Table 9. Acceptability and evaluation of urban congestion pricing strategies.

Evaluation		Car or motorcycle	Non-motorized modes	Public transportation	Total Percentage
Strategy	Strategy A	37%	16%	48%	38%
	Strategy B	57%	9%	34%	41%
	Strategy C	79%	3%	17%	21%
TOTAL		54%	10%	36%	100%
Evaluation of the strategies in relation of current situation	Disadvantage	86%	2%	12%	32%
	Not important	60%	6%	34%	18%
	Advantage	33%	17%	50%	50%
TOTAL		54%	10%	36%	100%
Acceptability of payment	I use the same mode of transportation	-	17%	83%	44%
	I use other transportation modes	100%	-	-	24%
Value of congestion charge	< R$10	65%	5%	30%	24%
	R$11 to R$20	73%	15%	30%	24%
	R$21 to R$30	70%	15%	15%	1%
	R$31 to R$40	100%	-	-	1%
TOTAL		37%	41%	22%	100%

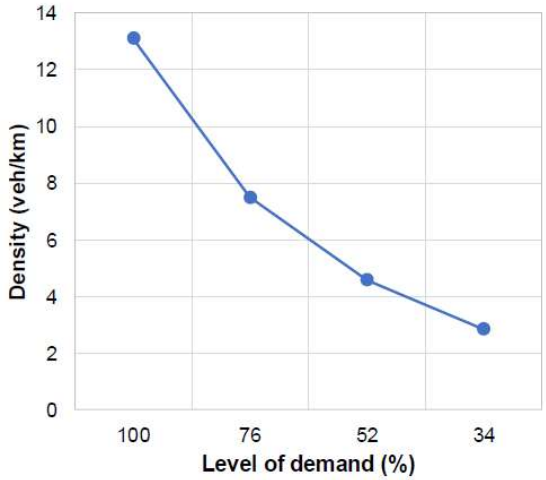

Fig. 5 Evaluation of the reduction of the demand for automobiles in the average values of the density.

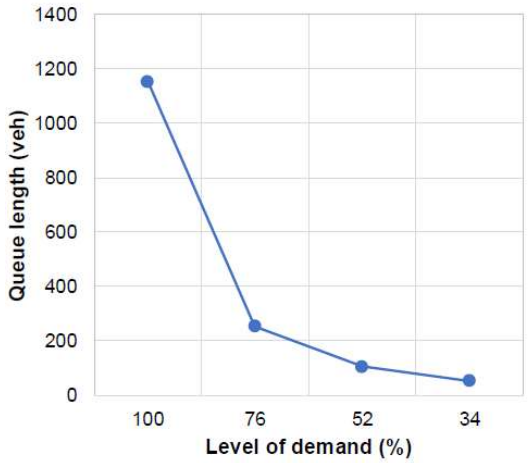

Fig. 6 Evaluation of the reduction of the demand for automobiles in the average values of the queue length.

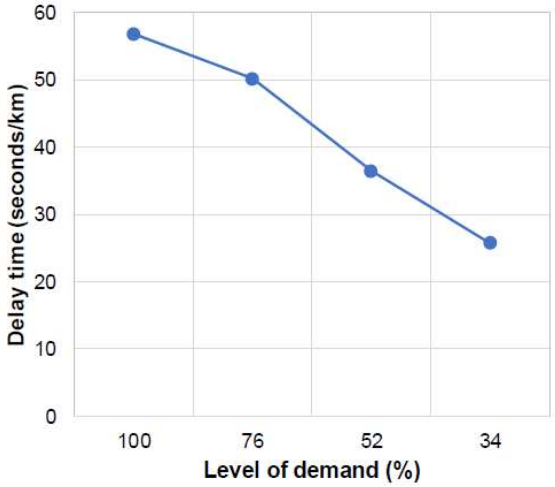

Fig. 7 Evaluation of the reduction of the demand for automobiles in the mean values of the delay time.

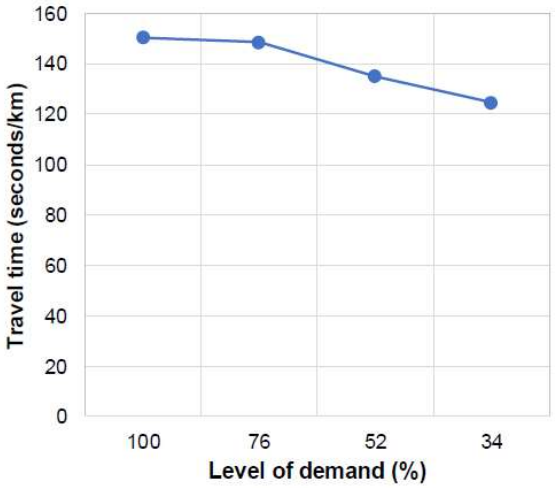

Fig. 8 Evaluation of the reduction of the demand for automobiles in the average values of travel time.

conclusions, it is worth noting the importance of directing more investments in mechanisms to minimize congestion, reduce traveling times, and improve environmental quality and economic efficiency of cities. Experts have expressed their opposition regarding investments in transport infrastructure (such as tunnels, viaducts, trenches) to increase road capacity, and have agreed that urban mobility management, focused on the improvement of vehicle speed, has social and environmental impacts. In general, considering the experts' viewpoint, the urban toll is a better solution to reduce congestion than to reduce the emission of pollution caused by cars.

