MONASH University

IMPROVING METHODS TO ESTIMATE THE TRAFFIC CONGESTION IMPACTS OF URBAN PUBLIC TRANSPORT

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A thesis submitted for the degree of Doctor of Philosophy at
Monash University in 2018

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Abstract

Traffic congestion has been a major issue in many cities worldwide. It causes delay, energy waste and environmental pollution. Public transport is considered to be an efficient solution that can deal with traffic congestion. It provides an alternative transport mode for riders and reduces the number of car trips on the road network. Transport researchers have developed a number of approaches which aim to assess the benefits of public transport such as cost saving or pollution reduction. However, from a literature review the traffic congestion effects associated with public transport have been explored by only limited studies which adopted unrealistic assumptions and presented simplistic constructs. No systematic methods have been proposed to estimate these impacts. Given this deficiency in the literature, this thesis proposes that further research should be undertaken with the aim of developing a more precise approach for assessing the traffic congestion impacts of public transport.

To achieve the overall research aim, seven stages of work have been identified. The first stage involves the review of relevant literature on the traffic congestion effect of public transport. The second stage is to gain an in-depth understanding of mode shift from public transport when public transport is unavailable and to explore factors influencing mode shift. In the third stage, a transport network modelling is used to assess the network-wide congestion relief effect of urban public transport. The net congestion impacts of individual public transport modes (bus, tram and train) are explored in the fourth stage, fifth stage and sixth stage. In the final stage, the net traffic congestion effect of the entire public transport system is assessed by integrating both positive and negative effects of public transport.

The main methodology using to assess the congestion impacts associated with public transport is to contrast the level of congestion on the road network in two scenarios ‘with public transport’ and ‘without public transport’. The Victorian Integrated Transport Model (VITM), a strategic transport modelling platform, provides the general assessment of congestion level of the road network in the scenario ‘with public transport’ but it cannot model correctly the negative impacts that public transport itself can have on vehicle traffic. In addition, VITM does not give detailed information about the level of congestion in the scenario ‘without public transport’. In my research, this model is significantly improved to estimate the level of congestion in two scenarios ‘with public transport’ and ‘without public transport’. The difference between these two levels of congestion is considered to be the traffic congestion effect of public transport. Hence, using this extended model, it is now possible to estimate the effects of public transport on traffic congestion.

The findings show that in the morning peak hours, Melbourne's public transport system contributes to reduce vehicle time travelled and total delay on the road network by around 48%. The public transport system also reduces the number of severely congested links by more than 60%. The congestion impact of public transport varied spatially across regions. The highest effect in relieving traffic congestion is in inner areas, traditionally the most congested part of the city.

The major contribution of this research is the development of a more comprehensive methodology that can be used to measure the traffic congestion effects associated with public transport. With the new method, traffic authorities can identify the effectiveness of public transport in relieving traffic congestion on a particular corridor or an area. Based on the results, they can decide whether a public transport system needs to be improved. In addition, understanding the congestion relief impact of public transport can provide guidance both from an operational and a strategic point of view. From the operational perspective, routes and corridors facing congestion can be targeted for attention to seek a desired level of congestion relief. From a strategic perspective, appropriate public transport policies can be developed to encourage desired development in designated locations and again seek desired levels of congestion relief.

In summary, the traffic congestion effects associated with urban public transport have been examined through a qualitative, quantitative, microsimulation and macrosimulation modelling approach detailed in this thesis. Results from the analyses indicate that the net effect of the entire Melbourne's public transport system on traffic congestion is significant and positive.

Declaration

This thesis contains no material which has been accepted for the award of any other degree or diploma at any university or equivalent institution and that, to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

Publications during enrolment

The following publications have arisen from the research reported in this thesis

Refereed Journal Papers

1. **Nguyen-Phuoc, D.Q.**, Currie, G., De Gruyter, C. & Young, W., 2017, 'Local and system-wide traffic effects of urban road-rail level crossings: A new estimation technique', *Journal of Transport Geography*. Vol. 60, pp. 89-97.
   SSCI, Q1, IF=2.68
2. **Nguyen-Phuoc, D.Q.**, Currie, G., De Gruyter, C. & Young, W., 2017, 'Net Impacts of Streetcar Operations on Traffic Congestion in Melbourne, Australia', *Transportation Research Record: Journal of the Transportation Research Board*. Vol. 2648, pp. 1-9.
   SCI, Q2, IF=0.60
3. **Nguyen-Phuoc, D.Q.**, Currie, G., De Gruyter, C. & Young, W., 2018, 'Understanding public transport user behaviour adjustment if public transport ceases - A qualitative study', *Transport Research Part F*.
   SSCI, Q2, IF=1.83
4. **Nguyen-Phuoc, D.Q.**, Currie, G., De Gruyter, C. & Young, W., 2018, 'Transit user reactions to major service withdrawal – A behavioural study'. *Transport Policy*.
   SSCI, Q2, IF=2.27
5. **Nguyen-Phuoc, D.Q.**, Currie, G., De Gruyter, C. & Young, W., 2018, 'The impact of public transport strike on travel behaviour and traffic congestion', *International Journal of Sustainable Transportation*. DOI: 10.1080/15568318.2017.1419322.
   SSCI, Q2, IF=1.96

Journal Papers in Under Review

1. **Nguyen-Phuoc, D.Q.**, Currie, G., De Gruyter, C. & Young, W., 2017, 'Traffic congestion relief consequent on public transport: The state of the art', *Transport Review*. (Pass 1st round, submitted the revision)
   SSCI, Q1, IF=3.33
2. **Nguyen-Phuoc, D.Q.**, Currie, G., De Gruyter, C., Kim, I. & Young, W., 2017, 'Net impact of bus operations on traffic congestion in Melbourne', *Transport Research Part A*. (Pass 1st round with minor revision, submitted the revision)
   SCI, Q1, IF=2.67
3. **Nguyen-Phuoc, D.Q.**, Currie, G., De Gruyter, C. & Young, W., 2017, 'Congestion relief and public transport: An enhanced method using disaggregate mode shift evidence', *Case Studies on Transport Policy. (Under Review)*
4. **Nguyen-Phuoc, D.Q.**, Currie, G., De Gruyter, C. & Young, W., 2017, 'Quantifying the net traffic congestion effect of urban public transport – Including both negative and positive effects', *Public Transport. (Under Review)*

Peer-Reviewed Conference Papers

1. **Nguyen-Phuoc, D.Q.**, Currie, G., De Gruyter, C. & Young, W., 2018, ' Quantifying the net traffic congestion effect of urban public transport – Including both negative and positive effects', Transportation Research Board (TRB) 97th Annual Meeting, Washington, D.C., United States.
   ERA Ranking – A, ERA Conference ID – 44128
2. **Nguyen-Phuoc, D.Q.**, Currie, G., De Gruyter, C. & Young, W., 2017, ' Estimating the net traffic congestion impact associated with urban public transport – A Melbourne, Australia Case Study', 39th Australasian Transport Research Forum (ATRF), Auckland, New Zealand.
   ERA Ranking – A, ERA Conference ID – 42260
3. **Nguyen-Phuoc, D.Q.**, Currie, G., De Gruyter, C. & Young, W., 2017, 'Transit user reactions to major service withdrawal - A behavioural study', Transportation Research Board (TRB) 96th Annual Meeting, Washington, D.C., United States.
   ERA Ranking – A, ERA Conference ID – 44128
4. **Nguyen-Phuoc, D.Q.**, Currie, G., De Gruyter, C. & Young, W., 2017, 'Exploring the impacts of public transport strikes on travel behaviour and traffic congestion', Transportation Research Board (TRB) 96th Annual Meeting, Washington, D.C., United States.
   ERA Ranking – A, ERA Conference ID – 44128
5. **Nguyen-Phuoc, D.Q.**, Currie, G., De Gruyter, C. & Young, W., 2017, 'Net impacts of street car operations on traffic congestion in Melbourne', Transportation Research Board (TRB) 96th Annual Meeting, Washington, D.C., United States.
   ERA Ranking – A, ERA Conference ID – 44128
6. **Nguyen-Phuoc, D.Q.**, Currie, G., De Gruyter, C. & Young, W., 2016, 'Modelling the direct impact of tram operations on traffic', 23rd World Congress on Intelligent Transport System (ITS), Melbourne, Australia.
7. **Nguyen-Phuoc, D.Q.**, Currie, C. & Young, W., 2016, 'Estimating net traffic congestion relief associated with public transport - preliminary results', 14th World Conference on Transport Research (WCTR), Shanghai, China.
   ERA Ranking – A, ERA Conference ID – 44255
8. **Nguyen-Phuoc, D.Q.**, Currie, G., De Gruyter, C. & Young, W., 2016, 'Understanding public transport user behavior adjustment if public transport ceases - A qualitative study', 38th Australasian Transport Research Forum (ATRF), Melbourne, Australia.
   ERA Ranking – A, ERA Conference ID – 42260
9. **Nguyen-Phuoc, D.Q.**, Currie, G., De Gruyter, C. & Young, W., 2016, 'Modelling the Net Traffic Congestion Relief Impact of Street Car Networks – A Melbourne, Australia Case Study', 38th Australasian Transport Research Forum (ATRF), Melbourne, Australia.
   ERA Ranking – A, ERA Conference ID – 42260
10. **Nguyen-Phuoc, D.Q.**, Currie, C. & Young, W., 2015, 'New method for evaluating public transport congestion relief', Conference of Australian Institutes of Transport Research (CAITR), 33rd. Year 2015.
    ERA Ranking – C, ERA Conference ID – 42633
11. **Nguyen-Phuoc, D.Q.**, Currie, C. & Young, W., 2015, 'Public transport congestion relief measurement–a new framework and its impacts', 37th Australasian Transport Research Forum (ATRF), Sydney, New South Wales, Australia.
    ERA Ranking – A, ERA Conference ID – 42260

