The impact of a congestion charging exemption on the demand for new low-emission vehicles

Jake Whitehead\textsuperscript{1,2}, Joel P. Franklin\textsuperscript{2}, Simon Washington\textsuperscript{3}

\textsuperscript{1}Double PhD Candidate, KTH Royal Institute of Technology, Teknikringen 10A, Stockholm, Sweden SE-100 44 and Queensland University of Technology, 1 George Street, Brisbane, Australia 4000; Tel. (Sweden) +46 7 6252 1284; Tel. (Australia) +61 4 3040 4974; Email: jake.whitehead@abe.kth.se

\textsuperscript{2}Associate Professor, KTH Royal Institute of Technology, Teknikringen 10A, Stockholm, Sweden SE-100 44; Tel. (Sweden) +46 87 908 374; Email: joel.franklin@abe.kth.se

\textsuperscript{3}Professor and TMR Chair, Queensland University of Technology, 1 George Street, Brisbane, Australia 4000; Tel. (Australia) +61 7 3138 9990; Email: simon.washington@qut.edu.au

EXTENDED ABSTRACT:

Numerous initiatives have been employed around the world in order to address rising greenhouse gas (GHG) emissions originating from the transport sector. These measures include: travel demand management (congestion-charging), increased fuel taxes, alternative fuel subsidies and low-emission vehicle (LEV) rebates. Incentivizing the purchase of LEVs has been one of the more prevalent approaches in attempting to tackle this global issue. LEVs, 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, 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 in line with the Swedish Government’s ambition to operate a fossil free fleet by 2030, a number of policies were implemented targeting the transport sector. Foremost amongst these was the combination of a congestion charge – initiated to discourage emissions-intensive travel – and an exemption from this charge for some LEVs, established to encourage a transition towards a ‘green’ vehicle fleet. Although both policies shared the aim of reducing GHG emissions, the exemption for LEVs carried the risk of diminishing the effectiveness of the congestion charging scheme. As the number of vehicle owners choosing to transition to an eligible LEV increased, the congestion-reduction effectiveness of the charging scheme weakened. In fact, policy makers quickly recognized this potential issue and consequently phased out the LEV exemption less than 18 months after its introduction (1).

Several studies have investigated the demand for LEVs through stated-preference (SP) surveys across multiple countries, including: Denmark (2), Germany (3, 4), UK (5), Canada (6), USA (7, 8) and Australia (9). Although each of these studies differed in approach, all involved SP surveys where differing characteristics between various types of vehicles, including LEVs, were presented to respondents and these respondents in turn made hypothetical decisions about which vehicle they would be most likely to purchase.

Although these studies revealed a number of interesting findings in regards to the potential demand for LEVs, they relied on SP data. In contrast, this paper employs an approach where LEV choice is modelled by taking a retrospective view and by using revealed preference (RP) data. By examining the revealed preferences of vehicle owners in Stockholm, this study overcomes one of the principal limitations of SP data, namely that stated preferences may not in fact reflect individuals’ actual choices, such as when cost, time, and inconvenience factors are real rather than hypothetical.

This paper’s RP approach involves modelling the characteristics of individuals who purchased new LEVs, whilst estimating the effect of the congestion charging exemption upon choice probabilities and subsequent aggregate demand. The paper contributes to the current literature by examining the effectiveness of a toll 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 location, commuting patterns, number of children, age, gender and income.
The two main research questions motivating this study were:

- Which individuals chose to purchase a new LEV in Stockholm in 2008?; and,
- How did the congestion charging exemption affect the aggregate demand for new LEVs in Stockholm in 2008?

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

The effect of the exemption policy on the probability of purchasing LEVs was estimated in the second stage of the analysis by focusing on the groups of vehicle owners that were 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 commutes 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 LEV for these two groups of vehicle owners. The intra-cordon residency indicator 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 LEV ownership across the different groups of vehicle owners in relation to the cordon boundary. In order to address this counter-hypothesis, an additional analysis was performed on data from a city with a similar geo-demographic pattern to Stockholm, Gothenburg - Sweden’s second largest city. The results of this analysis provided evidence to support the argument that the coefficient of the variable representing commutes across the cordon was capturing the effect of the exemption policy.

Based upon this framework, the predicted vehicle type shares were calculated using the estimated coefficients of the MNL model and compared with predicted vehicle type shares from a simulated scenario where the exemption policy was inactive. This simulated scenario was 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 second stage of the analysis led to results showing that the exemption had a substantial effect upon the probability of purchasing and aggregate demand for exempt LEVs in Stockholm during 2008.

By making use of unique evidence of revealed preferences of LEV owners, this study identifies the common characteristics of new LEV owners and estimates the effect of Stockholm's congestion charging exemption upon the demand for new LEVs during 2008. It was found that the variables that had the greatest effect upon the choice of purchasing an exempt LEV included intra-cordon residency (positive), distance of home from the cordon (negative), and commuting across the cordon (positive). It was also determined that owners under the age of 30 years preferred non-exempt LEVs (low CO₂ LEVs), whilst those over the age of 30 years preferred electric vehicles.

In terms of electric vehicles, it was apparent that those individuals living within the city had the highest propensity towards purchasing this vehicle type. A negative relationship between choosing an electric vehicle and the distance of an individuals’ residency from the cordon was also evident.

Overall, the congestion charging exemption was found to have increased the share of exempt LEVs in Stockholm by 1.9%, with, as expected, a much stronger effect on those commuting across the boundary, with those living inside the cordon having a 13.1% increase, and those owners living outside the cordon having a 5.0% increase. This increase in demand corresponded to an additional 538 (+/- 93; 95% C.I.) new exempt LEVs purchased in Stockholm during 2008 (out of a total of 5 427; 9.9%).

Policy makers can take note that an incentive-based policy can increase the demand for LEVs and appears to be an appropriate approach to adopt when attempting to reduce transport emissions through encouraging a transition towards a 'green' vehicle fleet.
Key References:


