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Impact of electronic road pricing (ERP) changes on transport modal choice☆

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ABSTRACT

This paper analyzes the effect of periodical congestion toll rate adjustment on the change of commuters' transport modal choice in Singapore's context. Among several alternatives that commuters can choose when they face increase of congestion tax, this study specifically tests the impact on the modal change to public bus transportation. This study finds that commuters switch to public bus services by 12% to 20% in the morning hours after S$1 increase and by approximately 10% in the evening after toll adjustment of S$0.50 to S$1.00 in the affected gantry area compared to the counterfactual through difference-in-difference method. Also, we find that the increase in bus ridership has long-lived effect at least within two months and commuters from area with lower income level respond more to the toll increase. When we repeat the same test for robustness with arbitrary time slot during which the toll is not levied, we find no significant modal change. Other confounding factors from macro-economic standpoint and service quality cannot explain the results as the modal change occurred in short period within specific area and time. We also find that commuters from low income area respond more to the toll rate adjustment.

1. Introduction

It is known that traffic congestion imposes social deadweight cost (Foster, 1974; De Borger and Proost, 2001; Lomax and Schrank, 2005). Tennøy (2010) suggests a few ways to reduce urban traffic volumes. The first is to encourage efficient land development that requires less traffic. Second is to impose physical and fiscal restrictions, which include road pricing, parking regulation, or traffic regulation. Third is to improve the social infrastructure to provide better environment for public transportation, walking, or cycling. de Palma and Fosgerau (2013) find that parking fees appear to be easy to carry out with less political conflict. Parking fee policy is even more effective when fee is time-varying or combined with early bird specials. This paper focuses on the effect of the second policy, especially on the road pricing. Road pricing has been adopted in many countries including Singapore, Sweden, and UK. Menon and Guttikunda (2010) finds that Singapore's road pricing system reduced 20–30% of the downtown passenger car traffic and Stockholm's traffic volume decreased by at least 20%. In the same paper, the authors show several options for drivers to avoid congestion tax. Drivers can a) pay ERP charge; b) change the time or route of the journey to pay less or to avoid ERP charge; c) switch to a public transportation; and d) modify destination or give up the trip. Ubbels and Verhoef (2005) add a few more options to those introduced by Menon and Guttikunda (2010). They add change in vehicle occupancy, change in driving style (e.g. speed modulation), class choice (for public transport), etc.

The effect of road pricing or congestion tax has been long studied in the transport policy area. In a sense, the transport policy seems to benefit drivers. de Palma et al. (2006) find that users, especially in the cases of 4 European cities including Paris, Brussels, Oslo and Helsinki, can get sizable amount of benefit from commuting time reduction, cost saving in vehicle management, or enhanced quality of public transportation when road pricing is introduced in each country. However, it doesn't always appear to be the case. Just like other policies, there are countries where the effort to curb down the traffic volume didn't turn out to be success. Indirect assessment of transport policy was conducted in Mexico City and Santiago by Gallego et al. (2013). This paper investigates the effects of two separate transport policies in both countries. Both countries were suffering from severe air pollution and the car traffic. The governments introduced policy measures to retire old public transportation and restrict car use. However, the result of the study shows that both policies were not successful, especially in long-term, to control traffic levels and CO levels. Instead of lower level of CO after the implementation of the policy, the authors found that the CO level and commuting hours in both cities increased in the long-term.

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Percoco (2014) studied a unique transport policy to restrict the vehicle inflow to the CBD in Milan, Italy. In 2008, the city started to charge €2–€10 depending on the cars' engine emissions standard. This policy was successful in controlling the number of less fuel-efficient vehicle in the CBD, while it failed to restrict total traffic volume in the CBD as more of toll-exempt vehicles that use liquefied petroleum gas or bi-fuel and toll-exempt hybrid vehicles entered CBD area.

While all the existing studies examine the magnitude of change in car use, it is hardly known how the commuters change their transportation modal choice. It has been proved that the drivers show responses to the transport policies. From the perspective of policy makers, it would be much better if drivers change their transportation mode from self-driving to eco-friendly mode, such as cycling, or public transportation. Instead of natural experiment research, a few papers conducted surveys. According to the survey result of Ubbels and Verhoef (2005) in the Netherlands, switching to public transportation ranked as the second highest[1] response to hypothetical implementation of peak and off peak kilometer charge. Similar survey was conducted in New Zealand and the result of O'Fallon et al. (2004) found that the 21% of survey respondents were willing to choose to walk and to use public transportation, while 67% insisted that they would still drive cars when congestion tax were to be introduced. The survey of Hu and Saleh (2005) found that almost 37% of car users were willing to spend less or change the shopping destination if they had been asked to pay congestion tax for their shopping trip to the CBD. As aforementioned, all the extant studies find the effect of the transportation policy in the car use or air pollution levels after introducing policies or through hypothetical surveys. However, the results from survey have limitation in that it is just hypothetical answers that are not always connected to actual behavioral change. As it is obvious that the demand for road during the commuting hours, especially in the morning peak hours, is quite inelastic, the increase of the public transportation ridership can be interpreted as the decrease of self-driving modal choice. This interpretation can be justified by a public report from Land Transport Authority (LTA). According to a public report[2] by LTA, number of bus fleet per million persons is 756. This figure is higher than that of New York (527) and Tokyo (163). Also average fare per boarding is S$0.63, which is the lowest among Singapore, Hong Kong, London, New York, and Tokyo.[3] Another transportation statistics report[4] of Singapore states that total number of bus stops in Singapore amounts to 4638. Thus, the bus services in Singapore are affordable and dense enough to provide easy access for the commuters. With this background, this paper investigates real change of modal choice after the toll increase through natural experiment in Singapore.

