Gasoline demand and gasoline tax simulation; A time varying parameter model for Sweden and the UK

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Outline of Paper

- Motivation
- Objectives of Paper
- Method and data for Paper
- Results of Paper
- Conclusions

Motivation

1. Increasing concerns on GHG´s and policy formulation in reducing them.
2. How important is technology and consumers' taste in the dynamics of price and income elasticities?
3. The possibility that price and income elasticities are varying overtime rather than being constant and the implication for policy.

Objectives of the Paper

1. Asses the impact of unobserved trend (UEDT) for gasoline on price and income elasticities.

2. Investigate whether the elasticities significantly vary overtime.

3. Use the model to forecast various gasoline tax scenarios on level of gasoline consumption.

Model Specification

The following Econometric models are common in the literature .

1.Static Model

2.Lagged Endogeneous model

3.Vehicle stock model

4.Vehicle Characterstic Model

5.Inverted -V model

6. Cointegration and ECM

7.Structural Time Series Model

- The most popular Econometric models are;

1. Static models
2. Lagged endogeneous models

For details on various models, see, Taylor(1977), Bohi(1981), Bohi and Zimmerman(1984), Drollas (1984), Dahl(1986), Dahl and Sterner(1991a,1991b), Goodwin(1992), Espey(1998), Goodwin et al(2004), Graham and Glaister(2002), Basso and Oum(2006), and Dahl(2011).

Structural Time Series Model(STSM)

- Following Harvey(1989), a series X_t can be express as;

$$X_t = \mu_t + K_t + \varepsilon_t, \ \ \varepsilon_t \sim NID(0, \sigma_\varepsilon^2).....(1)$$

μ_t = Trend

K_t = Vector of explainatory variables

ε_t = Random error term

Transition Equation

$$\mu_t = \mu_{t-1} + \beta_{t-1} + \eta_t, \eta_t \sim NID(0, \sigma_\eta^2).....(2)$$

$$\beta_t = \beta_{t-1} + \nu_t, \nu_t \sim NID(0, \sigma_\nu^2).....(3)$$

$$Equation(2) = level\ equation$$

$$Equation(3) = Slope\ equation$$

$$\sigma_\eta^2, \sigma_\nu^2 = hyperparimeters$$

Nature of Trend

Table 1: Classification of Trend model for annual data

	LEVEL	
	Fixed Level $Lvl \neq 0, \sigma_v^2 = 0$	*Stochastic Level* $Lvl \neq 0, \sigma_v^2 \neq 0$
SLOPE No Slope $Slp = 0, \sigma_\xi^2 = 0$	**a**. Conventional regression with a constant but no time trend	**b**. Local Level Model random walk plus noise
Fixed Slope $Slp \neq 0, \sigma_\xi^2 = 0$	**c**. Conventional regression with a constant and time trend	**d**. Local Level Model with Drift
Stochastic Slope $Slp \neq 0, \sigma_\xi^2 \neq 0$	**e**. Smooth Trend Model	**f**. Local Trend Model

Gasoline Demand Model (CPM)

$$A(L)q_t = B(L)p_{gt} + C(L)p_{dt} + D(L)y_t + \mu_t + \varepsilon_t \ldots\ldots(4)$$

$$A(L) = 1 - \phi_1 L - \phi_2 L^2 - \phi_3 L^3$$

$$B(L) = \theta_0 + \theta_1 L + \theta_2 L^2 + \theta_3 L^3$$

$$C(L) = \rho_0 + \rho_1 L + \rho_2 L^2 + \rho_3{}^3$$

$$D(L) = \psi_0 + \psi_1 L + \psi_2 L^2 + \psi_3 L^3$$

q_t =Gasoline consumption per capita

P_{gt} =real price of gasoline

P_{dt} =real price of diesel

Y_t =real GDP per capita

- All lower case variables are in logarithms.
- The approach is that of general to specific modelling.
- We drop all insignificant lagged variables and retain only the significant ones in the TVP model.

