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The effects of congestion charging on road traffic casualties: A causal analysis using difference-in-difference estimation

Haojie Li, Daniel J. Graham*, Arnab Majumdar

Centre for Transport Studies, Department of Civil and Environmental Engineering, Imperial College London, London SW7 2AZ, UK

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ABSTRACT

This paper aims to identify the impacts of the London congestion charge on road casualties within the central London charging zone. It develops a full difference-in-difference (DID) model that is integrated with generalized linear models, such as Poisson and Negative Binomial regression models. Covariates are included in the model to adjust for factors that violate the parallel trend assumption, which is critical in the DID model. The lower Bayesian Information Criterion value suggests that the full difference-in-difference model performs well in evaluating the relationship between road accidents and the London congestion charge as well as other socio-economic factors. After adjusting for a time trend and regional effects, the results show that the introduction of the London congestion charge has a significant influence on the incidence of road casualties. The congestion charge reduces the total number of car accidents, but is associated with an increase in two wheeled vehicle accidents.

1. Introduction

Since the first congestion charging scheme was introduced by Singapore in 1975, several studies have been conducted to better understand the effects induced by congestion charging. It has been shown that congestion charging can decrease congestion effectively (Olszewski and Xie, 2005) and consequently affect the traffic flow conditions such as the traffic volume, volume-to-capacity ratio (V/C) and traffic flow speed, all of which have direct impacts on the occurrence likelihood and severity of road traffic casualties (Lord et al., 2005).

The objective of this paper is to test the causal effect of the London congestion charge (LCC) on road accidents. The difference-in-difference (DID) method is introduced as an evaluation tool to make causal inferences and this method is frequently applied to evaluate the impact of policies (Ashenfelter and Card, 1985; Card and Krueger, 1994; Finkelstein, 2002; Donald and Lang, 2007; Athey and Imbens, 2006; Abadie et al., 2010) but, to the best of our knowledge, has not been used for road accident related transport research. The DID approach is applied using generalized linear models (GLMs), such as Poisson and Negative Binomial models, to estimate the effect of congestion charging on the counts of accidents, which are categorized by casualty type and severity. Covariates are introduced to the DID model to adjust for factors that might lead to the violation of the parallel trend assumption in DID estimation.

The paper is organized as follows. The literature review is presented in Section 2. Section 3 describes the method and the data sources used in this analysis and this is followed by the results and discussion in Section 4. The conclusions are given in the final section.

2. Literature review

Causal relationships can be distinguished from pure statistical relationships given that a plausible mechanism underpinning the relationship between target variables and the treatment (Elvik, 2011) is outlined. To estimate the causal relationship between the LCC and road accidents, it is necessary to understand and outline the mechanisms by which road pricing may affect road traffic accidents.

Most previous research on road traffic accidents has explored various factors contributing to risk, including the traffic characteristics, road characteristics, demographics and the environment (Wier et al., 2009; Quddus, 2008a,b; Dissanayake et al., 2009). In recent years, researchers have paid close attention to economic factors, such as fuel prices and road taxation. As fuel prices and road users' taxes rise, cars will tend to be driven less and consequently there will be less traffic congestion. It may be hypothesized that since a higher tax leads to fewer miles travelled, roads will be emptier of traffic and probably safer. However, this line of argument is ambiguous, because when road taxation is more expensive, travellers will switch to other travel modes like bicycle and motorcycle, which may be more vulnerable to severe accidents (White, 2004;

* Corresponding author. Tel.: +44 20 7594 6088; fax: +44 20 7594 6107.
E-mail address: d.j.graham@imperial.ac.uk (D.J. Graham).

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Leigh and Wilkinson, 1991; Crandall and Graham, 1989). Nevertheless, many researchers have shown that there does seem to be a relationship between fuel prices and road casualties, although the direction of the relationship depends on the type of accidents. Hyatt et al. (2009) investigated the relationship between motor vehicle injury and mortality rates and fuel prices. By using monthly fuel price and fatality panel data, they found higher gasoline prices were related to increased motorcycle casualties and the authors explained this increase was more a factor of the increasing number of motorcycles on the road. Grabowski et al. (2006) generated panel data on the total number of traffic fatalities for the 48 continental U.S. states during the period 1982–2000. Their results suggested that exogenous increases in state gasoline taxes were plausibly associated with fewer traffic fatalities. Many other studies have also presented similar results (Leigh and Wilkinson, 1991; Haughton and Sarkar, 1996; Grabowski and Morrisey, 2004). All the above studies suggest that fuel tax, as one mode of road taxation, has an influence on road casualties. Similarly, we could hypothesize that congestion charging, another such mode of road taxation which aims to alleviate congestion, may also affect traffic accidents.

