DIESEL OIL DEMAND FOR ROAD TRANSPORT IN BRAZIL: CONSUMER PREFERENCE AND CO2 EMISSIONS

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OVERVIEW

Since 2000, diesel oil consumption in the road transport segment has increased strongly in Brazil, at a 2% growth rate by year. Diesel oil consumption raised from 223 million toe in 2000 to 334 million toe in 2016. As Brazilian diesel production grew at a slower pace, diesel import increased, from 37 million toe in 2000 to 50 million toe in 2016 (ANP, 2017). Diesel imports is currently a major concern of Brazilian authorities. New refineries were planned but as Petrobras is in a deep financial crisis, projects were postponed or suspended. As refining is not attractive in Brazil, the domestic supply must not increase substantially in the next years.

Understanding diesel oil demand is crucial to refinery expansion planning as well to establish Brazilian energy policy. The Brazilian Biodiesel Program is an important policy to mitigate CO2 emissions. Currently, mandatory mix of biodiesel in diesel is 8% and it must increase to 10% in March 2018.

In this sense, precise estimation of price and income elasticity of diesel oil demand is very important. Energy demand has special feature. It is an indirect demand as it results from the use of equipments that consume energy sources. In the case of diesel oil demand, it results from the use of the vehicle fleet. So, energy consumption quantity depends on the technological level imbedded on the equipment stock. Therefore, we must consider technological progress as to estimate energy demand functions.

Embedded technology in energy user equipment depends on a combination of endogenous and exogeneous factors. There is a debate on the way that technical efficiency must be considered on energy demand functions. One approach considers technological progress as an endogenous process that can be represented through asymmetric price responses (APR) and asymmetric income responses (AIR) (Gately and Huntington, 2002; Adeyemi and Hunt, 2007). Another approach considers technological progress as an exogeneous process and it must be represented as a time trend, here called Underlying Energy Demand Trend (UEDT) (Hunt et al, 2003; Al Rabbaie and Hunt, 2006). There are recent papers (Adeyemi et al, 2010; Adeyemi and Hunt,2014) that combines both analysis. They suggest a dual role of technological progress, endogenous and exogeneous. Both must be considered on the estimation model.

This papers intends to show the relevance of stochastic UEDT and APR and AIR on fuel demand modelling using Brazilian data. Therefore, to properly incorporate those effects, this papers use a Structural Time Series Model (STSM) suggested by Harvey (1997). The objective of this paper is to analyze the determinants of diesel oil demand from January 2008 to December 2015. This article also presents forecasts of the consumption of diesel oil for the 2017-2025 horizon in two price and income scenarios to verify the impact on the balance between supply and demand and the emission of CO2.

Method

Diesel oil demand was estimated by Structural Time Series Model (STSM), combined with the dynamic model called Autoregressive Distributed Lag (ARDL) model, according to the following specifications:

$$A(L)e_t = UEDT_t + B(L)p_t + C(L)y_t + D(L)f_t + E(L)\gamma_t + \varepsilon_t \quad (1)$$

$UEDT_t$ follows the following stochastic process:

$$UEDT_t = \mu_t + irregular\ interventions + level\ interventions + slope\ interventions \quad (2)$$

$$\mu_t = \mu_{t-1} + \beta_{t-1} + \eta_t \quad (3)$$

$$\beta_t = \beta_{t-1} + \xi_t \quad (4)$$

The seasonal component can be expressed as:

$$S(L)\gamma_t = \omega_t \quad (5)$$

where e_t is consumption of diesel oil in the transport segment, y_t is national income, p_t is real price of diesel oil, and f_t is estimated fleet. All variables have monthly periodicity represented in logs. The ratios $\frac{B(L)}{A(L)}$, $\frac{C(L)}{A(L)}$ e $\frac{D(L)}{A(L)}$ represent long term price, income and fleet elasticities. Component $A_i(L)$ is lag operator polynomial $1 - \emptyset_1 L - \emptyset_2 L^2 - \ ... - \emptyset_p L^p$ and p is lag length; as well as $B_i(L) = \pi_0 + \pi_1 L + \pi_2 L^2 + \ ... + \pi_p L^p$; $C_i(L) = \varphi_0 + \varphi_1 L + \varphi_2 L^2 + \ ... + \varphi_p L^p$; $D_i(L) = \tau_0 + \tau_1 L + \tau_2 L^2 + \ ... + \tau_p L^p$; and $E_i(L) = 1 + L + L^2 + \cdots + L^{12}$.

