed Parameters, Stochastic Trend and Asymmetric Price Responses.

$$A(L)e_t = B(L)\,y_t + C(L)\,p_t^{max} + D(L)\,p_t^{rec} + E(L)\,p_t^{cut} + \mu_t + \varepsilon_t \qquad (4)$$

$$\mu_t = \mu_{t-1} + \beta_{t-1} + \acute{\eta}_t\,; \qquad \acute{\eta}_t \sim NID\,(0, \sigma_n^{\,2}) \qquad (5)$$

$$\beta_{t=}\,\beta_{t-1} + \xi_t \qquad \xi_t \sim NID\,(0,\, \sigma_\xi^2) \qquad (6)$$

Research Method

iii) Structural Time Series Modelling with Time Varying Parameters, Stochastic Trend and Asymmetric Price Responses.

$$e_t = \lambda_{1,t}y_t + \lambda_{2,t}p_t^{max} + \lambda_{3,t}p_t^{rec} + \lambda_{4,t}p_t^{cut} + \mu_t + \varepsilon_t \qquad (7)$$

$$\lambda_{i,t} = \lambda_{i,t-1} + v_{i,t} \qquad \text{where } i = 1,2,3,4 \qquad (8)$$

$$\mu_t = \mu_{t-1} + \beta_{t-1} + \acute{\eta}_t; \qquad \acute{\eta}_t \sim NID\,(0,\sigma_n^2) \qquad (9)$$

$$\beta_t = \beta_{t-1} + \xi_t \qquad \xi_t \sim NID\,(0,\ \sigma_\xi^2) \qquad (10)$$

Research Data

- The U.S. gasoline consumption and price data is obtained from Energy Information Administration (EIA, 2010).

- Gross Domestic Product, Consumer Price Index and Population are obtained from U.S. Department of Commerce Bureau of Economic Analysis (BEA, 2010) for the period 1949 and 2005.

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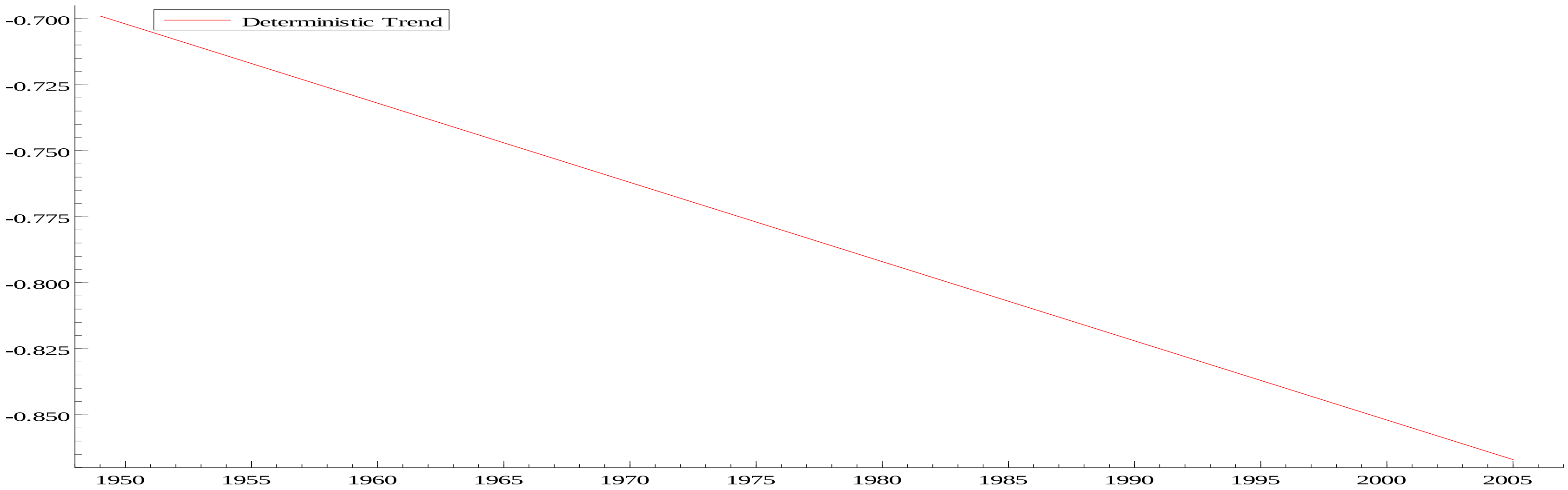
Estimation Results

i) For ECM with Fixed Parameters, Deterministic Trend and Asymmetric Price Responses. (as in Huntington,2010)

$$\Delta e_t = -0.699 - 0.505\,\Delta y_t - 0.277\Delta p_t^{max} - 0.072\, e_{t-1} - 0.055\, p_{t-1}^{max} + 0.205\, y_{t-1} - 0.003t - 0.063 p_t^{submax} + 0.369\,\Delta e_{t-1} + 0.160\,\Delta p_{t-1}^{max} - 0.006 p_{t-1}^{submax} - 0.368\,\Delta y_{t-1} - 0.434Rho$$