Time varying Parameter model(TVP)

$$q_t = \alpha_{1,t} p_{gt} + \alpha_{2,t} p_{dt} + \alpha_{3,t} y_t + \mu_t + \varepsilon_t \ldots\ldots\ldots\ldots\ldots(5)$$

$$\alpha_{i,t} = \alpha_{i,t-1} + \lambda_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(6)$$

Data

Swedish data sources include;

- Swedish Petroleum Institute (SPI)
- Statistics Sweden

UK´s data are taken from;

- Digest of UK Energy Statistics (DUKES)
- Office of National Statistics (ONS)

The variables of interest include the following;

- Aggregate gasoline consumption
- Nominal GDP
- Nominal gas price
- Nominal Diesel Price
- Population
- Consumer Price Index(CPI).

Result -CPM

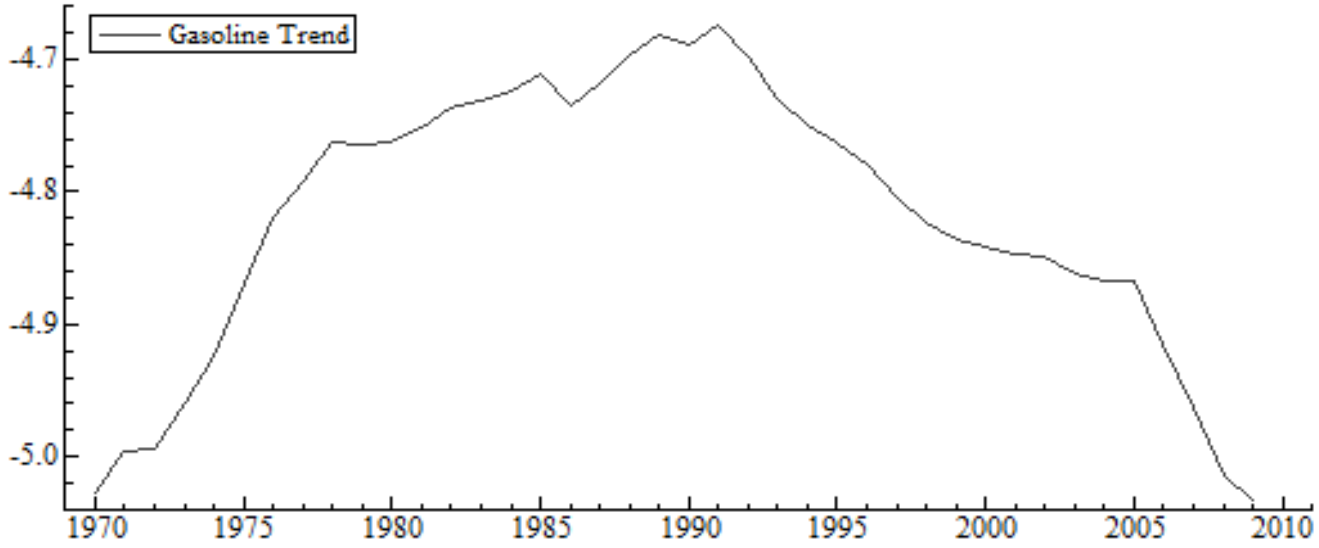
	Sweden			UK
Variables	Coefficients	P-value	Coefficients	P-value
P_{gt}	-0.240***	0.000	-0.127***	0.001
P_{dt}	-0.020	0.555	0.036	0.378
y_t	0.499***	0.000	0.658***	0.000
y_{lag}			-0.311**	0.039
$Outlier_{1992}$	0.044***	0.000		
$Outlier_{1980}$			0.043***	0.001
Lvb_{1974}	-0.103***	0.001		
Lvb_{1994}			-0.061***	0.000

