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Vehicle type choice under the influence of a tax reform and rising fuel prices

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ABSTRACT

Differentiated vehicle taxes are considered by many a useful tool for promoting environmentally friendly vehicles. Various structures have been implemented in several countries, e.g. Ireland, France, The Czech Republic, and Denmark. In many countries the tax reforms have been followed by a steep change in new vehicle purchases toward more diesel vehicles and more fuel-efficient vehicles. The paper analyses to what extent a vehicle tax reform similar to the Danish 2007 reform may explain changes in purchasing behaviour. The paper investigates the effects of a tax reform, fuel price changes, and technological development on vehicle type choice using a mixed logit model. The model allows a simulation of the effect of car price changes that resemble those induced by the tax reform. This effect is compared to the effects of fuel price changes and technology improvements. The simulations show that the effect of the tax reform on fuel efficiency is similar to the effect of rising fuel prices while the effect of technological development is much larger. The conclusion is that while the tax reform appeared in the same year as a large increase in fuel efficiency, it seems likely that it only explains a small part of the shift in fuel efficiency that occurred and that the main driver was the technological development.

1. Introduction

Reductions in car use are very challenging (Graham-Rowe et al., 2011; Moore et al., 2010; Poudenx, 2008). This has motivated a growing political interest in improving the fuel efficiency of private vehicles. It is seen as one of the most important measures available to achieve significant reductions in emissions (Frondel et al., 2011; Stanley et al., 2011). Various initiatives have been suggested as ways of increasing fuel efficiency, e.g. national standards for the average fuel efficiency of new vehicles (Shiau et al., 2009) and tax instruments to enhance the purchase of fuel-efficient vehicles (Brand et al., 2013). An efficient way to reduce the problem would be to introduce a tax per unit of emissions. As noted by West (2004) this would induce households to drive fewer miles and buy vehicles with higher fuel efficiency and lower emissions per km. In principle, such effects could be achieved for through fuel taxes. The effects of gasoline taxes are investigated, e.g. in Goldberg (1998), West (2004), and Gillingham (2011). But raising fuel taxes substantially is highly controversial in most countries, so a lot of research has been done to evaluate the effects of alternative vehicle taxes on vehicle ownership and use. Another tax instrument is to differentiate taxes on vehicle purchase according to vehicle weight (Arnberg et al., 2008), carbon-emission (Giblin and McNabola, 2009; Rogan et al., 2011; Zimmermannova, 2012), or engine size (Fershtman et al., 1999).

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The Danish registration tax on private vehicles was changed in 2007 toward a differentiation based on fuel efficiency. Petrol vehicles capable of more than 16 km/l and diesel vehicles capable of more than 18 km/l became up to 19% cheaper. Petrol vehicles capable of less than 16 km/l and diesel vehicles capable of less than 18 km/l became up to 4% more expensive. The intention of the reform was to increase fuel efficiency in the Danish vehicle fleet, and looking at descriptive statistics it seemed to be very successful, because the fuel efficiency of new cars registered in Denmark during 2007 rose throughout the year. The average fuel efficiency increased from 15.9 km/l across the four months before the reform in May to 17.4 km/l across the eight months after the reform. The increase was partly driven by an increase in the diesel share from 0.24 before May to 0.40 after May 2007. But the fuel efficiency also increased conditional on fuel type. For petrol cars, the corresponding average fuel efficiency rose from 15.1 km/l to 16.0 km/l from the first to the third trimester, and for diesel cars it rose from 18.6 km/l to 20.0 km/l as seen in Table 1. Table 1 also shows that these changes are large compared to the changes in previous years, e.g. in 2006 the average fuel efficiency increased from 15.8 km/l to 16.0 km/l and the diesel share increased from 0.20 to 0.23.

In this paper, I develop a model to analyse and compare the tax reform to several other possible causes of the changes in purchasing behaviour that occurred in 2007. First, the changes could be a result of seasonal variation in car sales. But looking at Table 1, the numbers from 2005 and 2006 show no sign of seasonal variation. Second, changes in technology in the vehicles could also drive a shift in fuel types and fuel efficiency. Third, another factor that could have induced individuals to purchase more fuel efficient cars was the price of fuel, which in general rose throughout 2007. If consumers take fuel prices into account when purchasing, this could also at least partly explain some of the changes in purchasing behaviour. Fourth, a driver for the changes could be the increased attention globally toward the environment, e.g. as manifested in the Stern Review (2006). While the first three causes are analysed in this paper together with the tax reform, the fourth cause is not analysed due to data limitations.

The factors above could have an effect not only on the composition of the new-vehicle purchases but also on the total amount, e.g. if a factor influences an individual to buy a car that would not otherwise have done so or if a factor makes an individual substitute a new car for a used car. Concerning the latter, Goldberg (1995) estimates a model including both new and used cars and concludes that these are rather poor substitutes.

To focus the paper, I only analyse how the factors affect the composition of the new-vehicle market assuming the population of new-car buyers to be fixed. I develop a mixed logit model to capture vehicle type choice. The use of discrete choice models to model vehicle type choice dates back to the late 1970s. Early applications based on logit and nested logit models were Lave and Train (1979), Manski and Sherman (1980), Train (1985), Berkovec and Rust (1985). Literature reviews of more recent applications to vehicle choice using the same as well a more advanced models can be found in Bhat et al. (2009), Potoglou and Kanaroglou (2008), and De Jong et al. (2004).

Using the model, I analyse the purchasing behaviour to see to what extent a vehicle tax reform similar to the 2007 reform may explain changes in vehicle type choice. I simulate market shares with and without the tax reform to calculate average fuel efficiency and the diesel share. I also test to what extent the changes in average fuel efficiency and the diesel share may be explained by the rise in fuel prices and technological development.

Two recent papers (Rogan et al., 2011; Zimmermannova, 2012) have both evaluated similar tax reforms to the Danish and concluded that they were very successful when looking at the differences in fuel efficiency before and after the reform. This paper does not contradict these findings but it does highlight that there could be other sources that influenced the change toward more fuel efficiency cars simultaneously. In particular, it highlights the role of technological development as a (main) driver in the changes of fuel efficiency which has also been observed in the U.S. (Greene, 2009).

The remainder of the paper is organised as follows. In the next section, the modelling framework used to analyse vehicle type choice is presented. Next, the data and the estimation results are described in Section 3. Section 4 discusses the effect of the tax reform and the fuel price variation applying the model to various scenarios. The final section presents a conclusion and some future directions of research.

Table 1
Average fuel efficiency and fuel type across trimesters from 2005 to 2008.

		January–April	May–August	September–December
2005	Average petrol fuel efficiency (km/l)	15.2	15.1	14.9
	Average diesel fuel efficiency (km/l)	20.2	20.0	19.3
	Diesel share	0.18	0.19	0.20
2006	Average petrol fuel efficiency (km/l)	15.1	15.2	15.2
	Average diesel fuel efficiency (km/l)	19.1	18.9	18.8
	Diesel share	0.20	0.23	0.23
2007	Average petrol fuel efficiency (km/l)	15.1	15.7	16.0
	Average diesel fuel efficiency (km/l)	18.6	19.8	20.0
	Diesel share	0.24	0.36	0.44
2008	Average petrol fuel efficiency (km/l)	16.4	17.0	17.4
	Average diesel fuel efficiency (km/l)	20.2	20.3	20.2
	Diesel share	0.42	0.40	0.36