Measuring the Effects of Ethanol and Flex-Fuel Vehicles on Brazilian Gasoline Supply & Demand

A Simultaneous Equations Approach

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Brazilian Flex Fuel Vehicles (1 of 2)

Flex-fuel and ethanol powered vehicles have been supported by Brazil’s Proalcol program. From 1990 to the introduction of flex-fuel vehicles in 2003, gasoline was favored over ethanol. During that time Brazil used gasoline imports to control inflation, a policy still in favor with the central government.

Source: Brazilian Association of Automotive and Vehicle Manufacturers (ANFAVEA)
Brazilian Flex Fuel Vehicles (2 of 2)

Although flex-fuel vehicles are the fastest growing vehicle class, gasoline powered vehicles make up the majority of the light duty fleet. As of September 2013, flex fuel vehicles make up 29 percent of the fleet, although almost 9 out of 10 new cars sold are flex-fuel. Natural gas and natural gas hybrid vehicles market share has also seen a small surge, but these technologies remain in the minority.

Source: Brazil Department of Transportation (DENETRAN), 2013
Brazilian Crude Oil

Brazilian crude production has steadily increased since 1979. With new investment in production, exports have also increased from close to 0 MBPD in 2000, reaching 731 MBPD in 2010, before a sharp drop in 2012 and 2013. The surge in crude production, combined with increasing instability in the Brazilian Real, has led downward pressure on gasoline prices in Brazil. This has placed a level of uncertainty on the Brazilian ethanol markets.

Source: Banco Central do Brasil
Transportation Fuels in Brazil

Evidence of a run on gasoline in Brazil can be found from the JODI Oil Database. Beginning in 2011, gasoline imports have been increasing, while ethanol production has decreased slightly.

Source: Banco Central do Brasil
Literature Review

- **Alves and Silviera-Bueno (2003):** Estimated demand elasticities in response to increasing gasoline demand in the 1990s. Prior to adoption of flex-fuel vehicles, Alves and Silviera-Bueno estimated long-run price elasticity of demand at -0.46.

- **Du and Carriquiry (2013):** Analyzed the impact of flex-fuel vehicle adoption on the price of transportation fuels. Used vehicle data from Brazilian association of automakers (ANFAVEA). Found that flex-fuels allow for arbitrage at the pump, where the ethanol-gasoline price ratio settles at 0.7.

- **Salvo and Huse (2011):** Described a kinked demand curve for ethanol in Brazil. FFVs cause the price elasticity of ethanol to vary depending on the ethanol-gasoline price ratio.

- **Coyle, Debacker, and Prisinazo (2012):** Used a 3SLS econometric model to estimate supply and demand in the United States. Estimated a price elasticity of -0.075.

- **Gasoline Elasticity Surveys:** Basso and Oum (2007) and Dahl and Sterner (1991) have reviewed the extensive literature of gasoline demand elasticity. Estimates for gasoline demand, across a variety of countries range from -0.12 to -0.41 in the short run, while long run elasticities range -0.14 to -0.58.
Econometric Model

A 3SLS model is used to account for endogenous determination of prices and quantities. This model incorporates supply and demand to reduce uncertainty about endogenous prices. Gasoline demand is a function of prices, income, ethanol prices, and employment. Supply is a function of price, the price of crude feedstock, and refining costs.

\[
\ln G_t^S = \alpha_0 + \alpha_1 \ln P_t^S + \alpha_2 \ln Z_t^S + \alpha_3 \ln V_t^S + \epsilon_t^S
\]

\[
\ln G_t^D = \beta_0 + \beta_1 \ln P_t^D + \beta_2 \ln Y_t^D + \beta_3 \ln E_t^D + \beta_4 \ln M_t^D + \epsilon_t^D
\]
Results & Policy Implications

During the FFV “era” in Brazil, gasoline has become more elastic. The evidence suggests that FFVs are a critical part of biofuel policy designed to curb petroleum based transportation fuel consumption.

### Demand


dependant variable = ln(MBPD Gasoline Consumption)  |  estimate  | std. error  | t value | pr(>|t|)
---|---|---|---|---
(Intercept)  | -3.95674 | 1.135862 | -3.48346 | 0.000669
ln(Gasoline Price)  | -1.00834 | 0.151393 | -6.66041 | 6.45E-10
ln(Ethanol Price)  | 0.524758 | 0.096789 | 5.42166 | 2.66E-07
ln(Income)  | 0.48405 | 0.077486 | 6.24695 | 5.17E-09
ln(Employment)  | 0.778257 | 0.150904 | 5.1573 | 8.80E-07

### Supply


dependant variable = ln(MBPD of Gasoline Production)  |  estimate  | std. error  | t value | pr(>|t|)
---|---|---|---|---
(Intercept)  | 3.047728 | 0.9412123 | 3.23809 | 0.0015145
ln(price)  | 0.2323871 | 0.0800907 | 2.90155 | 0.0043374
ln(price of crude)  | -1.1907867 | 0.162039 | -7.34877 | 1.72E-11
ln(variable refining costs)  | 1.2313393 | 0.1324346 | 9.29771 | 4.44E-16