The equation to be estimated consists on equation (1) with (2), (3), (4) and (5). We assume that error terms are independent and mutually non-correlated. Equations (3) and (4) represent the trend intercept and slope, respectively. Price and income can be decomposed as follows:

$$x_t = x_{max,t} + x_{rec,t} + x_{cut,t} \quad (6)$$

where $x_{max,t}$ represents the natural log of maximum income and maximum price in month t; $x_{rec,t}$ is accumulated increase of the sub maximum of natural log of the price and of the income in month t; and $x_{cut,t}$ is accumulated decrease of natural log of the price and income in month t. The data set ranges from January 2008 to December 2015. To quantify carbon dioxide (CO2) emissions, Tier 1 of the IPCC (2006) was applied, which is based on the carbon content of diesel oil consumed in road transport segment, as follows:

$$ECO_{2t} = \sum(e_t * FE_t) \quad (7)$$

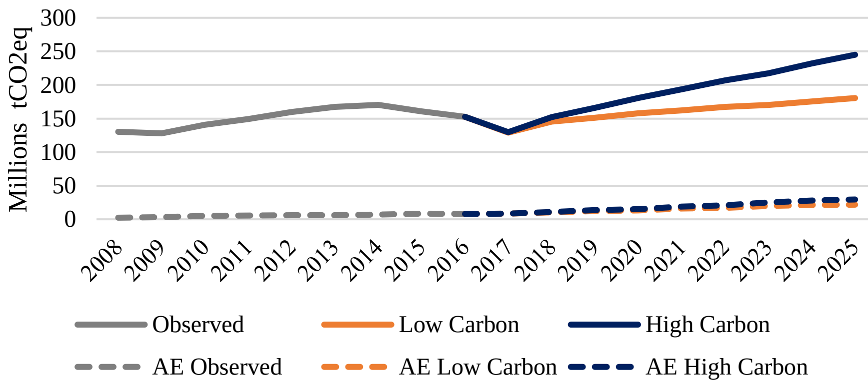
where ECO_2 is emissions in tonnes of CO2eq in period t, e_i is diesel consumption in GJ in period t, and FE is the emission factor in tCO_2/GJ on time t.

Results

Estimation was carried from the general to the specific model incorporating price and income asymmetric responses and an underlying stochastic trend. The results suggest that UEDT and APR and AIR have important role to explain energy efficiency and other unobservable factors on the diesel oil demand in Brazil. The UEDT has a soft format, with intercept and a stochastic slope.

Regarding price elasticity, consumers are not sensible to maximum price changes on the long term, as this coefficient was not significant. Elasticities of recovering and cut price are low on the long term -0.24, -0.33, respectively. The long run income elasticity is a few higher ($y_{max} = 0.74$; $y_{rec} = 0.86$; and $y_{cut} = 0.47$). Finally, we estimated that diesel oil demand is very sensible to vehicle fleet changes, 1.71.

Figure 1. CO2 Emissions in Million tCO2eq and Avoided Emissions (AE) in the High Carbon and Low Carbon Scenario



Source: Elaborated by the authors

In the Low Carbon scenario, CO2 emissions increase moderately and in 2025 reach a similar level of 2014, 283 million tCO2eq. While in the High Carbon scenario the emissions increase significantly, reaching 352 million tCO2eq in 2025.

Conclusions

Our results show the importance of considering a stochastic trend to estimate UEDT on Brazilian diesel oil demand. As simple deterministic trend is unable to incorporate features of exogeneous effects, it can result on biased estimations of elasticities. In order to improve the policy of reducing CO2 emissions Brazilian authorities should increase the mandatory mix of Biodiesel, encourage the adoption of more efficient engines for the transportation of cargo and passengers and the use of more efficient modes of transport, such as BRTs (Bus Rapid Transit), subway and trains.

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