Dignostic Test for CPM

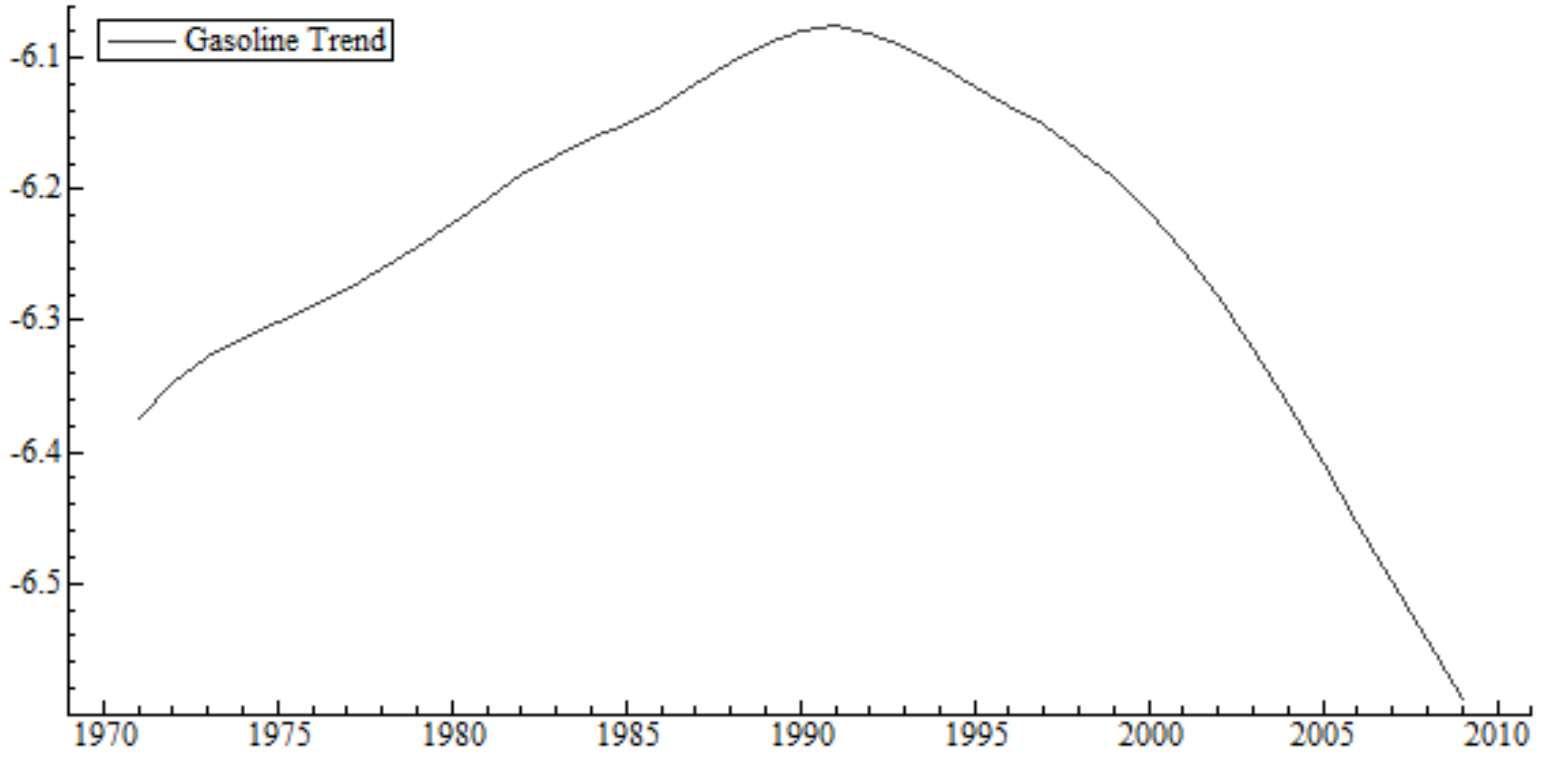
	Sweden	P-value	UK	P-value
Normality	2.7214	0.256	0.614	0.735
Heteroske	1.165	0.402	0.506	0.8 51
Serial Corr.	3.367	0.498	7.237	0.120
R^2	0.97		0.99	
R^2_d	0.87		0.84	
AIC	-7.757		-7.9679	
BIC	-7.419		-7.5879	
PFT	3.987	0.262	0.093	0.992
LR Test	**31.108**	**0.0000**	**117.451**	**0.0000**
Nature of Trend	LTM		STM	

- Normality test is perform using Bowman – Shelton statistic
- Heteroske denotes heteroskesdasticity test
- Serial correlation is perform using Box-Ljung Q-statistic
- R^2_D denote coefficient of determination in first difference
- PFT is the prediction failure test to check the stability of the model

Estimated Trend for Sweden-CPM



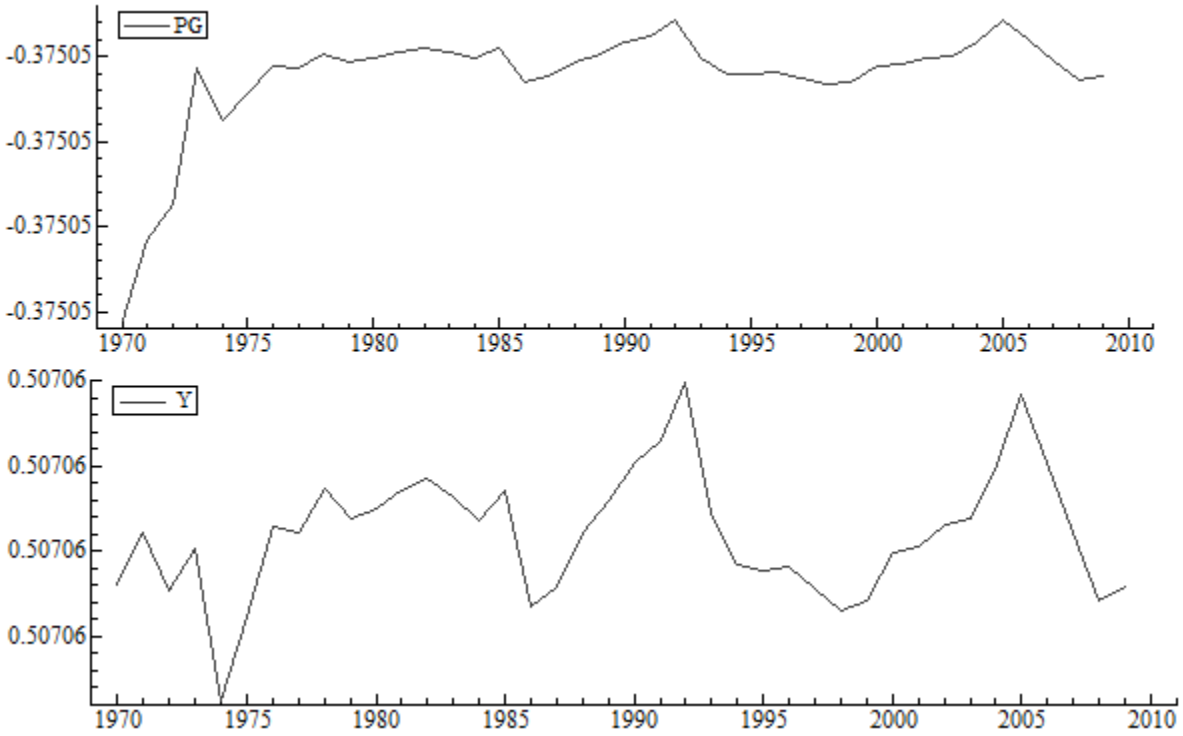
Estimated Trend for UK-CPM



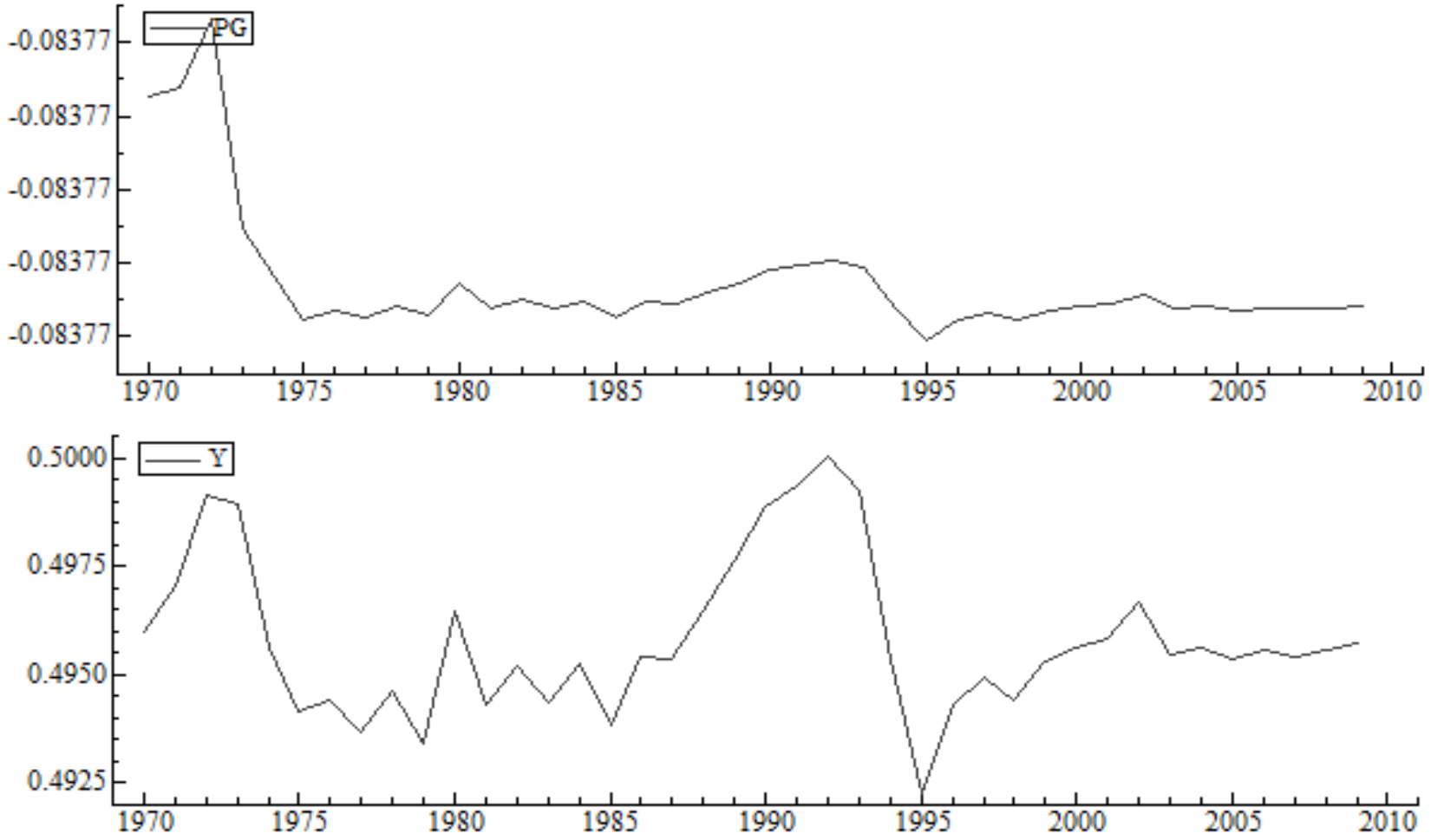
Dignostic Test –TVP

	Sweden		UK	
Normality	2.728	0.255	3.905	0.141
Heteroske	0.948	0.534	0.809	0.627
Serial Corr.	6.612	0.157	7.031	0.134
R^2	0.991		0.995	
R^2_d	0.958		0.979	
AIC	-8.974		-9.534	
BIC	-8.678		-9.154	
PFT	4.174	0.243	3.204	0.361
LR Test	**10.45**	**0.0012**	**29.81**	**0.0000**
Nature of Trend	LTM		STM	

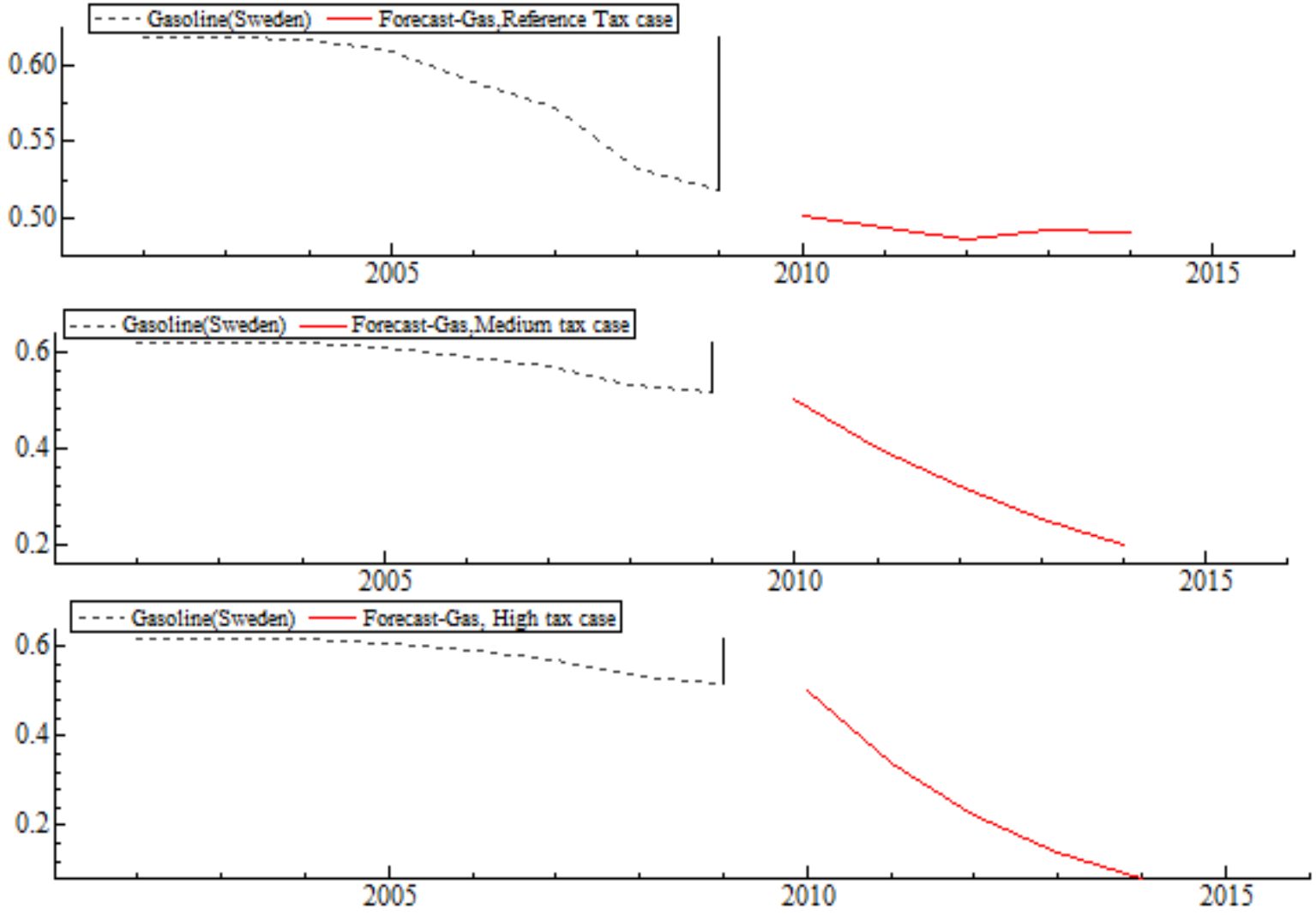
Result-TVP(Sweden)