The results also indicated that the adoption of congestion pricing could be a favorable measure for public transportation users since it reduces travel time and brings improvements to service quality. Thus, congestion pricing can be an economic system of positive redistribution of road space, in which users of cars/motorcycles pay for the use of urban roads, with the possibility of reversing revenues in benefits for urban mobility, being acceptable by experts. Still, the experts consider that the monetary resources obtained from the congestion pricing scheme should be invested in the improvements of services and infrastructure of public transportation by bus (considering the method of successive intervals) and in the implementation of railway transportation system (considering factorial analysis). The investment in non-motorized transport is the best option for users of this mode of transportation.

For the implementation of congestion pricing to promote demand management, the transparency and participation of the population in the process, as well as the legal commitment of the governments in the issues and decisions concerning the investment of the revenues are crucial matters.

Thus, we conclude that demand management tools must be associated and that urban toll implementation cannot be an isolated solution. Therefore, we must invest in improvements of public transportation and non-motorized modes and in a more restrictive parking policy in the central areas of cities to enhance the success of the congestion-pricing scheme.

Still, in this paper, we presented the acceptability of residents of the Belo Horizonte Metropolitan Area in relation to congestion pricing. Considering the literature reference and Law 12,587/2012, we developed a questionnaire to identify the travel frequency of respondents to the central area (possibly toll zone), the acceptability of congestion pricing, the availability for payment, and the prioritization of solutions for the improvement of urban mobility.

The results presented in this paper indicate that the congestion charging in the central area of Belo Horizonte is a challenge for urban planners and administrators. In this case, there is a significant percentage of the respondents who declare that they do not accept payment. In contrast, respondents consider reducing congestion as a major challenge for urban mobility enhancement. These results also corroborate with the literature: acceptability can be considered low, and there is behavioral change when the residents perceive the benefits of the implementation of congestion pricing revenues in the improvements of public and non- motorized transportation. However, before the implementation of congestion pricing, there should be investments in public transportation and non-motorized systems that meet the aspirations of the population and allow the modal shift of users of private transport.

Finally, we simulate the traffic impacts with the reduction of car demand, considering the Central Area of Belo Horizonte. The results demonstrate the benefits of this measure to reduce the congestion (considering the queue length and delay time).

Considering the results, we conclude that transport demand management is essential for cities due to its influence on the main transportation mode of residents, especially if non-motorized modes and public transportation systems are effective. Considering these transportation alternatives, the congestion pricing could reduce urban traffic (related to car and motorcycle) and, consequently, the congestion.

However, the congestion pricing is an unpopular solution given that no one would like to spontaneously pay for the use of a 'public' road space, which has always been available for citizens free. Also, we have identified that, in Brazil, the participants agreed that, in order to increase the acceptability, transparency, and participation of the population throughout the urban toll implementation process, it is important to have the public authorities committed with the effectiveness of alternative transportation schemes to replace cars for daily commutes.

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REFERENCES

Anas, A. & Lindsey, R. (2011) Reducing urban road transportation externalities: road pricing in theory and in practice. *Review of Environ. Economics Policy*, **5**(1), 66-88, doi: 10.1093/reep/req019

Bartley, B. (1995) Mobility impacts, reactions and opinions: traffic demand management options in Europe: The MIRO Project. *Traffic Engin. Control*, **36**(11), 596-602.

Basso, L. J., Guevara, C. A., Gschwender, A., Fuster, M. (2011). Congestion pricing, transit subsidies and dedicated bus lanes: Efficient and practical solutions to congestion. *Transport Policy*, **18**, 676-684, doi: 10.1016/j.tranpol.2011.01.002

Bessa Jr., J. E. & Setti, J. R. (2018) Evaluating Measures of Effectiveness for Quality of Service Estimation on Two-Lane Rural Highways. *J. Transportn. Engin. Part A: Systems*, **144**, 1-10.

Bessa Jr., J. E., Setti, J. R. & Washburn, S. S. (2017) Evaluation of Models to Estimate Percent Time Spent Following on Two-Lane Highways. *J. Transportn. Engin., Part A: Systems*, **143**, 1-9.

Brasil (2012) Law No 12.587, de 3 de janeiro de 2012. Brasília.