Singapore has been known as one of the countries with most efficient road pricing system. Singapore implemented road pricing system in 1975 with the name of Area License Scheme and started to collect toll electronically from 1998 by having all the vehicles equipped with car transponder, which is called In-vehicle Unit or IU, where preloaded cash cards are inserted. Total number of gantries[5] was 45 in 2004 and it amounted to 71 in 2013. After quarterly traffic speed review, the Land Transport Authority (LTA) adjusts the toll rate by the increment of S$0.50 or S$1.00. This paper studies the effect of toll increase, which was announced on July 29th, 2013, on the commuters' transportation modal choice. Especially we closely investigate the change of public bus use around the gantries that went through toll increase after the toll adjustment compared to the other areas before the increase by using difference-in-difference method. The LTA announced that it would increase toll rate by S$1.00 for 6 gantries and S$0.50 for 1 gantry. 6 of them were affected during the morning peak hours and only 1 gantry had toll increase in the evening peak hours with effective date of August 5th, 2013.[6] Due to a small number of bus lines that operate in the southern area, where two of the gantries were affected in the morning hours, this paper focuses only on the five gantries in the central and northern area of Singapore during morning and evening peak hours. Our dataset contains all the bus card use information, including boarding time, alighting time, travelling distance, bus number, and direction. We set the treatment area by drawing 1 km radius circle around the affected gantries and sort all the bus numbers that stop at the bus stops within the 1 km circle. We set a control area that doesn't overlap with the treatment area in the same manner to get the bus numbers. By using diff-in-diff method, we compare the bus ride numbers of the treatment area to those of control area before and after the toll increase. As the dataset starts from 1st of August, 2013, our control period constitutes 4 days and treatment period ends at the end of September 2015. To figure out the heterogeneous responsiveness in time, we test two different treatment periods: one with August data and the other with August and September.

Our study contributes in a few ways. First of all, we show the empirical responsiveness to the change of road pricing with natural experiment. Even if there are a few studies that conducted tests on the effect of new implementation of road pricing, our paper is the first paper that studies the toll increase after implementation. Secondly, we show the varied responsiveness over time and during the day. This study enabled us to figure out the magnitude of response in the morning and in the evening, when the demand for road is quite inelastic with respect to road pricing (Ferrari, 2010). By applying our findings to the real policy scheme, each government can establish more effective and efficient traffic control system. Thus, policy implication of this study is clear. Thirdly, we can test if the electronic road pricing system in Singapore is salient enough to affect the commuters' modal choice. Finkelstein (2009) argues that adopting electronic road pricing system makes tolling system less salient and drivers pay less attention to the toll increase compared to the case of manual toll collection.

To preview the result, we find that the commuters respond to the toll rate increase during our study window. Especially, the commuters in the morning peak hours show greater responsiveness compared to the evening peak hours. This seems to be the phenomenon caused by more inelastic demand for road in the morning than in the evening. Also, we find that the positive increase of bus ride after the toll increase in the treated area doesn't revert to its previous level in short-term, at least in two months. Thus, we show that toll increase has long-lived effect on the transportation modal choice among commuters. When we investigate the effect of arbitrary toll increase hours during the same study window as a robustness test, we find insignificant results throughout all the model specifications. Additional estimation of changing the radii to 0.5 km or 1.5 km shows similar result. We also find that low income areas respond more to the toll rate adjustment.

This paper is organized as follows. Sections 2 and 3 discuss the road pricing system in Singapore and the data/methodology respectively. Section 4 documents the responsiveness of commuters to the toll increase and results from additional robustness tests, and Section 5 concludes.

2. Urban road pricing in Singapore

Singapore is a small island-country with its size of 716.1 km^2 and connected to Malaysia via two links. Singapore's government

[1] The highest response was to travel at other times (47.7%). 17.6% of respondents answered that they would use public transport when toll is levied.

[2] http://www.lta.gov.sg/ltaacademy/doc/J12%20Nov-p68Stats_Key%20Transport%20Statistics%20of%20World%20Cities.pdf.

[3] Average fare per boarding is S$1.20, S$0.89, S$1.24, and S$1.59 for Hong Kong, London, New York, and Tokyo respectively.

[4] https://www.lta.gov.sg/content/dam/ltaweb/corp/PublicationsResearch/files/FactsandFigures/Statistics%20in%20Brief%202014.pdf.

[5] Gantry means a structure that looks like overhead bridge. Electronic sensors are installed on gantries and toll amount is deducted when cars pass under gantries. For more details, please see Appendix 1 and Appendix 2.

[6] For more detail, see Appendix 3.