London provides a unique opportunity to study this hypothesis. The London congestion charging (LCC) scheme was introduced in central London on 17 February 2003 at a flat rate of £5 per day between the hours of 7:00 am and 6:30 pm, Monday to Friday. The charge was then raised from £5 to £8 on 4 July 2005. A western extension of the charging zone was implemented on 19 February 2007 and the charging hours were reduced to 7:00 am to 6:00 pm. The western charging zone was removed and the charge was increased to £10 on 4 January 2011. Fig. 1 shows the area of the initial central London charging zone and the western extension. The LCC scheme aims to reduce congestion and travel delay and thereby improve journey quality. Congestion in central London reduced by up to 30% and average traffic speeds increased from 13 km/h to 17 km/h during the initial charging period (TfL, 2004). It has also been showed that the number of traffic accidents reduced significantly in both the original and extended charging zone (TfL, 2007). Periods and treatments are shown below:

(1) 2003–2004: Initial congestion charge in central London £5.
(2) 2005–2006: Congestion fee increase from £5 to £8.
(3) 2007–2010: Western extension of charging zone.

Tuerk and Graham (2010) conducted research on the impacts of the LCC scheme on traffic volumes. Traffic volumes crossing central London were measured by automatic traffic counters and aggregated at the hourly level. DID estimation was used to analyse the traffic data and the results indicate a reduction in traffic due to the increase in the congestion fee for the LCC (7.8% for inbound vehicles).

Other papers have focused on relationship between the congestion charge and the travel modes, environment and business activity matters (e.g. Eliasson and Mattsson, 2006; Wichiensin et al., 2007). All these studies show that the congestion charge does have effects on travel costs, travel time and the transit market. However, little research has directly investigated the relationship between the LCC and road accidents in London.

Quddus (2008a,b) conducted a time series analysis of traffic accidents in Great Britain and his results for the London congestion charge suggested an average 33% reduction of casualties in each month after the LCC. Noland et al. (2008) examined the effects of

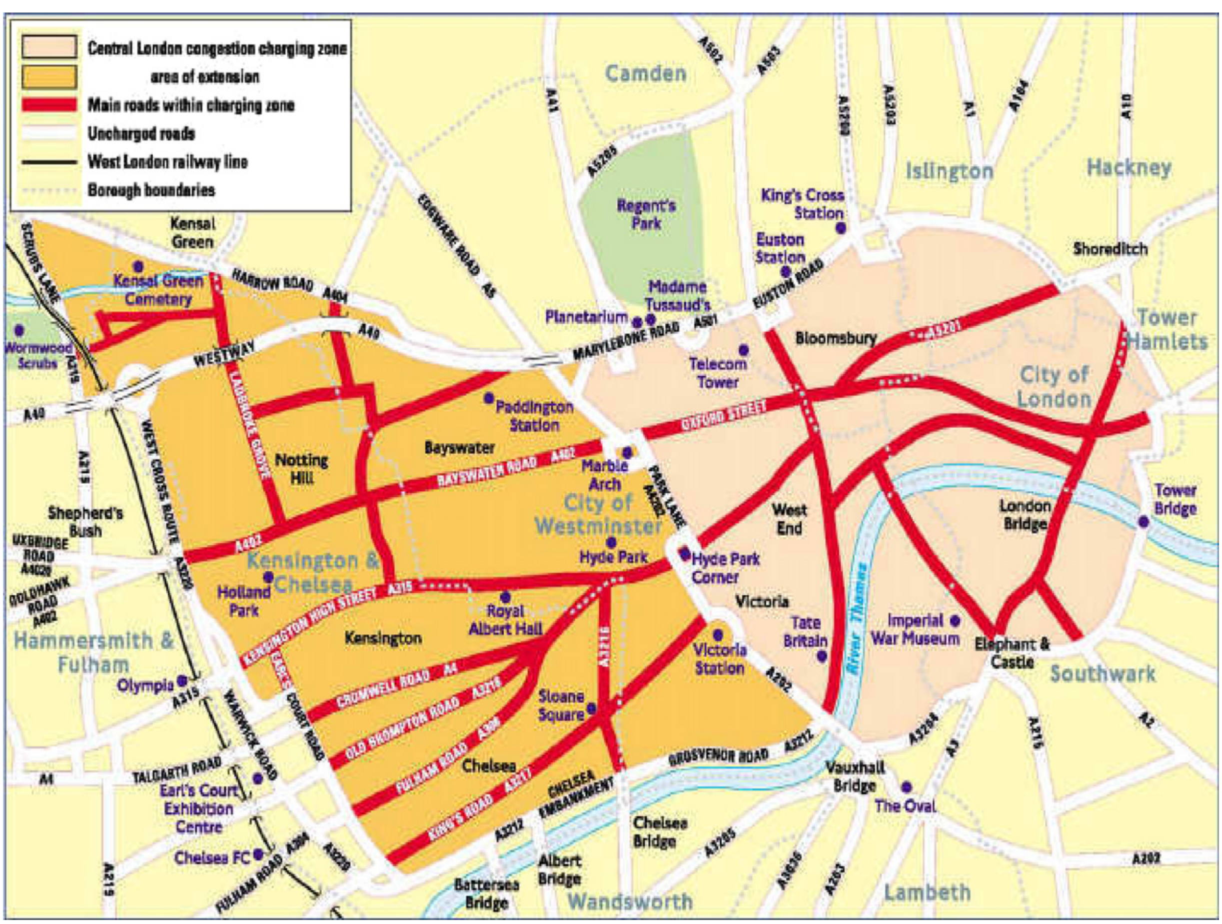

Fig. 1. Map of the London congestion charging zone.