Brasil (2015) Reference Book for Elaboration of Urban Mobility Plan. National Secretariat of Transportation and Urban Mobility, Brasília. (in Portuguese)

Brasil (2018) Frota de veículos – 2018. Available at http://www.denatran.gov.br/estatistica/635-frota-2018

Child, D. (2006) *The essentials of factor analysis*. Continuum International Publishing Group, New York.

Chorus, C. G., Annema, J. A., Mouter, N. & Wee, B. (2011) Modeling politicians' preferences for road pricing policies: a regred-based and utilitarian perspective. *Transport Policy*, **18**, 856-861, doi: 10.1016/j.tranpol.2011.05.006

Ciommo, F. D., Monzón, A. & Fernandez-Heredia, A. (2013) Improving the analysis of road pricing acceptability surveys by using hybrid models. *Transportn. Res. Part A*, **49**, 302-316, doi: 10.1016/j.tra.2013.01.007

Cools, M., Brijs, K., Tormans, H., Moons, E., Janssens, D. & Wets, G. (2011) The socio-cognitive links between road pricing acceptability and changes in travel-behavior. *Transportation*

Research Part A, 45, 779-788, doi:10.1016/j.tra.2011.06.006

Eliasson, J. (2009) A cost-benefit analysis of the Stockolm congestion charging system. *Transportn. Res. Part A*, **43**, 468-480, doi:10.1016/j.tra.2008.11.014

Eliasson, J. & Jonsson, L. (2011) The unexpected "yes": Explanatory factors behind the positive attitudes to congestion charges in Stockholm. *Transport Policy*, **18**(4), 636-647, doi:10.1016/j.tra.2008.11.014

Eliasson, J. & Mattsson, L. G. (2006) Equity effects of congestion pricing: quantitative methodology and a case study to Stockholm. *Transportn. Res. Part A*, **40**, 602-620, doi: 10.1016/j.tra.2005.11.002

Eriksson, L., Garvill, J. & Nordlund, A. M. (2006) Acceptability of travel demand management measures: the importance of problem awareness, personal norm, freedom, and fairness. *J. Environm. Psyc.* **26**, 15–26, doi: 10.1016/j.jenvp.2006.05.003

Figueiredo, M., Seco, A. & Silva, A. B. (2014) Calibration of microsimulation models – The effect of calibration parameters errors in the models' performance. *Proc.* 17th Meeting of the EURO Working Group on Transportation, 3, 962–971.

Fürst, E. W. M. & Dieplinger, M. (2014) The acceptability of road pricing in Vienna: the preference patterns of car drivers. *Transport.*, **41**(4), 765-784, doi:10.1007/s11116-013-9485-2

Garling, T. & Schuitema, G. (2007) Travel demand management targeting reduced private car use: effectiveness, public acceptability and political feasibility. *J. Social Issues*, **63**(1), 139-153, doi:10.1111/j.1540-4560.2007.00500.x

Giuffrè, O., Grana, A., Mauro, R., Silva, A. B. & Chiappone, S. (2015) Developing passenger car equivalents for freeways by microsimulation. *Proc.* 18th Euro Working Group on Transportation, 10, 93–102. DOI 10.1016/j.trpro.2015.09.059

Giuliano, G. (1992) An assessment of the political acceptability of congestion pricing. *Transport.*, **19**(4), 335-358, doi: 10.1007/BF01098638

Goh, M. (2002) Congestion management and electronic road pricing in Singapore. *J. Transport Geog.* **10**(1), 29-38, doi: 10.1016/S0966-6923(01)00036-9

Goldberg, D. E. (1989) *Genetic algorithms in search, optimization and machine learning*. Addison-Wesley, Reading, Massachussets.

Grange, L. & Troncoso, R. (2011) Impacts of vehicle restrictions on urban transport flows: the case of Santiago, Chile. *Transport Policy,* **18**, 862-869, doi:10.1016/j.tranpol.2011.06.001

Grisolía, J. M., López, F. & Ortúzar, J. (2015) Increasing the acceptability of a congestion charging scheme. *Transport Policy*, 39, 37-47, doi: 10.1016/j.tranpol.2015.01.003

Gu, Z., Liu, Z., Cheng, Q. & Saberi, M. (2018) Congestion pricing practices and public acceptance: A review of evidence. *Case Studies Transp. Policy*, **6**, 94-101. DOI 10.1016/j.cstp.2018.01.004

Hensher, D. A. (2013) Exploring the relationship between perceived acceptability and referendum voting support for alternative road pricing schemes. *Transportn.* **40**, 935-959, doi: 10.1007/s11116-013-9459-4

Hensher, D. A. & Li, Z. (2013) Referendum voting in road pricing reform: A review of the evidence. *Transport Policy*, **25**, 186-197, doi: 10.1016/j.tranpol.2012.11.012

Hutcheson, G. D. & Sofroniou, N. (1999) *The multivariate social scientist: Introductory statistics using generalized linear models*. Sage Publication Ltd, London.