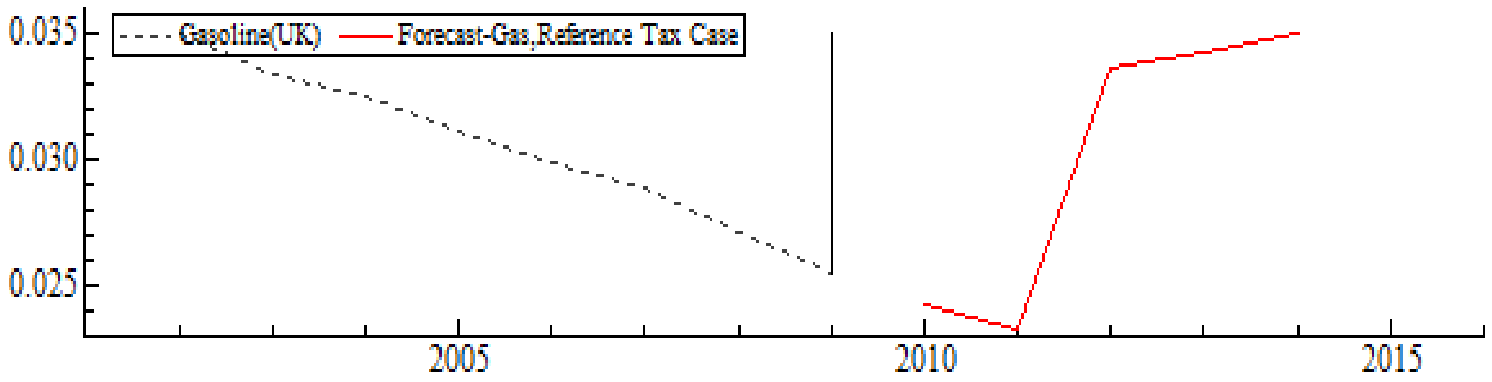


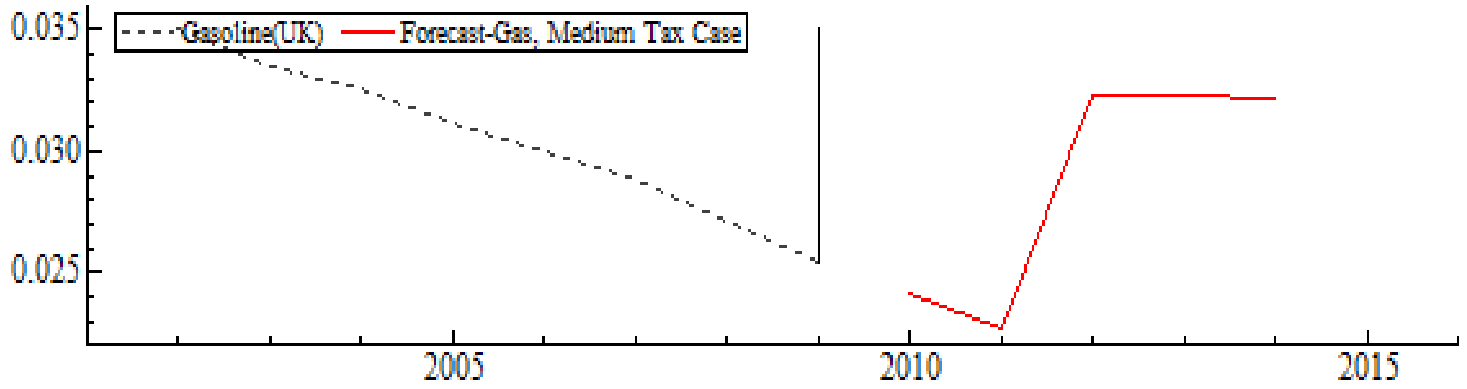
Result-TVP(UK)

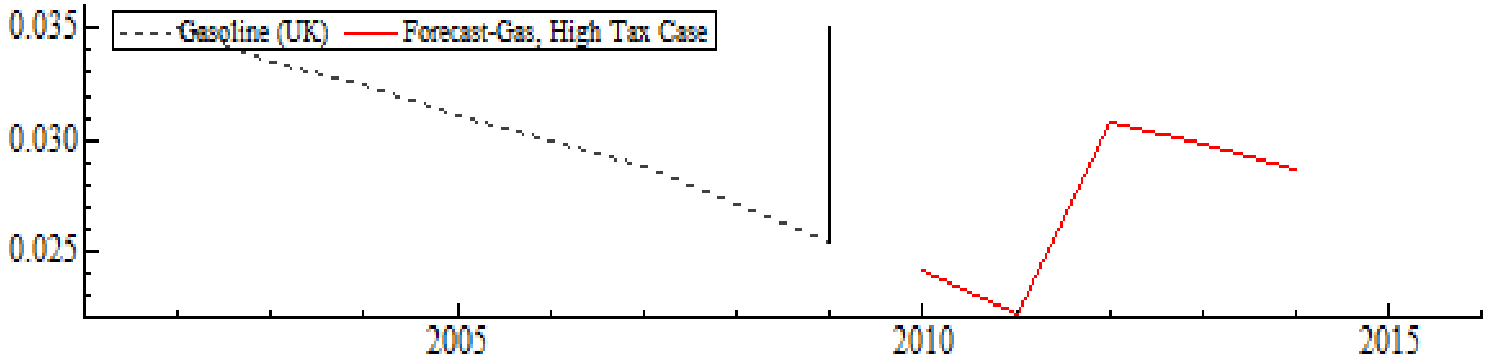


Tax simualtions




Gasoline(UK)
Forecast-Gas,Reference Tax Case
0.035
0.030
0.025
2005
2010
2015


Gasoline(UK)
Forecast-Gas, Medium Tax Case
0.035
0.030
0.025
2005
2010
2015


Gasoline (UK)
Forecast-Gas, High Tax Case
0.035
0.030
0.025
2005
2010
2015

Final Remarks

- We found that price and income elasticities do vary over time, but the variations are vary small .
- The year to year variations are much more smaller in Sweden than the UK.
- Trend do have a significant influence on gasoline price and income elasticities, with much impact on income elasticity.
- Higher taxes have more effects (reduction) in Sweden than in the UK.

Thank you.