Social welfare analysis of HOV to HOT conversion

M Rouhani, Omid

McGill University

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Omid M. Rouhani[1]

[1] School of Civil and Environmental Engineering, Cornell University, Hollister Hall, Ithaca, NY 14853, USA; Email: omrouhani@ucdavis.edu Tel: +1 530 204 8576

Abstract

In this article, I will examine the social welfare effects of implementing High Occupancy Toll (HOT) lanes, and Managed Lanes in general. HOT lanes, in contrast to existing general purpose (GP) lanes, allow motorists to use these express lanes if they either pay a toll or have a certain minimum number of occupants in their vehicle. HOT lanes are often implemented by either converting existing High Occupancy Vehicle (HOV) lanes to HOT lanes or by constructing new managed lanes (MLs) in the median strip of an existing highway. They offer two major benefits over HOV lanes: (i) mitigating inefficiencies arising from the underutilization of HOV and GP lanes; and (ii) generating new revenue while preserving user satisfaction. Despite such potential benefits from HOT lane conversions and ML adoption, a comprehensive study rigorously estimating social welfare benefits and costs has not yet been undertaken. This paper reviews and provides a guideline for HOV to HOT lane conversions, form the social welfare perspective.

Keyword- Value of time, Road pricing, Congestion pricing, Optimal toll, Profits, System-wide costs.

Introduction

Prior research on HOT lane and ML implementation has been focused mainly on optimal pricing strategies (Jang et al., 2014). Studies related to this research area have examined two major strategies: (a) deterministic pricing where the toll varies with respect to time of day using a predetermined schedule (Shin & Hickman, 1999; Sullivan et al., 2000; Sock-Yong & Toh, 2004); and (b) dynamic pricing that uses downstream traffic information updates to adopt to real-time conditions (Halvorson & Buckeye, 2006; Jang et al., 2014, Rouhani, 2014; Laval et al., 2015).

However, a big picture question is: do HOT lanes improve the quality of life for various transportation system stakeholders (Lin et al., 2009; Bunch et al., 2011; Madani et al., 2011)? If so, what are the underlying conditions with which HOT lanes enhance social welfare? Third, what are the equity impacts of such policies for different user groups (Rouhani, 2009; Burris &

Figueroa, 2010; Rouhani and Niemeier, 2011), various income groups, and various businesses and residents (from different geographic regions) (Rouhani et al., 2013b)? As our brief literature review shows (see below), the answers to those questions are not yet known.

In one of the few studies, Safirova et al. (2004) provided a simple welfare analysis of HOT lanes for Washington, D.C. without a comprehensive social welfare analysis since it does not take the following factors into account: (i) the choice of toll rates (tolls are exogenously determined) (Rouhani and Niemeier, 2014a); (ii) heterogeneity in value of time (VOT) (Rouhani, 2015); and (iii) environmental externalities (Rouhani, 2010; Rouhani, 2013a; Rouhani and Niemeier, 2014b). Moreover, it is a case-specific analysis and cannot be generalized to many other cases.

Using a simple model of heterogeneous commuters of a highway with multiple lanes, Konishi and Mun (2010) estimate the social benefits and costs of various road pricing schemes including HOV to HOT lane conversions. Their model ignores user heterogeneity (Rouhani and Gao, 2014), infrastructure and operating costs (Rouhani et al., 2013c; Rouhani et al., 2014b), and the disutility associated with carpooling (dropping and picking up other travelers). Similar studies have examined a very general social benefit/cost analysis on alternative approaches to HOT and managed lanes (HOV and tolls on all lanes) (e.g., Kim, 2000; Burris & Sullivan, 2006). This literature gap exists despite the fact that social welfare analysis has been used extensively in road pricing analysis. Welfare studies have been conducted to evaluate public-private partnership tolling schemes (Rouhani et al., 2014a), cordon tolls (Santos, 2002), and toll roads (Kalmanje & Kockelman, 2009). However, the application of welfare economics to the study of managed lanes will enhance policy understanding in several ways (Rouhani et al., 2015a).

