Transportation Research Part A 70 (2014) 24–40

Contents lists available at ScienceDirect

Transportation Research Part A

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

The impact of a congestion pricing exemption on the demand for new energy efficient vehicles in Stockholm

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ARTICLE INFO

Article history:
Received 5 February 2014
Received in revised form 30 July 2014
Accepted 30 September 2014
Available online 1 November 2014

Keywords:
Energy efficient vehicles
Congestion pricing
Incentive policies
Revealed preferences
Multinomial logit

ABSTRACT

As governments seek to transition to more efficient vehicle fleets, one strategy has been to incentivize 'green' vehicle choice by exempting some of these vehicles from road user charges. As an example, to stimulate sales of energy efficient vehicles (EEVs) in Sweden, some of these automobiles were exempted from Stockholm's congestion tax. In this paper the effect this policy had on the demand for new, privately-owned, exempt EEVs is assessed by first estimating a model of vehicle choice and then by applying this model to simulate vehicle alternative market shares under different policy scenarios. The database used to calibrate the model includes owner-specific demographics merged with vehicle registry data for all new private vehicles registered in Stockholm County during 2008. Characteristics of individuals with a higher propensity to purchase an exempt EEV were identified. The most significant factors included intra-cordon residency (positive), distance from home to the CBD (negative), and commuting across the cordon (positive). By calculating vehicle shares from the vehicle choice model and then comparing these estimates to a simulated scenario where the congestion tax exemption was inactive, the exemption was estimated to have substantially increased the share of newly purchased, private, exempt EEVs in Stockholm by 1.8% (±0.3%; 95% C.I.) to a total share of 18.8%. This amounts to an estimated 10.7% increase in private, exempt EEV purchases during 2008, i.e., 519 privately owned, exempt EEVs.

1. Introduction

Numerous initiatives have been employed around the world in order to address rising greenhouse gas (GHG) emissions originating from the transport sector. These measures have included: travel demand management (congestion pricing), increased fuel taxes, alternative fuel subsidies and energy efficient vehicle (EEV) rebates. Incentivizing the purchase of EEVs has been one of the more prevalent approaches in attempting to tackle this global issue. EEVs, whilst having the advantage of lower emissions and, in some cases, more efficient fuel consumption, also bring the downsides of increased purchase cost, reduced convenience of vehicle fuelling, and operational uncertainty. To stimulate demand in the face of these challenges,

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http://dx.doi.org/10.1016/j.tra.2014.09.013
0965-8564/

various incentive-based policies, such as toll exemptions, have been used by national and local governments to encourage the purchase of these types of vehicles.

In order to address rising GHG emissions in Stockholm, and to achieve the Swedish Government's ambition to operate a fossil-fuel free fleet by 2030, a number of policies were implemented, targeting the transport sector. Foremost amongst these was the combination of a congestion tax – initiated to discourage peak-hour emissions-intensive travel – and an exemption from this tax for some EEVs, established to encourage a transition towards a 'green' vehicle fleet. Although both policies shared the aim of reducing GHG emissions, the exemption for EEVs carried the risk of diminishing the effectiveness of the congestion-pricing scheme. As the number of vehicle owners choosing to transition to an eligible exempt EEV increased, the congestion–reduction effectiveness of the pricing scheme weakened. In fact, policy-makers quickly recognized this potential issue and consequently phased out the EEV exemption less than 18 months after its introduction (Hultkrantz and Liu, 2012).

Several studies have investigated the demand for EEVs through stated-preference (SP) surveys across multiple countries, including: Denmark (Mabit and Fosgerau, 2011) Germany (Hackbarth and Madlener, 2013; Ziegler, 2012), Norway (Dagsvik et al., 2002), United Kingdom (Batley et al., 2004), Canada (Ewing and Sarigöllü, 1998), USA (Brownstone et al., 1996; Bunch et al., 1993; Hess et al., 2012; Musti and Kockelman, 2011) and Australia (Beck et al., 2013). Although each of these studies differed in their approach, all involved SP surveys where characteristics were varied among different types of vehicles, including EEVs, and presented to respondents, who in turn made hypothetical choices about which vehicle they would be most likely to purchase.

As described in Section 2, although these studies have revealed a number of interesting findings regarding the potential demand for EEVs, they relied on SP data. In contrast, this paper employs an approach where EEV choice data are obtained retrospectively by collecting and using revealed preference (RP) data based on private vehicle registrations. By examining the revealed preferences of vehicle owners in Stockholm, this study overcomes one of the principal limitations of SP data – that stated preferences may not in fact reflect individuals' actual choices, such as when cost, time, and inconvenience factors are hypothetical rather than real. While the RP data used in this study are sufficient, a follow up SP survey of vehicle owners in Stockholm could be interesting for comparing RP and SP results across a variety of dimensions.

This paper's RP approach involves modeling the characteristics of private individuals who purchased new EEVs, whilst estimating the effect of the congestion tax exemption on marginal demand. The study specifically builds on work undertaken by Bunch et al. (1993), Musti and Kockelman (2011), Campbell et al. (2012), Graham-Rowe et al. (2012) and Ziegler (2012) in *Transportation Research Part A: Policy and Practice*, in attempting to identify individuals that are most likely to purchase an energy efficient vehicle. This paper also contributes to the current literature by examining the effectiveness of a tax exemption under revealed preference conditions, and by assessing the total effect of the policy based on key indicators for policy-makers, including: vehicle owner home and work locations, commuting patterns, number of children, number of vehicles, age, gender and income.

The two main research questions motivating this study are:

- Which private individuals chose to purchase different types of new EEVs in Stockholm in 2008? and,
- How did the congestion tax exemption affect the demand for new EEVs in Stockholm in 2008?

In order to answer these research questions the analysis is split into two stages. Firstly, a multinomial logit (MNL) model is used to identify which demographic characteristics were most significantly related to the purchase of an EEV over a conventional vehicle. The three most significant variables are found to be: intra-cordon residency (positive); commuting across the cordon (positive); and distance of residence from the CBD (negative). In order to estimate the effect of the exemption policy on vehicle purchase choice, the model includes variables to control for geographic differences in preferences, based on the location of the vehicle owners' homes and workplaces in relation to the congestion tax cordon boundary. These variables include one indicator representing commutes across the cordon and another indicator representing intra-cordon residency.

The effect of the tax exemption policy on the probability of purchasing EEVs is estimated in the second stage of the analysis by focusing on the groups of vehicle owners that are most likely to have been affected by the policy, i.e., those commuting across the cordon boundary (in both directions). Given the inclusion of the indicator variable representing commuting across the cordon, it is assumed that the estimated coefficient of this variable captures the effect of the exemption policy on the utility of choosing to purchase an exempt EEV for these two groups of vehicle owners. The intra-cordon residency variable also controls for differences between the two groups, based upon direction of travel across the cordon boundary.

A counter-hypothesis to this assumption is that the coefficient of the variable representing commuting across the cordon boundary instead only captures geo-demographic differences that lead to variations in EEV ownership across the different groups of vehicle owners in relation to the cordon boundary. In order to address this counter-hypothesis, an additional analysis is performed on data from a city with a similar geo-demographic pattern to Stockholm, Gothenburg – Sweden's second largest city.

Based upon this framework, the vehicle alternative market shares are calculated using the estimated coefficients of the MNL model and compared to predicted vehicle type shares from a simulated scenario where the exemption policy is inactive. This simulated scenario is constructed by setting the coefficient for the variable representing commutes across the cordon boundary to zero for all observations to remove the utility benefit of the exemption policy. Overall, the procedure of this