Estimation Results

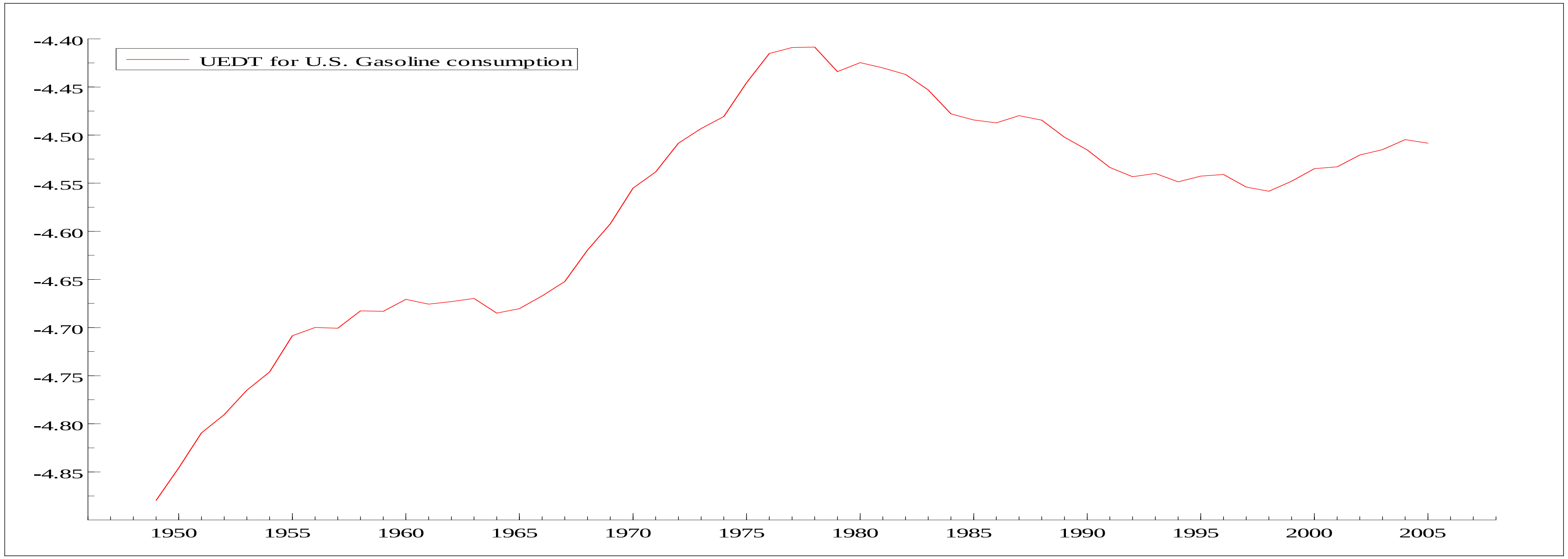
ii) For STSM with Fixed Parameters, Deterministic Trend and Asymmetric Price Responses