Social welfare framework

Our overarching goal is to develop a new social welfare framework and to conduct social welfare analyses on several case studies (Rouhani et al., 2011; Mirchi et al., 2012; Madani et al., 2014). Our proposed framework determines the overall social welfare change resulting from HOT lane conversions. However, it also provides detailed information about the effects on each stakeholder group (e.g., users, residents, businesses, communities, government, and the private sector) and on different types within each stakeholder group (users with different income levels, residents from various geographic regions, etc.) (Rouhani, 2016). Figure 1 shows a schematic framework detailing the key social welfare factors that could be affected by a HOT project's implementation.

The key insights that could be examined is: under which case-specific conditions, with which control variables: i.e., toll rates, investment levels (Poorzahedy and Rouhani, 2007), etc., and with what type of delivery: private vs public (Rouhani, 2012; Rouhani and Gao, 2015), do HOT lane conversions and ML projects generate net social welfare benefits over other options (Rouhani et al., 2015c; Rouhani et al., 2016a). Moreover, we need to examine the extent of those net benefits, considering who is affected by the change (or the distributional or equity effects of the choice, see e.g., Weinstein & Sciara, 2006; Luskin, 2015).

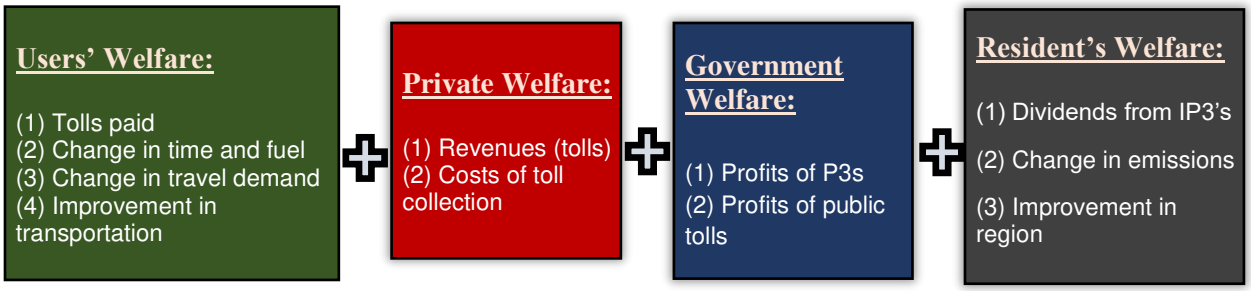

Fig. 1. Social welfare factors affecting each stakeholder type.

Proposed Methodology

To achieve the above research goals, we could perform the following tasks:

Task One – Develop Theoretical Modeling: In this task, we should develop a modeling framework that can be used for assessing various transportation infrastructure provision options, and create a theoretical model that can explain the conditions under which each option creates net benefits to society. This moves away from a case-specific approach and allows consideration of the effects of user income, the performance of HOTs and other travel alternatives, etc. The model will include major factors that may influence the welfare generated by HOT lane and ML

projects (see Figure 2). This task will show what natural conditions and which control variables (e.g., level of tolls) favor the use of HOT lanes from a social welfare perspective.