Thesis including published works General Declaration

I hereby declare that this thesis contains no material which has been accepted for the award of any other degree or diploma at any university or equivalent institution and that, to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

This thesis includes four original papers published in peer reviewed journals and four original papers submitted to peer reviewed journals. The core theme of the thesis is to develop enhanced methods for assessing the net short-term traffic congestion impact associated with the urban public transport system in Melbourne, Australia. The ideas, development and writing up of all the papers in the thesis were the principal responsibility of myself, the candidate, working within the Department of Civil Engineering under the supervision of Professor Graham Currie, Professor William Young and Dr Chris De Gruyter. The inclusion of co-authors reflects the fact that the work came from active collaboration between researchers and acknowledges input into team-based research.

In the case of Chapter 2 to Chapter 9 my contribution to the work involved the following:

Thesis chapter	Paper	Publication title	Publication status*	Nature and extent (%) of student's contribution
2	1	Traffic congestion relief consequent on public transport: The state of the art	*Returned for revision*	70%
4	2	Understanding public transport user behavior adjustment if public transport ceases - A qualitative study	*Published*	70%
4	3	Transit user reactions to major service withdrawal – A behavioural study	*Published*	70%
5	4	Congestion relief and public transport: An enhanced method using disaggregate mode shift evidence	*Under review*	70%
6	5	Net impact of bus operations on traffic congestion in Melbourne	*Returned for revision*	70%
7	6	Net traffic congestion impacts of street car operations in Melbourne, Australia	*Published*	70%
8	7	Local and system-wide traffic effects of urban road-rail level crossings: A new estimation technique	*Published*	70%
9	8	Quantifying the net traffic congestion effect of urban public transport – Including both negative and positive effects	*Under review*	70%

** e.g. 'published'/ 'in press'/ 'accepted'/ 'returned for revision'*

I have not renumbered sections of submitted or published papers in order to generate a consistent presentation within the thesis.

Student signature: **Date:**

The undersigned hereby certify that the above declaration correctly reflects the nature and extent of the student and co-authors' contributions to this work. In instances where I am not the responsible author I have consulted with the responsible author to agree on the respective contributions of the authors

Main Supervisor signature: **Date:**

Acknowledgements

This thesis is the result of a long journey that would not be completed without the support from a number of people. Firstly, I would like to express my sincere gratitude to my supervisors, Professor Graham Currie, Professor William Young and Dr Chris De Gruyter for both their excellent guidance and valuable advice. Their motivation, patience, enthusiasm and immense knowledge made me feel more confident and motivated on my way. From a student who did not know much about research and publication, they have assisted me in developing my skills as an independent researcher. I feel so lucky to be a student supervised by such talented individuals. I would like to thank Dr Inhi Kim for his assistance in dealing with VISSIM. He has shown me many skills which save me a lot of time.

Thank you all PhD students in the transport group who always remind me to never take things too serious and made my journey more enjoyable. I would also like to express my thanks to Jenny Manson, our Research and Postdoc manager for her support for almost all administrative matters.

My sincere thanks to Craig Somerville and Neville Wood from VicRoads for their assistance in accessing a transport network model. Dr Henry Le from AECOM is also acknowledged for his brilliant assistance in dealing with my issues that I faced in the transport model.

Most importantly, I would like to thank my wife Diep Su who always beside me when I feel stressed with my research. She was also a patient audience who listened to every presentation I practiced. Although she has also been a PhD student in Swinburne University, she had spent much time for taking care our small family, preparing my lunch and my dinner every day during my PhD journey. Special thanks to Cherry, my lovely daughter, whose face made me happy especially when my feeling was going down. I would also like to thank my parents for their distance encouragement that helped me deal with challenges and enjoy my life in Australia.

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