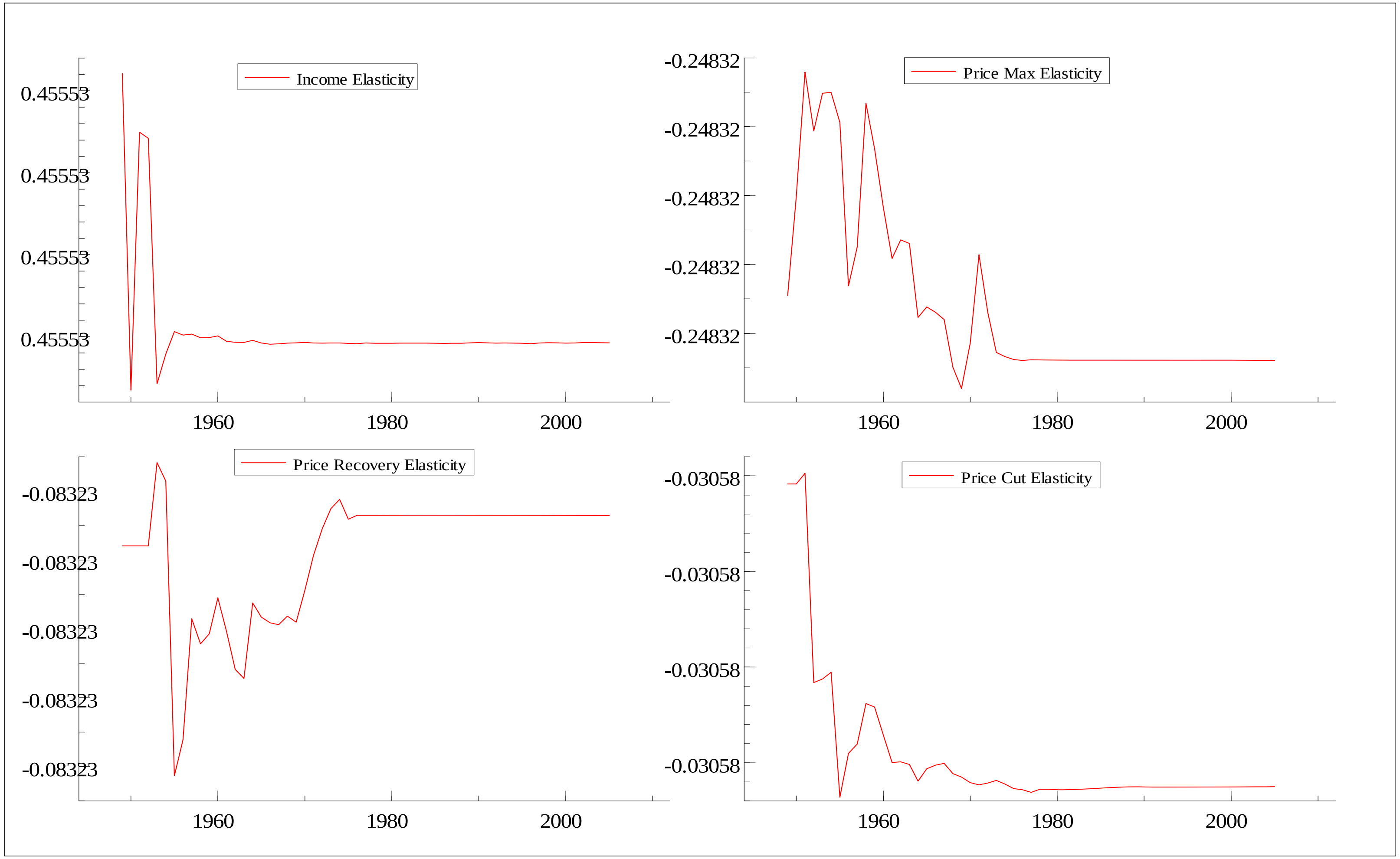
$$e_t = 0.45112y_t - 0.20385\, p_t^{max} - 0.09453p_t^{rec} - 0.03463\ Level\ Break\ 1979 + UEDT_{2005}$$

Estimation Results

iii) For STSM with Time Varying Parameters, Stochastic Trend and Asymmetric Price Responses