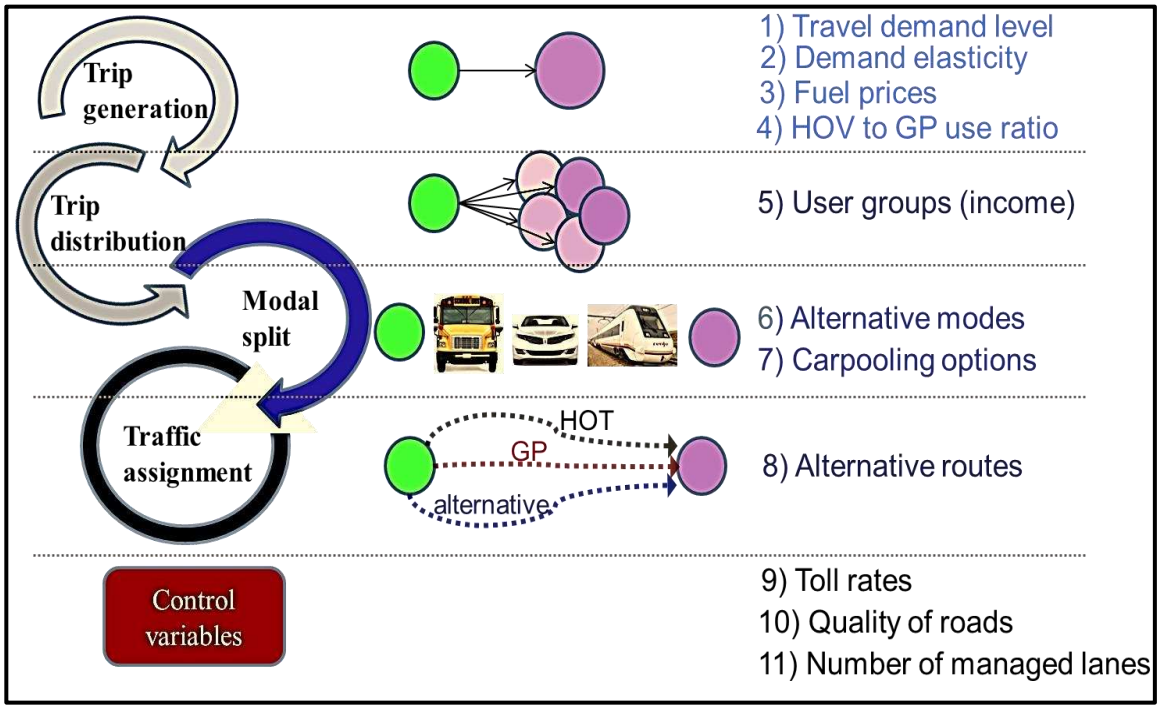

Fig. 2. Theoretical model with major parameters

Task Two – Conduct A Detailed Survey On Users: The analysis requires conducting a survey on users (in a real case study), examining two major issues: (i) who uses both GP and HOT lanes in terms of income, trip length and purpose, and willingness to pay for toll rates?; and (ii) what are the travel choices available to people (vehicle, mode, route, etc.)? We will use the survey outputs to expand our welfare analysis beyond what has been done before for the analysis of HOT lanes.

Task Three – Case-specific Social Welfare Analysis: Finally, a comprehensive social welfare analysis (Rouhani et al., 2016b) focusing on major real-life managed lanes is required, which collects additional data (beyond that gathered from the survey in the second task) on (i) traffic volumes of GP and HOT lanes and the corresponding toll rates before and after the HOT lane implementation; (ii) the traffic (demand) level on alternative modes (buses, high occupancy vehicles, other vehicles exempt from paying tolls (e.g., alternative-fueled vehicles, tolled low vehicle occupancy vehicles, and urban rail transportation) and on alternative routes (other highways or arterials that can be used to make the trip); (iii) the network conditions, population and employment figures; and (iv) the regional socioeconomic and environmental factors (Fitch

Ratings, 2013; Rouhani and Zarei, 2014). With these data, we could develop an in-depth social welfare analysis that captures the effects on transportation system performance (Rouhani et al., 2013a; Rouhani, 2013b; Rouhani and Kandel; 2013), environmental indices (Rouhani and Beheshtian, 2015; Rouhani et al., 2015b), equity across different groups of users and residents, certain types of risks associated with the delivery, and factors outside the transportation sector, such as employment, land use, safety (Geddes et al., 2015), and work hours. We will also run a sensitivity analysis on key parameters that significantly influence the results. Figure 3 shows how social welfare might change with respect to value of time for average toll lane users.

