JOURNAL OF GOVENANCE AND INTEGRITY (JGI)
ISSN: 2600-7479 e-ISSN: 2600-786X
VOL. 5, ISSUE 3, 370 – 381
DOI: https://doi.org/10.15282/jgi.5.3.2022.8497

ORIGINAL ARTICLE

LINKING INTEGRITY WITH ROAD PRICING CAUSE-AND-EFFECT MODEL: A SYSTEM DYNAMICS SIMULATION APPROACH

Masriah Mansur[1]*, Zetty Ain Kamaruzzaman[1,2], Ahmad Afif Ahmarofi[3], Jack Kie Cheng[1], Hamirahanim Abdul Rahman[1], Khairil Azman Masri[4], Nadirah Abdul Rahim[5] and S.Sarifah Radiah Shariff[6]

[1]Faculty of Industrial Management, Universiti Malaysia Pahang, Gambang, Malaysia
[2]Centre for Artificial Intelligence & Data Science (Data Science Centre), Universiti Malaysia Pahang, Gambang, Malaysia
[3]Faculty of Computer Science and Mathematical Sciences, Universiti Teknologi MARA Kedah, Merbok, Malaysia
[4]Faculty of Civil Engineering Technology, Universiti Malaysia Pahang, Gambang, Malaysia
[5]International Islamic University Malaysia, Kuala Lumpur, Malaysia
[6]Faculty of Computer Science and Mathematical Sciences, Universiti Teknologi MARA, Shah Alam, Malaysia

ABSTRACT – With Malaysia's rapid urbanisation and continuous improvement of living standards, vehicle ownership and trip volume continue to grow. Increases in motor traffic in large cities and their environs result in a number of social, environmental, and economic issues, which are frequently attributable to the widespread use of automobiles as the primary mode of urban transportation. This exacerbates traffic congestion on the country's highways, particularly in urban areas such as Kuala Lumpur. This traffic congestion poses an ongoing threat to the sustainability of transport development. Thus, the aim of this study is to establish a cause-and-effect relationship based on a system dynamics approach regarding the implementation of road pricing as a tool for reducing congestion and a stepping stone for enhancing sustainability. Road pricing is a direct charge assessed to drivers who use the road network with the goal of reducing the number of private vehicles on the road during peak hours. The developed Causal Loop Diagram (CLD) composed of five subsystems: road congestion, road attractiveness, new road construction, public transportation, and road pricing. The road congestion, new road construction, and road pricing all encounter mutual reinforcement as a result of a variety of negative polarities. As a result, authorities should place a greater emphasis on these loopholes, as they will inevitably result in unexpected changes. Additionally, by incorporating holistic perspectives from previous works and experts in the field, CLD can aid in identifying the primary factors underlying the problem being studied. Furthermore, the developed CLD could enlighten the Malaysian government and the stakeholders of road construction regarding the causal relationship towards road pricing strategy in reducing traffic congestion effectively.

ARTICLE HISTORY
Received: 5-7-2022
Revised: 10-10-2022
Accepted:3-11-2022
Published: 31-12-2022

KEYWORDS
Road Pricing
Traffic Congestion
Causal Loop Diagram
System Dynamics
Sustainable Transport
Integrity

INTRODUCTION

In light of the continuous urbanization of the world, it is essential to have a sustainable city. According to the United Nations (2018), 55% of the world's population lives in urban areas, a proportion that is expected to increase to 68% by 2050. Highway congestion is a global issue exacerbated by high population density, the proliferation of automobiles and their infrastructure, and the proliferation of rideshare and delivery services. It can be argued that there is a direct link between population growth, traffic congestion, and pertinent issues. Transportation growth comes with several challenges, including heavy congestion on roads and rail during rush hours, unreliable public transportation services, insufficient connectivity between modes, limited access to transparent public services, and a high reliance on private transport (Hong & Wong, 2017). Over the last decade, Malaysia's urban population has grown and continues to grow as people migrate to urban areas for economic and employment opportunities, particularly in Kuala Lumpur. Malaysian transportation statistics indicate that Kuala Lumpur's total vehicle fleet increased by 1.20% in 2020, the highest increase among Malaysian states.

Congestion consumes fuel and contributes to air pollution via carbon dioxide emissions. Additionally, stopped vehicles emit 17.3% more carbon dioxide than moving vehicles (Rajé, Tight, & Pope, 2018). As a result, those who live nearby suffer the most from these consequences. According to Ganesh (2019), Sunny Joseph, a clinical psychologist, believes that increased time spent on the road can result in stress. As a result, anxiety, frustration, a sense of loss of control (Jayaraman, Leow, Asirvatham, & Chan, 2021), security (Iqbal & Anggraini, 2019), and even health problems such as high blood pressure, changes in body temperature, and a weakened immune system (Ahmarofi et al., 2021) will affect people. Congestion is a significant issue that must be addressed appropriately, as the consequences are detrimental to the environment and human health.

*CORRESPONDING AUTHOR | Mansur, M. | ✉ maszreahrh@gmail.com

The United Nations adopted the Sustainable Development Goals (SDGs) in 2015, also known as a universal call to ensure that all people enjoy peace and prosperity by 2030 (Moyer & Hedden, 2020). Each of the 17 SDGs recognizes action in a single area that is harmoniously integrated with social, economic, and environmental sustainability. It is impossible to achieve sustainable development without radically altering how we construct and manage urban spaces. Consequently, SDG 11 has been introduced which seeks to promote sustainable transportation while minimizing environmental impact.

It is found that one of the effective solutions to achieve sustainable transportation in an urban area is road pricing (Ahmarofi et al., 2021). Road pricing is intended to charge the difference between a journey's marginal social and marginal private costs, to ensure that only those drivers travel whose benefits outweigh the costs they impose on themselves and others (Zefreh, Esztergar-Kiss, & Torok, 2021). However, the question that arose from the public is the readiness of road users in Kuala Lumpur if it is implemented in the next ten years after the public transportation network system is fully completed (Bernama, 2022). In this regard, this study establishes a causal loop diagram (CLD) for road pricing management to see the aspect of governance related to road congestion in the city and its impact on the residents by using the system dynamics (SD) method. CLD based on the SD method provides a lens through which complex systems' structure and dynamics can be viewed holistically and understood (Richards, Lupton, Allwod, 2021; Ahmarofi, Zainal Abidin, & Mahadzir, 2022). As a result, it has been widely applied to issues concerning transportation as presented by Ahmarofi et al. (2021), and Salmon et al. (2022), to name a few.

LITERATURE REVIEW

Road pricing in reducing road congestion and improving air quality

Economic theorists such as Pigou (1920) and Knight (1924) have long recognized road pricing as the most effective method of reducing traffic congestion. Since then, congestion has evolved from a scholarly curiosity to one of the most pressing issues confronting metropolitan regions and their transportation infrastructure (Verhoef, Nijkamp, & Rietveld, 1995; Yang & Huang, 2005). Road pricing has grown in popularity as a means of reducing congestion, protecting the environment, and generating revenue for transportation investment (Abulibdeh, 2020). Hence, several countries have implemented road pricing with favourable results.

The Area Licensing Scheme (ALS) was the first program in Singapore to address traffic congestion (Khan, 2001). As a result, traffic entering the zone decreased by 25% to 45% during morning rush hours, while travel speeds doubled (Goh, 2002; Khan, 2001). In addition, the scheme manages to prevent the emission of an estimated 175,000 lb of carbon dioxide each day (Federal Highway Administration, 2022). Singapore implemented electronic tolls for the first time in 2000 (Olszewski & Xie, 2005). In 2003, London introduced the first congestion charge. The primary objective of the London congestion charge was to alleviate traffic congestion (Croci, 2016). Between 2002 and 2003, traffic is estimated to have decreased by approximately 30%, while average travel speeds increased from 8.9 to 10.4 miles per hour, based on a straightforward before-and-after comparison (Croci, 2016). With the implemented scheme, London successfully reduced emissions of particulate matter and nitrogen oxides by 12% and fossil fuel consumption and carbon dioxide emissions by 20% (Federal Highway Administration, 2022).

After following a trial period and referendum, the Stockholm congestion charge was implemented in 2007. Following Stockholm's congestion charge implementation, traffic volume decreased by approximately 20%, and inner-city kilometre travel decreased by approximately 15% (Croci, 2016; Eliasson, 2009; Maria, Eliasson, Hugosson, & Brundell-freij, 2012). Simultaneously, travel times were reduced by approximately a third to half during these times, and the road toll resulted in a 4.5% increase in public transit ridership (Baranzini, Carattini, & Tesauro, 2021). Stockholm's congestion pricing system has led to a 10% to 14% drop in carbon dioxide emissions in its central area (Federal Highway Administration, 2022). In 2008, Milan introduced a road pricing scheme called EcoPass to combat the city's pollution problem (Rotaris, Danielis, Marcucci, & Massiani, 2010). The scheme was expanded further with the addition of the Area C congestion charge. Economists have advocated for congestion charges as a way to internalize the externalities of driving. Cities that have successfully implemented congestion charging have demonstrated the effectiveness of road pricing in addressing transportation issues such as congestion and pollution.

System dynamics modelling in transportation

Transportation systems in cities are extremely complex and operate under a variety of conditions. Simulating and analyzing them using conventional methods is impractical. As a result, complex analysis is viewed through the lens of system dynamics. Currently, system dynamics is frequently used to conduct systematic studies of road transportation issues, such as transportation systems, highways, road traffic emission policies, and congestion policies (Xue, Cheng, Wang, An, & Guan, 2020; Ahmarofi et al., 2021). Table 1 summarizes some of the literature on system dynamics modelling of road transportation issues. The widespread application of system dynamics to transportation issues demonstrates system dynamics' capability to address the issue.

Table 1. System dynamics works of literature in the road transportation field.

Author (Year)	Analysis
Rez (2019)	Demonstrate how system dynamics can develop and simulate models.
Suryani, Hendrawan, Adipraja, Wibisono, and Dewi (2019)	Address the urban mobility and traffic congestion problem under environmental dynamics.
Akbari and Mahpour (2020)	Develop a system dynamics model of Tehran transport to control air pollution.
Khosravi, Haghshenas, and Salehi (2020)	Use system dynamics to evaluate transport demand management policies.
Khosravi et al. (2020)	Determine the most effective policies to respond to changing travel demand by combining system dynamics and data envelopment.
Suryani, Hendrawan, Adipraja, et al. (2020)	To evaluate and improve the effectiveness of transportation systems and reduce traffic congestion.
Xue et al. (2020)	Use system dynamics to analyze the benefits of transit metropolis construction.
Suryani, Hendrawan, Mukti, and Zahra (2020)	To decrease congestion costs using transit-oriented development (TOD).

METHODOLOGY

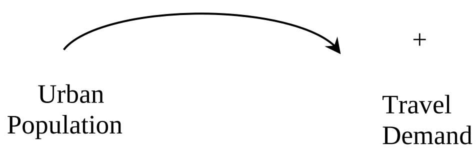
System dynamics is a technique for managers to analyze complex problems using computer-based simulations (Ahmarofi, Abidin, & Ishak, 2021). It was founded in the late 1950s at the Massachusetts Institute of Technology (MIT) by the prominent founder Forrester (Yearworth, 2014). Since the 1950s, the methodology has been widely used in a variety of fields of research, including constructing congestion charge models among others. The method is used to construct models of the real world and to understand how the structure of the model affects the dynamic behaviour of the model over time (Sterman, 2000). In general, it is a combination of both qualitative and quantitative aspects that is used to convey complicated concepts. The approach is based on the feedback control theory, equipped with computer simulation technology, and used in quantitative research in complicated socioeconomics fields (Vafa-Arani, Jahani, Dashti, Heydari, & Moazen, 2014).