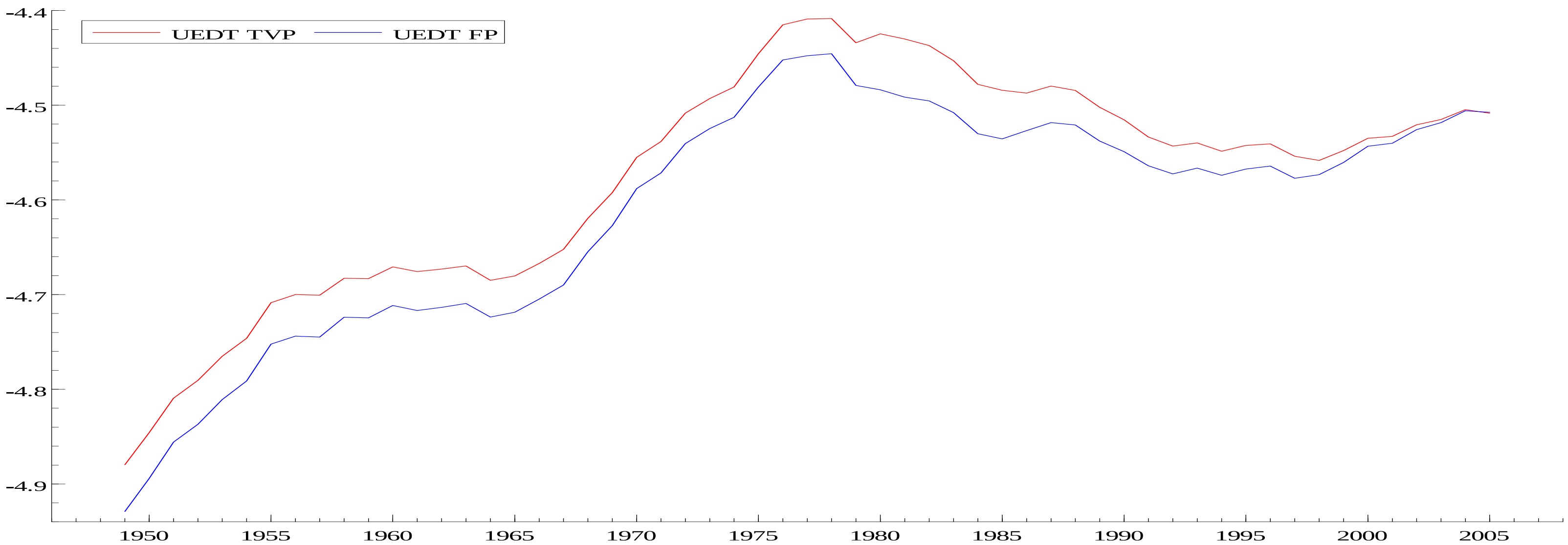
$$e_{2005} = 0.455534y_{2005} - 0.24831\, p_{2005}^{max} - 0.083233p_{2005}^{rec} - 0.0305781p_{2005}^{cut} - 0.1793\ Outlier1979 - 0.02309\ Slope\ Break\ 1978 + UEDT_{2005}$$




Income Elasticity
0.45553
0.45553
0.45553
0.45553
1960
1980
2000
Price Max Elasticity
-0.24832
-0.24832
-0.24832
-0.24832
-0.24832
1960
1980
2000
Price Recovery Elasticity
-0.08323
-0.08323
-0.08323
-0.08323
-0.08323
1960
1980
2000
Price Cut Elasticity
-0.03058
-0.03058
-0.03058
-0.03058
1960
1980
2000

Estimation Results

- In both of the stochastic trends between 1949 and 1978 the continuous increase of U.S. gasoline trend might be because of change in life styles, rebound effect, widespread of private car usage.
- In both of the stochastic trends between 1978 and 1997-1998 (1997 in FP model, 1998 in TVP model) the decrease of UEDT might be because of implication of CAFE standards in 1975 . This results suggest that improvement in vehicle fuel efficiency might be an effective tool for decreasing gasoline consumption.



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Comparison of Estimation Results

Variables	Error Correction Model	STSM with Fixed Parameters	STSM with TVP
	LR Elasticities	LR Elasticities	LR Elasticities
Income	1.03*	0.45	0.46
Pmax	-0.76	-0.20	-0.25
Prec	0	-0.10	-0.08
Pcut	0	0	-0.03
Trend	Deterministic	Stochastic	Stochastic

*****_Trend-adjusted income response combines energy-saving trend with income effect where the latter assumes 2.2% economic growth rate._

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Summary &Conclusions

- Time Varying Parameters Vs. Fixed Parameters

  - Although the parameters are let to follow a random walk process, this study suggest that the elasticities do not vary over time.

  - So we concentrate on comparing fixed parameters ECM with deterministic trend and fixed parameters STSM with stochastic trend.

- Asymmetric Vs. Symmetric Price Responses

  - This study confirms that asymmetry is important. Whatever the method is employed there is a distinction between coefficients of p^{max} ,p^{rec} and p^{cut}.

  - Price movements appear to affect U.S. Gasoline consumption asymmetrically. Changes in the maximum historical gasoline price have a greater impact on gasoline demand than price recoveries and price cuts. ($|\lambda p^{max}| > |\lambda p^{rec}| > |\lambda p^{cut}|$)

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Summary &Conclusions

- Stochastic Vs. Deterministic Trend

  - As illustrated above, there is a significant difference between the estimated elasticities of Coinegration/ECM model and STSM models.

  - But there is no notable difference between the Fixed Parameters with stochastic trend and time varying parameters with stochastic trend.

  - Therefore this study suggests the main source of difference between estimated elasticities is the specification of trend component.

Future Work

- Inclusion of UEDT in a stochastic form appears to have a large impact. And it should be investigated further.

- Arguably given that a more general specification is used here the results are more robust.

  However the failure to capture any dynamics may suggest that Huntington (2010) is more robust.

  More research is needed to attempt to reconcile these differences .

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Thank you for your attention...