Title: Changes in fuel economy: an analysis of the Spanish car market

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Objective

Technological advances have enabled a continuous improvement in fuel economy of passenger cars over time. However, a significant part of this improvement has been outweighed by an increase in the weight and engine power of new cars. This is due to higher household income leading to an increased demand for bigger cars and a shift from passenger cars to S.U.V.

This paper estimates the technological change that has taken place in the Spanish car market providing evidence on the trade-off between cars’ fuel economy and their main drivers: weight, horsepower and displacement [CID, Cubic Inch Displacement]. Using data from 1981 to 2013 we analyze the evolution over time of these trade-offs. In addition, the analysis of the estimated rate of change of fuel economy over this period allows us to test the impact of changes in the price of fuel and of the policies implemented to reduce fuel consumption such as regulatory standards or subsidies to green cars. Our results are useful for evaluating policy measures aimed at reducing energy consumption in the road transport sector. In particular, the estimated equation shows how fuel efficiency objectives can be attained through a combination of technological change, reductions in weight, horsepower or displacement and fleet composition changes.

Methodology

The empirical specification follows the work by Knitell (2012) who assumes that technological progress enters the fuel economy equation as a multiplicative factor ($T_t$). The equation to be estimated is:

$$fe_{it} = T_t * f(w_{it}, hp_{it}, d_{it}, X_{it}, e_{it})$$

where $fe_{it}$ is fuel efficiency, measured as kilometer per liter, $w_{it}$ is car weight, $hp_{it}$ is horsepower, $d_{it}$ is displacement, $X_{it}$ is a vector of other car attributes related to fuel consumption, $e_{it}$ is the error term and $i$ and $t$ refer to car model and time period, respectively.

An important issue in the equation specification is the selection of the explanatory variables. We select three attributes - weight, horsepower and displacement- that are directly related to fuel economy. However, in order to know how the fleet composition has affected fuel economy we also include dummy variables for S.U.V. and M.P.V. car types. Additionally, in some specifications dummies for car manufacturers are included to capture unobservable attributes related to fuel efficiency that are constant across manufacturers.

An interesting feature of the Spanish car market is the increasing share of diesel cars. The percentage of diesel cars registered has risen from around 15% at the end of the eighties to 70% in 2010. We estimate separate equations for diesel and gasoline cars which makes it possible to compare the progress of technological change between the two types of fuels.

Assuming a double-log functional form the fuel economy equation to be estimated is:
\[ \ln f_{iit} = \alpha + \lambda_t + \beta_1 w_{iit} + \beta_2 h p_{iit} + \beta_3 d_{iit} + \gamma' X_i + \varepsilon_{iit} \]
\[ t = 1981, \ldots, 2013 \]

where technological progress is modeled as a set of annual dummy variables, \( \lambda_t \). Following the methodology proposed by Matas and Raymond (2007), we allow the coefficients that affect the explanatory variables to vary over time to allow for changes in car technology.

An alternative way of estimating the coefficients of technological progress is the stochastic frontier approach, which has the advantage of separating the "noise" and the technical efficiency components. The results of both methodologies are shown to be very similar in our application.

Having estimated the fuel economy equation, we regress the change in the estimated coefficient for fuel efficiency on a set of potentially explanatory variables: fuel price and the changes in the regulatory standards. This second-stage estimated equation is:

\[ \Delta \ln I_t = \delta_0 + \delta_1 \ln p_t + \varphi' Z_t \]

Where \( I_t \) is the index of technological change, \( p_t \) is the fuel price and \( Z_t \) is a set of dummy variables for changes in regulatory standards.

**The data**

The data set covers a 33-year period from 1981 to 2013. Over this period we collect data for car models for which at least 1000 units were sold in a given year, representing around 95% of total registrations. The final sample consists of 5,503 observations. Given that no data is available for the different model versions, we chose the middle range version for each model. The characteristics and fuel efficiency of the car models are obtained from specialized magazines. Fuel economy is measured as an average of urban and interurban fuel economy.

At the moment of writing this abstract, we have a complete database for gasoline cars and we are about to finish the database for diesel cars. Therefore, the descriptive statistics and the preliminary results provided here refer only to the gasoline car market.

Between 1981 and 2013, the average fuel economy of passenger cars increased by 37%, along with an increase of 72% in engine power and of 40% in weight. During this period a clear trade-off between fuel efficiency and several other car attributes can be observed. The next figure plots the case of car weight vs fuel efficiency in 1986 and 2012.
Results

The estimations with the gasoline sample suggest that holding weight, horsepower and displacement at their 1981 levels fuel economy would have increased by 71% in 2013, whereas the actual increase has been 38%. Knittel (2012) obtains values of 60% and 15%, respectively, for the U.S. car market.

Although a significant trade-off appears to exist between fuel economy and its main determinants, the estimated coefficients show a trend over time. When coefficients are allowed to vary the elasticity of fuel economy with respect to horsepower decreases, whereas the one with respect to displacement increases. The elasticity with respect to weight also shows a decreasing trend.

A preliminary analysis of fuel economy across car manufacturers suggests that there are significant differences among them, with Audi, Mitsubishi in the first positions and Skoda and SEAT in the last ones. However, a more careful analysis is needed in order to compare efficiency across car manufacturers to be sure that all attributes affecting fuel consumption are included in the equation.

Finally, the estimated technological changes for fuel economy show the following path:

A simple regression of the annual rate of change of technological improvement on the price of gasoline suggests that gasoline price fosters technological change.

The results summarised here are still preliminary. However, after completing the database we will have a new version of the paper before June.

References: