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Changes in fuel economy: An analysis of the Spanish car market

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ABSTRACT

This paper estimates the role that technological change and car characteristics have played in the rate of fuel consumption of vehicles over time. Using data from the Spanish car market from 1988 to 2013, we estimate a reduced form equation that relates fuel consumption with a set of car characteristics. The results for the sales-weighted sample of vehicles show that energy efficiency would have improved by 30% and 42% for petrol and diesel cars respectively had car characteristics been held constant at 1988 values. However, the shift to bigger and more fuel-consuming cars reduced the gains from technological progress. Additionally, using the results of the fuel equation we show that, besides a natural growth rate of 1.1%, technological progress is affected by both the international price of oil and the adoption of mandatory emission standards. Moreover, according to our estimations, a 1% growth in GDP would modify car characteristics in such a way that fuel consumption would increase by around 0.23% for petrol cars and 0.35% for diesel cars.

1. Introduction

Technological advances have brought about a continuous improvement in the fuel economy of vehicles over time. At the same time, car manufacturers have used more powerful engines in order to satisfy consumers' preferences for bigger and faster cars. As a consequence, the potential efficiency gains from technological progress have been partially offset by a shift to more fuel-consuming vehicles. A clear example of this is the increasing penetration of four-wheel drive vehicles in the composition of the passenger car fleet. Recently, due to concerns regarding environment and energy dependence, a number of countries have adopted mandatory limits for fuel consumption or CO_2 emissions of new registered cars.[1] For instance, this is the case of the regulation adopted by the European Union in 2009 (EC, n° 443/2009) which set a CO_2 emission target of 130 g CO_2/km to be met by 2015. This policy has forced car manufacturers to take additional actions to further increase the efficiency in fuel consumption.

The aim of our work is twofold. In the first stage, we estimate the role that apparent technological change and car characteristics have played in the observed rate of fuel consumption of new registered cars over time. In this paper, we refer to technological improvements as "apparent" technological change. The reason for this is that data on fuel consumption correspond to laboratory tests. Recently, there has been evidence that these tests do not represent "real-world" conditions very

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[1] The amount of CO_2 increases linearly with the amount of fuel consumed. Thus, setting a limit on CO_2 emissions is equivalent to setting a limit on fuel consumption per kilometer driven.

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well. In particular, the tests allow several flexibilities in the procedures that permit manufacturers to optimize their vehicles for the tests. Consequently, real vehicle performance is below that obtained in the tests. Hence, our estimation of the improvement of fuel consumption includes both real efficiency gains and the ability of manufacturers to adapt their vehicles to the laboratory tests.

Using data from the Spanish car market from 1988 to 2013, we estimate a reduced form equation that relates fuel consumption with a set of explanatory variables, among them, car characteristics. We run separate estimations for petrol and diesel cars. From the estimated equations, we construct an index of apparent technological progress and an index of the contribution of changes in car characteristics to fuel consumption for the sales-weighted sample of cars. The indexes show that energy efficiency would have improved by 30% and 42% for petrol and diesel cars respectively had the weight and engine size been held constant at 1988 values. However, the shift to bigger and more fuel-consuming cars reduced the gains from technological progress, mainly for diesel cars. It is important to note that since 2008 the characteristics of new registered cars have moved in the opposite direction, mainly as a reaction by Spanish households to a severe economic crisis. Additionally, we provide evidence on the trade-off between fuel consumption and car characteristics -weight and engine size- as well as on the differentiated impact of four-wheel drive and similar types of vehicles. The results are robust to the assumptions made with respect to the specification of technological change.

In the second stage, we use the results of the fuel equation to regress the estimated apparent technological change and the estimated contribution of car characteristics to fuel consumption with respect to its main determinants. The results show that, besides a natural growth rate of around 1.1%, apparent technological progress is affected by both the international price of oil and the adoption of mandatory emission standards. Moreover, the GDP appears as the main determinant of car characteristics. According to our estimations, a 1% growth in GDP would modify car characteristics in such a way that fuel consumption would increase by around 0.23% for petrol cars and 0.35% for diesel cars.

There is a large and growing body of literature that analyses the changes in the fuel economy of cars from different perspectives. Firstly, there is a line of research that focuses on the analysis of consumer preferences for fuel efficiency and car characteristics.[2] A second line of research aims at studying how technology has contributed to improving fuel efficiency as well as the technical trade-off between energy efficiency and other car characteristics. Related to this second line, there are a growing number of papers which, using different methodologies, investigate the response of the car industry to the adoption of new fuel economy standards.[3]

Our work relates to those by Newell et al. (1999) and Knittel (2011) which provide an adequate framework for estimating the role that technological progress and product characteristics have played in the energy consumption of energy-using products. Knittel (2011) uses a reduced form equation to model fuel economy as a function of car characteristics using US data. His results reveal that if weight, horsepower, and torque were maintained at their 1980 levels, fuel economy could have increased by 58% between 1980 and 2006. He also finds that the rate of technological progress is correlated with the real gasoline price and the percentage change in the United States Corporate Average Fuel Efficiency (CAFE) standards.[4] Moreover, he uses his estimates to discuss the strategies available to achieve the most recent CAFE standards adopted in US. Recently, there has been a growing amount of research focused on evaluating the response of car manufacturers to public policies aimed at reducing fuel consumption and/or CO_2 emissions from passenger cars. Bento et al. (2015), using a sample of vehicles sold in the US market between 1975 and 2011, investigate how historical changes in the fuel economy standards impacted technological innovation in the automobile industry and estimate the changes in the rate of innovation in response to the changes in the standards. In addition to a natural rate of innovation of 1.19%, they estimate that 1 percent increase in the CAFE standards are associated with an additional 0.32% increase in the innovation rate of fuel economy of cars.

Reynaert (2015) evaluates the effect of emission standards on the European car market using panel data covering 1998–2011 for seven European countries.[5] He finds that between 1998 and 2007 technology improves by an average rate of between 0.7% and 1.6% over different specifications. After 2007, there is a significant increase in the rate of improvement with a yearly average of more than 4%. Moreover, the 14% reduction in emissions observed between 2007 and 2011 is fully explained by advances in technology. His findings suggest that car manufacturers react to the announcement of the EU compulsory new standards.

Klier and Linn (2016) investigate manufacturers' response to the recent changes in US and European emission standards.[6] The authors find evidence that, despite the regional differences in the stringency and form of the standards, both US and European standards affect the rate and the direction of technology adoption.[7] However, the magnitude of the effects are higher for

[2] See, Busse et al. (2013), Greene (2010) for a review, and Galarraga et al. (2014) for the Spanish car market.

[3] This literature suggests that manufacturers may respond to new fuel economy standards in three different ways: modifying the relative prices of high and low emission vehicles, trading off fuel efficiency for other vehicles' characteristics and improving technology. Some of the papers related to this topic are: Goldberg (1998), Klier and Linn (2012), Whitefoot et al. (2013), Klier and Linn (2016), Reynaert (2015), and Bento et al. (2015).

[4] The US Corporate Average Fuel Economy (CAFE) standards were introduced for passenger cars in 1978. CAFE standards target the sales-weighted average of the fuel economy of automobiles in all manufacturers that run business in the US. For passenger cars, CAFE standards were tightened in 2007 and 2009 in such a way that the limits to be met by 2016 were about 40% higher than 10 years before.

[5] The paper by Reynaert (2015) also evaluates the welfare effects of the European regulation by estimating a structural model.

[6] Klier and Linn (2016) extend previous analysis by matching engine data to vehicle model production data. Additionally, they estimate separate frontiers by engine, model and model-year.

[7] They define "direction" of technology adoption as the log of the ratio of the fuel consumption rate to horsepower or weight, respectively.