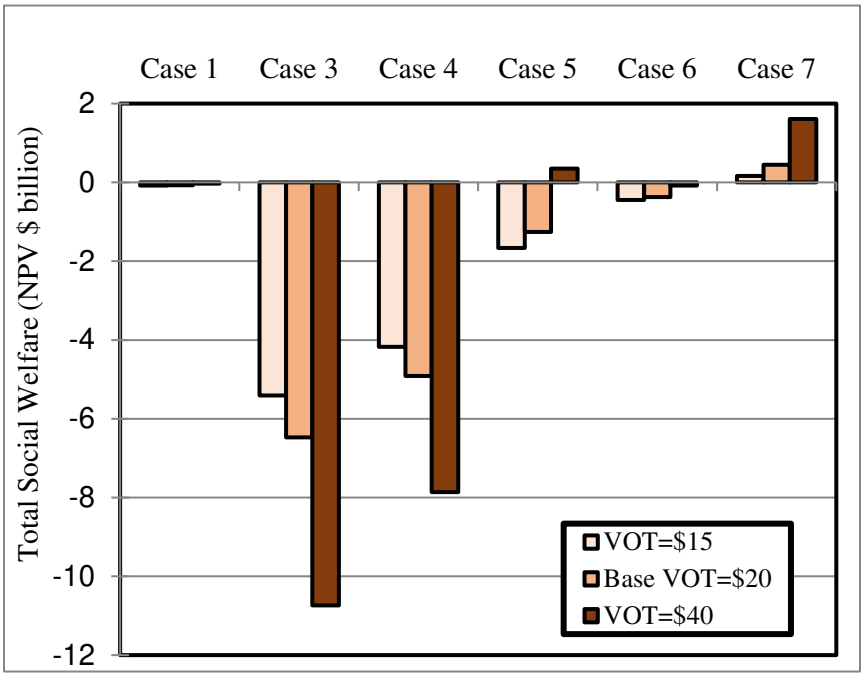

Fig. 3. Sensitivity of total social welfare change with respect to value of time (VOT)

Summary

Considering the increasing use of managed lanes worldwide (Fitch Ratings, 2012; Poole, 2013), a thorough analysis on their welfare implications is timely. The ultimate goal is to inform policy makers about the welfare implications of HOT lane conversions and ML projects. Such analysis will also have broader international applications considering the challenging public opinion (and political) environment that managed lane projects often face.

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References

Bunch, D. S., Greene, D. L., Lipman, T. E., Shaheen, S., Knittel, C., Fan, Y., Brownstone, D., McManus, W., Duleep, K.G., Marteen, E., Williams, B., Liu, C., Lentz, A., Rouhani, O.M., Mahmassani, A., Witt, M. (2011). Potential Design, Implementation, and Benefits of a Feebate Program for New Passenger Vehicles in California. California Environmental Protection Agency, Air Resources Board, Research Division.

Burris, M.,W. & Sullivan, E. (2006). Benefit-cost analysis of variable pricing projects: QuickRide HOT lanes. Journal of transportation engineering, 132(3), 183-190.

Burris, M. W., & Figueroa, C. F. (2010). Analysis of traveler characteristics by mode choice in HOT corridors. In Journal of the Transportation Research Forum (Vol. 45, No. 2).

Fitch Ratings (2012). Paying for Predictability U.S. Managed Lanes Projects. Special report, April 02, 2012.

Fitch Ratings (2013). U.S. Managed Lanes: Empirical Data Steers Credit Analysis. Special report, November 07, 2013.

Geddes, R. R., Li, X., & Rouhani, O. M. (2015). The Effects of Private Road Management on Traffic Safety: Evidence from Mexico. In Transportation Research Board 94th Annual Meeting (No. 15-3463).

Halvorson, R., Buckeye, K.R., (2006). High-occupancy toll lane innovations: I-394 MnPASS. Public Works Manage. Policy 10 (3), 242–255.

Jang, K., Chung, K., & Yeo, H. (2014). A dynamic pricing strategy for high occupancy toll lanes. Transportation Research Part A: Policy and Practice, 67, 69-80.

Kalmanje, S., & Kockelman, K. (2009). Toll roads in Texas: Traffic and welfare impacts. In Journal of the Transportation Research Forum,. 48(2), 5-22.

Kim, E. J. (2000). HOT Lanes: An Evolution of Costs, Benefits and Performance. University of California Transportation Center.

Konishi, H., & Mun, S. I. (2010). Carpooling and congestion pricing: HOV and HOT lanes. Regional Science and Urban Economics, 40(4), 173-186.

Laval, J. A., Cho, H. W., Muñoz, J. C., & Yin, Y. (2015). Real-time congestion pricing strategies for toll facilities. Transportation Research Part B: Methodological, 71, 19-31.

