Energy Policy 74 (2014) 286–299

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Do tax incentives affect households' adoption of 'green' cars? A panel study of the Stockholm congestion tax

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HIGHLIGHTS

- Uses a database of car owners to analyze impacts of a congestion tax on car fleet.
- Results show that the tax had a significant effect on ethanol car purchases.
- Prior ownership of ethanol car and education correlates with ethanol car purchases.

ARTICLE INFO

Article history:
Received 17 January 2014
Received in revised form
28 April 2014
Accepted 19 August 2014
Available online 26 September 2014

Keywords:
Ethanol cars
Congestion tax
Natural experiment

ABSTRACT

Policymakers have made several attempts to introduce local and national policies to reduce CO_2 emissions and stimulate the consumer adoption of alternative fuel vehicles (ethanol/E85 cars). The purpose of this paper is to analyze how a local policy measure impacts the composition of the car fleet over time. More specifically, we take advantage of the natural experiment setting caused by the introduction of the Stockholm congestion tax (2006) to analyze how the tax affected purchases of ethanol cars that were exempted from the tax. To estimate effects, we employ a Difference-in-differences methodology. By using a comprehensive database of the car fleet and car owners, sociodemographic and geographic factors are analyzed, which is unique in the existing literature. Our results suggest that the congestion tax had a significant impact on ethanol car purchases although the effect fades away over time. Furthermore, there is a positive relationship between the level of education and ethanol car purchases. Previous adoption of an ethanol car is found to be the strongest predictor of ethanol car purchases. Finally, data indicate that Stockholmers substantially increased purchases of ethanol cars half a year before the introduction of the congestion tax, which we refer to as an anticipation effect.

1. Introduction

In 2010 the transportation sector accounted for 22% of world-wide CO_2 emissions and approximately three quarters of these were due to road traffic (IEA, 2012). Decreasing the emissions of car traffic and making the car fleet less dependent on fossil oil has been the goal of international agencies and national governments for many years, and it has also spurred an interest in finding the most effective policies for shifting the car fleet towards increased environmental sustainability. Based on a unique set of register data, we compare the development in the consumer adoption of alternative fuel vehicles (AFVs; specifically ethanol/E85 cars) in the three largest cities of Sweden following the introduction of the Stockholm congestion tax in 2006. We are able to estimate the effect of the congestion tax on car purchasing behavior since ethanol cars were exempt from the congestion tax between 2006 and 2009. Thus, although the introduction of the congestion tax was not explicitly aimed at people's car choices, it provides a natural experiment for testing the effectiveness of economic incentives on the purchasing of AFVs. In addition, the dataset permits the uncovering of more socio-economic factors of AFV adopters and non-adopters than reported in previous studies.

The Stockholm congestion tax is one of several national and local policies aimed at decreasing congestion but also increasing consumer adoption of AFVs and sales of alternative fuels such as bioethanol and gas. As an over-arching goal for the transport

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http://dx.doi.org/10.1016/j.enpol.2014.08.029

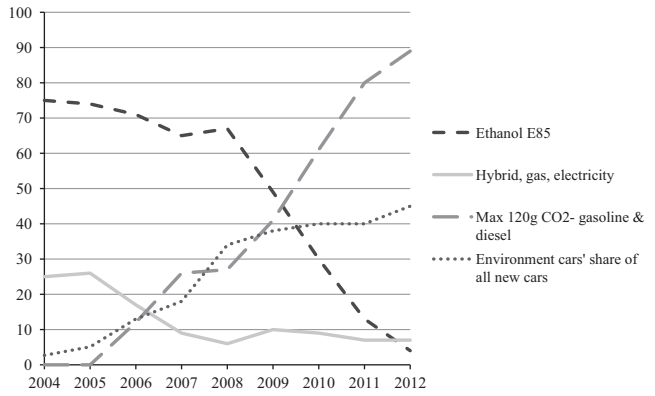

Fig. 1. The proportions of different types of environment cars of all environment car purchases in Sweden 2004–2012, and the total share of all environment car purchases of all car sales. New car registrations per year (Bil Sweden, 2013).

sector, the Swedish Parliament has set a target for zero greenhouse gas emissions in 2050 and a milestone of having a fossil oil independent car fleet by 2030 (Regeringskansliet, 2009). Furthermore, Sweden was the first country in Europe to create incentives for ethanol/E85[1] cars through tax breaks on the fuel as well as a law mandating fueling stations to invest in pumps for alternative fuels[2] (Riksrevisionen, 2011). According to a government regulation adopted in 2004, "environment cars[3]" are flexible fuel vehicles that can run on ethanol, electricity or biogas provided that they, when driven on gasoline, do not emit more than 218 g CO_2 per km (SFS, 2004: 1364). In addition, diesel cars and gasoline cars that emit less than 120 g CO_2 per km were also labeled "environment cars", but only cars that run on ethanol, electricity or gas were exempted from the Stockholm congestion tax. As shown in Fig. 1, at a national level these policies appear to have had a substantial effect on car purchases since 2004. Early on, ethanol cars dominated the "environment car" market. For example, in 2008 ethanol cars had a 68% share of the "environment car" market (corresponding to a 23% share of the total car purchases that year (Bil Sweden, 2013)). Since 2009, low CO_2-emitting diesel and gasoline cars have taken over as the most sold "environment cars" (e.g., Kågeson, 2012). Fig. 1 shows that the total market for "environment cars" expanded from 3% of all new car sales in 2004 to 45% in 2012, but it can also be concluded that ethanol cars have dropped over time as other types of "environment cars" have been introduced and become popular among consumers.

Although some evaluations of policies targeting the sales of biofuels and AFVs in Sweden have been conducted, most of them are partial or merely adopting a descriptive approach (e.g., City of Stockholm, 2009; Riksrevisionen, 2011). Hence, it is difficult to draw more specific conclusions as to how a specific policy such as the Stockholm congestion tax is linked to changes in the car fleet over time and about what factors that can explain the adoption of more environmentally friendly vehicles. From a research perspective, there is a wealth of published studies using different types of survey methods to clarify barriers and drivers of consumer adoption of AFVs (Diamond, 2009; Egbue and Long, 2012; Ozaki and Sevastyanova, 2011). Some studies have also utilized panel data (e.g., Ryan et al., 2009) to model the CO_2 intensity of the new car fleet, but this study did not analyze AFV adoption as such. However, there are no published studies based on register data that pool demographic and time series data in order to produce a more nuanced picture of how policies influence the car fleet depending on local or non-local policy to reduce environmental impact using alternative fuels.

To our knowledge there is yet no study of AFV adoption based on representative panel data with information on socio-economics and demographics. This type of analysis may add important insights to the existing knowledge of incentive mechanisms behind changes in AFV adoption. The purpose of the paper is to contribute to the understanding of how selective taxes and population characteristics influence the composition of the car fleet against this background. More specifically, our aim is to estimate the causal link between tax exemptions for AFVs and purchases of such vehicles, and to describe the socio-economic and demographic characteristics of AFV consumers. We do this by utilizing a natural experiment created by the introduction of the congestion tax in Stockholm (Sweden) in 2006. Since this tax was not introduced anywhere else in Sweden until 2013, and since ethanol/E85 cars were exempted from the tax, we are able to estimate how the tax affected incentives to purchase ethanol cars. Our rich register data further allows us to estimate the correlation between socio-economic and demographic characteristics and ethanol car purchases.

1.1. *The Stockholm congestion tax and the exemption for AFVs: a natural experiment*

Research has pointed towards policies as important factors behind the composition and development of the car fleet (e.g., de Haan et al., 2006; Potter and Parkhurst, 2005). Today, CO_2 taxation is well established in large parts of the European Union. Nineteen EU Member States (ACEA, 2012), among them Sweden, currently apply some form of CO_2 tax to the registration and/or ownership of passenger cars, based on the car's CO_2 emissions and/or fuel consumption. There are, for example, vehicle taxes such as the annual vehicle tax. These types of taxes affect the entire car fleet and aim to give incentives to choose more fuel-efficient cars (Ryan et al., 2009). In addition to the national taxation schemes there are also local taxes and subsidies implemented to attempt to steer the car fleet in less environmentally harmful and less fossil fuel intensive directions.[4] Local policies that affect the composition of the car fleet are exemption from congestion tolls and free parking for cars that pollute less.

During recent years, several policies have been implemented in Sweden in order to increase the adoption of AFVs and fuel-efficient cars. From 2007 to 2009 a national cleaner car purchase rebate was enacted that subsidized the purchase price of all new AFVs with SEK 10,000 (approximately 1000 Euros). Furthermore, a congestion tax was introduced in Stockholm in 2006, initially as a six-month trial. After close monitoring of traffic patterns and public opinions and a referendum in and around Stockholm city, the tax was made permanent in August 2007. According to Börjesson et al. (2012) the tax had both immediate and longer term effects on decreasing traffic congestion. In their study they also found that the tax had a considerable effect on the sale of AFVs due to the fact that these vehicles were exempted from the tax (to varying degrees) up until 2012 (Börjesson et al., 2012). In a national comparison they also show that the sales of AFVs in Stockholm were higher than the Swedish average in 2006 and

[1] E85 is a blend of 85% ethanol and 15% gasoline (summer quality; in the winter the mix is 75/25). It is the most commonly available blended fuel for use in flex-fuel vehicles (FFVs) in Sweden. In this paper we refer to cars that can run on E85 as ethanol cars.

[2] By the end of 2011 there were 2885 fueling stations in Sweden and 59% of these sold E85 (SBPI, 2013).

[3] The term "environment car" has been used by the Swedish legislators and is not a term invented or endorsed in this paper.

[4] It should be noted that these vehicle taxes impose a fixed cost on car ownership and therefore probably have very little effect on how the car is actually used, i.e., how much emission it produces. Hence, from an economics perspective, these policies are seen as second best; a unit tax on the CO_2 content in fuels would likely be a more cost-effective policy.