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Safety effects of the London cycle superhighways on cycle collisions

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ABSTRACT

This paper evaluates the effects of the London Cycle Superhighways (CS) on cycle collisions. A total of 45 CS segments and 375 control segments are observed for a period of 8 years in London. Variables such as road characteristics, crash history and socio-economic information are included in the data set. Traffic characteristics including traffic volume, cycle volume and traffic speed are obtained from Department for Transport. We first estimate the safety effects on the CS routes using Empirical Bayes methods. Then propensity score matching methods are also applied for comparison. The introduction of cycle superhighways caused cycling traffic volumes to increase dramatically along CS routes with no significant impacts on collision rates. Our models find that the increase in traffic was associated with a rise in annual total cycle collisions of around 2.6 per km (38% in percentage). However, when we re-estimate the effects based on cycle collision rates rather than levels, our results also show that the CS routes are not more dangerous or safer than the control roads. Among the four CS routes, CS3 performs the best in protecting cyclists with a large proportion of segregated lanes whilst the cyclists have to share the lanes with motorists on other routes. It is recommended that consistent safety designs should be applied on all CS routes for a safer cycling environment.

1. Introduction

Cycling is a sustainable and healthy travel mode, which helps to cut traffic congestion and reduce emissions and parking demand. There has been a dramatic increase in the number of cyclists over the past few decades in European cities, including London. Daily journeys by bicycle in Greater London have increased from 380,000 in 2004 to 610,000 in 2014 (Transport for London, 2014). The growth in cycling is closely related to a number of policies and the investment in new facilities inspiring the usage of bicycle, including the Barclays Cycle Hire (later renamed Santander Cycles), Biking Boroughs and the Cycle Superhighways (CS), all of which are designed to meet the Mayor's target of a 400% increase in cycling by 2026.

Cycle Superhighways are cycle paths running from outer London into and across central London, aiming to increase commuter cycling, breaking down barriers to commuting by bicycle through a unique package of measures. The first two pilot routes, CS3 and CS7 were opened in July 2010. As reported by Transport for London (2011b), the Cycle Superhighways scheme has significantly increased the number of cyclists. Cycling has increased by 46% along CS7 and 83% along CS3 during the first year, while a number of cyclists along both routes experienced more than 100 per cent growth. However, the safety effects of the Cycle Superhighways are not evaluated in the report by Transport for London (2011b) due to the lack of post-intervention accident data.

The estimation of the impacts of the London Cycle Superhighway can be complicated. On one hand, drivers become more aware and better at anticipating cyclist behavior with increased number of cyclists. Hence injury rates will decrease with increased cycling rates, so called "safety in numbers" (Robinson, 2005; Jacobsen, 2003). On the other hand, there have been continuous critical opinions on the safety of London's cycle superhighways. A frequent criticism is that the Cycle Superhighways are nothing more than blue paint due to a lack of consistent high level of protections for cyclists.

This paper aims to evaluate the safety effects of the London Cycle Superhighways based on panel data from 2007 to 2014. To control for the regression to mean and time trend effects, we employ the widely used Empirical Bayes (EB) method. A common issue with the before-after control study is the justification of the similarity between treated and control groups. Hence propensity score matching (PSM) method is also applied to address this issue and the results are compared with the ones from the EB method. Another

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issue which has not been fully addressed in previous studies is the lack of traffic exposure. The failure to control for the change in cycle traffic volume could also bias the estimation results. In this study, the cycle volume data is extracted from road traffic statistics produced by Department for Transport.

The paper is organized as follows. The introduction of the London Cycle Superhighways and literature review is presented in the next section. The method and data used in the analysis are described in Sections 3 and 4. The results are presented and discussed in Section 5. The conclusions are given in the final section.

2. Background

Twelve new cycle routes, termed as the Cycle Superhighways, were announced in 2008, aiming to provide safer, faster and more direct cycle journeys into the city. As shown in Fig. 1, twelve routes were planned to radiate from central London based on the clock face layout. Two routes (CS6 and CS12) have been cancelled, while CS10 has been replaced by a new East-West route. Only four routes have been put into use by 2015, including CS2 (Stratford to Aldgate), CS3 (Barking to Tower Gateway), CS7 (Merton to the City) and CS8 (Wandsworth to Westminster).

The Cycle Superhighways were chosen to provide good geographic coverage in areas where there are lots of existing cyclists and where there is future potential for people to cycle to work with right facilities. The cycle lanes are at least 1.5 m wide and use blue surfacing to distinguish them from other existing cycle lanes in London. According to the results of independent customer satisfaction surveys by Transport for London (TfL), 61% of cyclists said that the blue surfacing made them feel safer and encouraged them to use the routes (Transport for London, 2011b). There are also new signs, road markings and information about journey time and links to other routes. A variety of measures have been undertaken to improve safety for cyclists to commute by bike on the CS routes. These include (Transport for London, 2011a):

(1) Realigned traffic and bus lanes to create more space for cyclists on busy stretches of the routes;
(2) Re-designed junctions to make them safer for cyclists (e.g. by removing left-turn slip roads);
(3) Segregated cycle lanes at particular sections of the routes;
(4) Blind spot visibility mirrors at signalized junctions in order to improve the visibility of cyclists to heavy goods vehicles;
(5) New Advanced Stop Lines and extensions to existing ones (to a minimum of 5 m) in order to help cyclists move away from signals before other traffic.