Lin, C. Y. C., Zhang, W., Rouhani, O. M., Prince, L. (2009). The Implications of an E10 Ethanol-Blend Policy for California. ARE Update 13(2), 1-11.

Luskin, D. (2015). Income Inequality, the Value of Travel Time Savings, and Benefit-Cost Analysis. Discussion paper at TRB Annual Meeting 2015, Congestion Pricing Economics Joint Subcommittee.

Madani, K., Rouhani, O. M., Pournazeri, S., Moradi, M., & Sheikhmohammady, M. (2011). Can we rely on renewable energy sources to overcome global warming. In *Proceedings of the 2011 World Environmental and Water Resources Congress, ASCE* (pp. 3319-3326).

Madani, K., Rouhani, O. M., Mirchi, A., & Gholizadeh, S., (2014). A negotiation support system for resolving an international trans-boundary natural resource conflict. *Environmental Modelling & Software*, *51*, 240-249.

Mirchi, A., Hadian, S., Madani, K., Rouhani, O. M., & Rouhani, A. M. (2012). World energy balance outlook and OPEC production capacity: implications for global oil security. *Energies*, *5*(8), 2626-2651.

Poole, R. (2013). Priced managed lanes are proliferating. Reason Foundation Newsletter.

Poorzahedy, H., & Rouhani, O. M., (2007). Hybrid meta-heuristic algorithms for solving transportation network design. *European Journal of Operational Research*, 182(2), 578–596.

Rouhani O. M., (2009). Road privatization and sustainability. *MIT Journal of Planning*, 6, 82-105.

Rouhani, O. M., (2010). Gas Consumption Information: A Substitute for Congestion Pricing?. In the Proceedings of the Transportation Research Forum, 51st Annual Forum, Arlington, Virginia, USA.

Rouhani, O. M., (2012). *Frameworks for Public-Private Partnerships*. Ph.D. dissertation, University Of California, Davis.

Rouhani, O.M., (2013a). Clean Development Mechanism: An appropriate Approach to reduce Greenhouse Gas Emissions from Transportation? *Transportation Research Board 2013 92*, No. 13-3195.

Rouhani, OM. (2013b), Modified RPS Calculator: Inputs, updating procedure, and outputs. Report prepared for California Energy Commission, MPRA Paper_53679.

Rouhani, O.M. (2014). Road Pricing: An Overview. MPRA_paper_59662.

Rouhani, O.M. (2015). Impact of Value of Time (VOT) on toll roads. MPRA_paper_65087.

Rouhani, O.M. (2016). Next Generations of Road Pricing: Social Welfare Enhancing. Sustainability, 8, 265; DOI: 10.3390/su8030265.

Rouhani, O.M., & Niemeier, D., (2011). Urban network privatization: A small network example. *Transportation Research Record*, 2221, 46–56.

Rouhani, OM, Kandel, A. (2013). The Randomizer Program: Procedure and operating methods. Report prepared for California Energy Commission, MPRA Paper_53540.

Rouhani, O. M., & Gao, H. O., (2014). An advanced traveler general information system for Fresno, California. *Transportation Research Part A: Policy and Practice*, *67*, 254-267.

Rouhani, O.M., & Niemeier, D., (2014*a*). Flat versus spatially variable tolling: A case study of Fresno, California. *Journal of Transport Geography*, *37*, 10–18.

Rouhani, O. M., & Niemeier, D., (2014*b*). Resolving the property right of transportation emissions through public–private partnerships. *Transportation Research Part D*, 31, 48–60.

Rouhani, O.M., & Zarei, H., (2014). Fuel Consumption Information: A Substitute for Congestion Pricing? *Road and Transport Research* 23 (3), 52.

Rouhani, O.M., Beheshtian, A. (2015). Energy Management. Chapter 1 in Multi Vol. Set on Energy Science and Technology, Executive Editor J.N. Govil, Studium Press LLC, USA, ISBN 1-62699-073-5, 1-25.

Rouhani, O.M.; Gao, O. (2015). Evaluating various Road Ownership Structures and Potential Competition on an Urban Road Network. Network and Spatial Economics. pp. 1-24. DOI: 10.1007/s11067-015-9309-3.

