Estimating the Factor Demand for Natural Gas as an Alternative Fuel: (A U.S. Case)

Valeria Oscherov, Klaus Moeltner, Jason Grant
Virginia Tech

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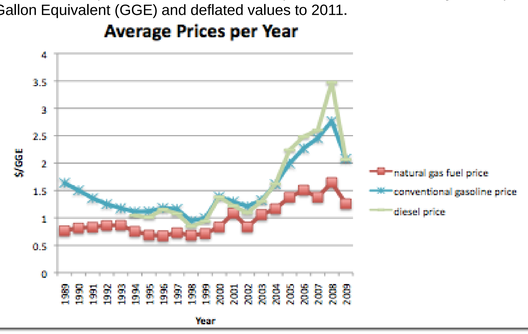
Introduction

•There has been an increase in the demand for oil due to expanding economies such as China and India. In order to reduce America's dependence on foreign oil Alternative fuel vehicles (AFVs) must be considered, one of which is the Natural Gas Vehicle (NGV).

•In the United States most of the NGVs are used by transit buses and large trucking corporations. Thus the perfect substitute for natural gas fuel is diesel fuel.

•There are numerous benefits of natural gas fuel over diesel fuel:

- •NGVs last two to three years longer than diesel vehicles, (Energy Efficiency & Renewable Energy, 2011).
- •Compressed Natural gas (CNG) trucks produce 75% lower carbon monoxide, 49% lower nitrogen oxide emissions, and 95% lower particulate matter emissions than diesel trucks of similar age, (Energy Efficiency & Renewable Energy, 2011).
- •Natural Gas vehicle fuel prices are lower than diesel prices and conventional gasoline prices in Gasoline-Gallon Equivalent (GGE) and deflated values to 2011.



Objectives

•Estimate the factor demand for Natural Gas Fuel in the U.S. market, as a perfect substitute to diesel fuel.

•Use a similar theoretical framework to that of Anderson 2011, that accounts for preferences towards two different fuels. However, instead of consumer utility maximization we apply it to firm's cost minimization.

•Estimate the market share for Natural Gas fuel.

•Estimate the own-price and the cross-price elasticity with diesel fuel.

Theory & Econometrics

Theory

Firm Level:

•When minimizing the "firm's" cost function with respect to diesel and natural gas fuel, the Kuhn-Tucker conditions imply that the firm will use CNG exclusively when:

$$q_{it} = q_n - q_d \text{ £ } p_d - p_n = p_{it}$$

•Where n is for natural gas fuel, d is for diesel fuel, p is for the respective fuel prices, and q is the non-price marginal cost component for each fuel type.

Aggregate level:

•The aggregated demand over the entire state can be written as:

$$\ln(Q_n) = \ln(N) + \ln(E(q)) + \ln(H(p))$$

•Where Q the the aggregate demand for natural gas fuel, N is the total number of firms, q is the demand for for the individual firm, and H(.), is the preference distribution function.

•In our paper we choose to use the Laplace distribution function since it covers negative values, is continuous, and becomes a linear function of p after taking logs.

Econometrics

Estimable Econometric Equation:

$$\ln(Q_{n_{it}}) = \ln(N_{it}) + \ln(E(q_{it})) + (\log(\tfrac{1}{2}) - \frac{p_{\max}}{g}) + \frac{1}{g} p_{it} + X_{it}' b + e_{it}$$

•Where g is the scale parameter for the Laplace distribution function. X is a matrix of time-varying region characteristics, in our model it is the number of natural gas stations in each state and the number of the firm-vehicles that run on natural gas, and e_{it} is the error term.

•We include region and year-fixed effects. In which the data is split up into seven regions across the United States.

Two-Stage Least Squares Regression (2SLS):

$$\ln(Q_{n_{it}}) = b_0 + b_1(p_{n_{it}} - p_{d_{it}}) + b_2 \log(\hat{veh}_{it}) + b_3 \log(st_{it}) + e_{it}$$

$$\log(\hat{veh}_{it}) = a_0 + a_1 \log(pop_{it}) + u_{it}$$

•In order to avoid simultaneous bias we apply 2SLS.

•Where veh stands for natural gas vehicles, st is for number of natural gas stations in each state, and pop is the population in each state.

Results

Econometrics Results

Table 3: Original Estimation

Variable	FE	Pooled OLS
constant	6.945****	6.438****
	(.323)	(.213)
log(stations)	0.033	-.157***
	(.065)	(.077)
log(vehicles)	0.997****	1.145
	(.049)	(.049)
$P_d - P_n$	0.031	0.042
	(.094)	(.059)
Region 1	.158	
	(.177)	
Region 2	0.114	
	(.139)	
Region 4	0.176*	
	(.119)	
Region 5	0.164	
	(.144)	
Region 6	0.293	
	(.160)	
Region 7	0.455****	
	(.137)	

Table 3: Significance at the (*) 20%, (**) 10%, (***) 5%, (****) 1%

Table 4: 2SLS

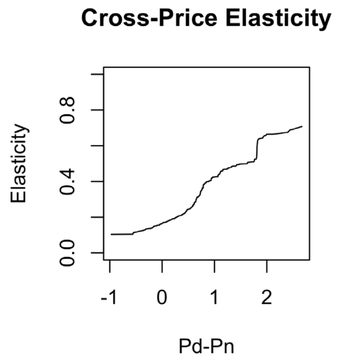
Variable	FE	Pooled OLS
constant	8.227****	7.807****
	(.568)	(.425)
log(stations)	0.837****	.718****
	(.0811)	(.075)
log(vehicles)	0.462****	0.515****
	(.081)	(.069)
$P_d - P_n$	0.193*	0.706****
	(.118)	(.104)
Region 1	1.372****	
	(.248)	
Region 2	0.568****	
	(.184)	
Region 4	0.472****	
	(.150)	
Region 5	0.614****	
	(.193)	
Region 6	0.373*	
	(.253)	
Region 7	1.554****	
	(.182)	

Table 4: Significance at the (*) 20%, (**) 10%, (***) 5%, (****) 1%

Elasticities:

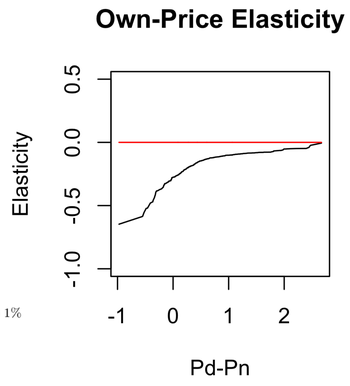
Cross-price Elasticity:

$$e_{Q,p_g} = \frac{h(P_d - P_n)}{H(P_d - P_n)} * P_d$$



Own-price Elasticity:

$$e_{Q,p_n} = \frac{h(P_d - P_n)}{H(P_d - P_n)} * (-1) P_n$$



Conclusions

•2SLS is preferred.

•The market share of natural gas fuel increases as the price difference between diesel fuel and CNG increases.

- •An increase of $1.00 in the price of diesel, or a decrease of $1.00 in the price of CNG will increase the consumption for CNG by 19%.

•The most important result from this analysis is that the cross-price elasticities are significantly positive and increase as the price premium increases.

- •This result implies that natural gas is a possible alternative fuel
  - •Is a possible competitor to the flexible-fuel vehicle.
  - •Should be promoted due to its societal benefits and the implication of reducing America's dependence on foreign oil.

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