Jaensirisak, S., Wardman, M. & May, A. D. (2005) Explaining variations in public acceptability of road pricing schemes. *J. Trans. Econ. Policy*, **39**(2), 127-154.

Jakobsson, C., Fujii, S. & Garling, T. (1999) Determinants of cars users' acceptance of road pricing. In Urban Transport System, Lund (Sweden).

Janssens, D., Cools, M., Moons, E., Wets, G., Arentze, T. & Timmermans, H. (2009) Road pricing as an impetus for environment-friendly travel behaviour: results from a stated adaptation experiment. *Transpn. Res. Rec.: J. Transpn. Res. Board*, **2115**, 50-59, doi: 10.3141/2115-07

Kaiser, H. F. (1974) An index of factorial simplicity. *Psychometrika*, **39**(1), 31-36, doi: 10.1007/BF02291575

May, A. D., Koh, A., Blackledge, D. & Fioretto, O. (2010) Overcoming the barriers to implementing urban road user charging schemes. *European Transport Research Review*, 2(1), 53-68, doi: 10.1007/s12544-010-0026-1

Moreno, A. T., Llorca, C., Washburn, S. S., Bessa Jr., J. E. & Garcia, A. (2018) Operational Considerations of Passing Zones for Two-lane Highways: Spanish Case Study. *Promet-Traffic Transport.* **30**, 601-612.

Ozer, G. (2012) Do you accept mi? Acceptability of Milan's congestion charging in the light of London and Stockholm. Master of Science in Urban Planning and Policy Design. Politecnico di Milano.

Providelo, J. K. & Sanches, S. P. (2011) Roadway and traffic characteristics for bicycling. *Transportn.* **38**, 765-777, doi: 10.1007/s11116-011-9353-x

Raux, C., Souche, S. & Pons, D. (2012) The efficiency of congestion charging: some lessons from cost-benefit analyses. *Res. Transp. Economics*, **36**, 85-92, doi: 10.1016/j.retrec.2012.03.006

Rentziou, A., Milioti, C., Gkritza, K. & Karlaftis, M. G. (2011) Urban road pricing: Modeling public acceptance. *J. Urban Plan. Develop.* **137**(1), 56-64, doi: 10.1061/(ASCE)UP.19435444.0000041#sthash.ogUxx1oS.dpuf

Ryley, T. & Gjersoe, N. (2006) Newspaper response to the Edinburgh congestion charging proposals. *Transport Policy*, **13**(1), 66-73, doi: 10.1016/j.tranpol.2005.08.004

Schade, J. & Baum, M. (2007) Reactance or acceptance? Reaction towards the introduction of road pricing. *Trans. Res. Part A*, **41**, 41-48, doi: 10.1016/j.tra.2006.05.008

Schade, J. & Schlag, B. (2003) Acceptability of urban transport pricing strategies. *Trans. Res Part F: Traffic Psych. Behr.* **6**(1), 45-61, doi: 10.1016/S1369-8478(02)00046-3

Schaller, B. (2010) New York City's congestion pricing experience and implications for road pricing acceptance in the United States. *Transport Policy*, **17**(4), 266-273, doi: 10.1016/j.tranpol.2010.01.013

Schlag, B. & Teubel, U. (1997) Public acceptability of transport pricing. *IATSS research*, **21**, 134-142. DOI 10.1108/9781786359506-001

Schuitema, G., Steg, L. & Forward, S. (2010) Explaining differences in acceptability before and acceptance after the implementation of a congestion charge in Stockholm. *Transportn. Res. Part A*, **44**, 99-109, doi: 10.1016/j.tra.2009.11.005

Sikow-Magny, C. (2003) Efficient pricing in transport: overview of European Commission's Transport Research Programme. In: Schade, J., Schlag, B. (Eds.), Acceptability of Transport Pricing Strategies. Elsevier: Oxford, 13-26, doi: 10.1108/9781786359506-002

Sugiarto, S., Miwa, T., Sato, H. & Morikawa, T. (2015) Understanding the effects of various factor on the public response to congestion charge: a latent class modeling approach. *J. Transp. Techn.* **5**, 76-87, doi: 10.4236/jtts.2015.52008

Tabachnick, B. G. & Fidell, L. (2007) *Using Multivariate Statistics*. Allyn and Bacon, Boston.

Taeihagh, A., Bañares-Alcántara, R. & Givoni, M. (2014) A virtual environment for the formulation of policy packages. *Transportn. Res. Part A*, **60**, 53-68, doi:10.1016/j.tra.2013.10.017

TSS (2015) *AIMSUN User's Manual – Version 8.1*. Transport Simulation System – TSS.