Rouhani, O. M., Madani, K., & Gholizadeh, S. (2010). Caspian Sea negotiation support system. In Proceeding of the 2010 world environmental and water resources congress, ASCE, Providence, Rhode Island (pp. 2694-2702).

Rouhani, O.M., Niemeier, D., Knittel, C. R., & Madani, K., (2013a). Integrated modeling framework for leasing urban roads: A case study of Fresno, California. *Transportation Research Part B*, 48(1), 17–30.

Rouhani, O. M., Kandel, A., & Christian, M. (2013b). The Renewable Portfolio Standard's Impacts on the California's Electricity Sector. International Journal of Power and Energy Systems, 33(3), 130-134.

Rouhani, O.M.; Gao, O.; Beheshtian, A. (2013c). Social and Private Costs of Driving. Lecture presentation at the 2013 Annual Conference of the International Transportation Economics Association, Northwestern University, Evanston, Illinois.

Rouhani, OM, Gao, HO, Geddes, R, Bel, G, & Zarei, H, (2014a). Social Welfare Analysis for Alternative Investment Public-Private Partnership Approaches. Lecture presentation in *the 2014 Transportation Research Board conference*, Washington D.C.

Rouhani, O.M., Knittel, C., & Niemeier, D., (2014b). Road Supply in London: Addition of an Ignored Social Cost. *Journal of Transportation Research Forum*, 53 (1), 49–64.

Rouhani, O.M., Gao, O., & Geddes, R. R., (2015a). Policy lessons for regulating public-private partnership tolling schemes in urban environments. *Transport Policy*, 41, 68-79.

Rouhani, O. M., Gao, H. O., Zarei, H., & Beheshtian, A. (2015b). Implications of Fuel and Emissions Externalities, Spillovers to the Outside, and Temporal Variations on Zonal Congestion Pricing Schemes. In *Transportation Research Board 94th Annual Meeting* (No. 15-0905).

Rouhani, O.M., Geddes, R., Gao, H.O., Beheshtian, A. (2015c). Revenue-Risk-Sharing Approaches for Public-Private Partnership Provision of Highway Facilities. MPRA_paper_67662.

Rouhani, O.M.; Niemeier, D.; Gao, O.; Bel, G. (2016a). Benefits and Costs of Various California Renewable Portfolio Standard Targets: Is 33% RPS Optimal? Renewable and Sustainable Energy Reviews, 62, pp. 1122-1132.

Rouhani, O.M.; Geddes, R.; Gao, O.; Bel, G. (2016b). Social Welfare Analysis for Alternative Investment Public-Private Partnership Approaches. Transportation Research Part A, 88, pp. 86-103, http://dx.doi.org/10.1016/j.tra.2015.11.003.

Safirova, E., Gillingham, K., Parry, I., Nelson, P., Harrington, W., & Mason, D. (2004). 8. Welfare and Distributional Effects of Road Pricing Schemes for Metropolitan Washington DC. Research in Transportation Economics, 9, 179-206.

Santos, G. (2002). Double cordon tolls in urban areas to increase social welfare. Transportation Research Record: Journal of the Transportation Research Board, (1812), 53-59.

Shin, S., Hickman, M., (1999). Effectiveness of the katy freeway HOV-lane pricing project preliminary assessment. Trans. Res. Rec.: J. Trans. Res. Board 1659 (1), 97–104.

Sock-Yong, P., Toh, R.S., (2004). Road congestion pricing in Singapore: 1975–2003. Trans. J. 43 (2), 16–25.

Sullivan, E.C., (2000). California. Dept. of Transportation HOVSB, California Polytechnic State University SLOAR, Development F, 2000. Continuation Study to Evaluate the Impacts of the SR 91 Value-Priced Express Lanes. California, Dept. of Transportation, Traffic Operations Program, HOV Systems Branch.
http://worldcat.org,http://ceenve3.civeng.calpoly.edu/sullivan/SR91/final_rpt/FinalRep2000.pdf

Weinstein, A., & Sciara, G. C. (2006). Unraveling Equity in HOT Lane Planning A View from Practice. Journal of Planning Education and Research, 26(2), 174-184.