However, the promised improvements are not consistently met and the superhighways are frequently criticized as "nothing but blue paint". Table 1 summarizes the characteristics of the four routes in operation. These routes were opened during 2010 and 2011 with an average length of about 10 km. The superhighways run between central London and outer London mostly via main roads. Fig. 2 shows some examples of the pros and cons of the Cycle Superhighways. Compared to the sporadic designs which provide high level of protection for cyclists (as shown in pictures A, B and C), inadequate functionality (as shown in pictures D, E and F) is more prevalent along these routes. The main issues regarding cycling safety are described below:

(1) Lack of segregated cycle lanes.
(2) Cycle lanes shared with buses and other road users.
(3) Conflicts between cyclists and buses and parked vehicles.
(4) Significant hook risks remains at key junctions, e.g. Bow roundabout in east London.

Although the safety effects of the London Cycle Superhighways have been rarely studied, a limited amount of studies have been conducted to examine the impacts of cycle lanes on collisions (e.g. Lusk et al., 2011; Teschke et al., 2012; Reynolds et al., 2009; Park et al., 2015; Zangenehpour et al., 2016; Pulugurtha and Thakur, 2015; Abdel-Aty et al., 2014; Chen et al., 2012). For example, Reynolds et al. (2009) reviewed 23 studies of the impact of transportation infrastructure on cyclist safety. Their results suggest that separated cycle lanes (on-road, off-road, segregated by physical barriers or color paint) can reduce the risk of collisions and injury severities compared to cycling on road with motorists or pedestrians. Another review study by Thomas and DeRobertis (2013) conclude that one-way cycle tracks are generally safer than two-way, and constructing cycle tracks reduces collisions and injuries when effective intersection treatments are employed. Park et al. (2015) employed both before-after with empirical Bayes and cross-sectional methods to determine relationships between the safety effects of adding a bike lane and the roadway characteristics. Ten years data from 2003 to 2012 for Florida is used in this study. The results show that adding a bike lane is more effective in reducing bike crashes than all crashes. Zangenehpour et al. (2016) investigate the safety effects of cycle tracks at signalized intersections using a case-control study based on video data. The results highlight the important role of cycle tracks and the factors that increase or decrease cyclist safety. However, the before-after approach is not applied in this study because no data from the before period is available. Another case-control study conducted in the city of Charlotte shows that bicycle lanes reduce all crashes due to conscious driving on segments with on-street bicycle lane by motorists (Pulugurtha and Thakur, 2015).

Despite the empirical evidence of the positive impacts of cycle lanes on safety, the quantification of such effects can be complicated due to various confounding factors. For example, roads with parked vehicles are expected to have more cyclist injuries compared to roads without parking, because parked vehicles may restrict sight distances and increase the risk of conflict with parking vehicles or car doors (Pai, 2011; Rifaat et al., 2011). Similarly, the presence of public transport stops (e.g. bus and tram) is also expected to increase the risk of cyclist collisions due to frequent bus and pedestrian activities (Pei et al., 2010). In addition, the effects of cycle lanes are also related to risk perception of cyclists as well as motorists. It is suggested the presence of cycle lane may increase cycle use, and the perception that a route contains cycle lanes increases the likelihood that it will be chosen (Noland and Kunreuther, 1995; Hoehner et al., 2005). Parkin and Meyers (2010) conclude that with a cycle lane motor traffic may pass closer to a cyclist than they would if the cyclist and the motor driver were sharing the same lane.

Besides, there are several outstanding issues which have yet to be fully addressed in the previous studies on the safety effects of cycle lanes. Most studies to date have used either before-and-after or case-control methods (Daniels et al., 2008, 2009; Jensen, 2007, 2008; Park et al., 2015; Vandenbulcke et al., 2014). In these studies, a comparison group is usually applied in order to account for the general trend in accidents and provide an estimation of counterfactual outcomes for a study group. One consideration is regarding the similarity between treated and comparison groups. Ideally comparison groups should have the same or similar traffic levels and road characteristics, i.e. the comparison group must be representative of the intervention sites. For example, "an effort was made in order to avoid consequences of larger differences between general comparison group and treated roads, where bicycle facilities were applied. Trends for different types of crashes and injuries of the general comparison group were compared" (Jensen, 2007). However, in previous research, not only is there insufficient justification of the