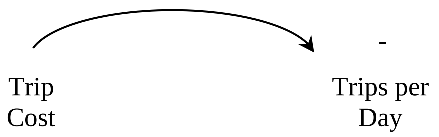
There are four stages in SD simulation namely the articulation of a problem, the development of the CLD model, the construction of a stock-flow diagram (SFD), and a model evaluation. However, this research only develops a CLD model to inspect the cause and effect of road pricing implementation to reduce road congestion.

In terms of data collection, the data was obtained through journals and research papers that have the same area regarding road pricing and road congestion problem. All materials were retrieved from different scientific databases; Scopus, Emerald Insight, and Researchgate.

In addition, Vensim software was utilized in this research for developing the CLD model since the software obtain the highest score in terms of the learning curve, i.e., the degree of easiness in developing the simulation model (Ahmarofi et al., 2021). System dynamics is fundamentally reliant on the causal loop diagram (CLD) as a simple mind map for describing the dynamic relationship between multiple factors. It is capable of displaying the effect of each variable on the other variables concurrently. In developing CLD, each causal link is polarised, either positive or negative, to indicate how changes in the independent variable affect the dependent variable (Sterman, 2000). Table 2 shows the link polarity in the development of a causal loop diagram.

Table 2. Link polarity in the development of causal loop diagram.

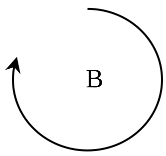
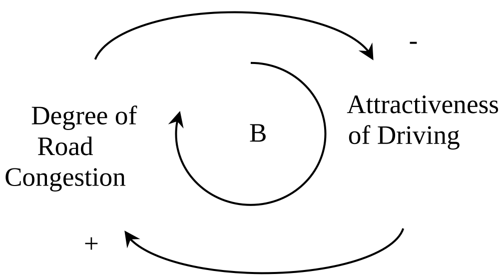
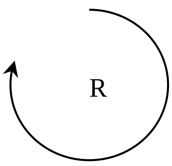
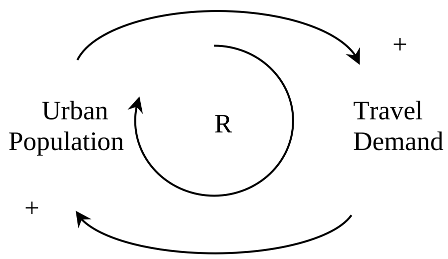
Example of a causal relationship	The explanation of the relationship
	The (+) in an arrow indicates that if the parameter of the Urban Population variable increases, the parameter of the Travel Demand variable increases. In contrast, if the parameter of the Urban Population variable decreases, so does the Travel Demand.

	The (-) in an arrow indicates that if the parameter of the Trip Cost variable increases, the parameter of the Trips per Day variable decreases. In contrast, if the parameter of the Trip Cost variable decreases, the parameter of the Trips per Day increases.

In addition, a feedback loop is one of the important processes involved in the development of CLD. Table 3 below explains the reinforcing loop and balancing loop polarities applied in this study. If the number of negative link polarities is even, then the loop polarities are positive. In contrast, if the number of negative link polarities is odd, then the loop polarity is negative.

A reinforcing feedback loop is a positive (+) feedback system and is normally indicated by capital "R". It modifies variables in two conditions whether to increase or decrease value (Sterman, 2000). In contrast, a negative feedback loop is a balancing loop with a negative (-) sign and is normally indicated by capital "B". It looks for stability that causes a variable away from the target. The balancing feedback loop describes processes that tend to be self-limiting and look for balance and equilibrium (Sterman, 2000).

Table 3. Description of loop polarity in the causal loop diagram.

Symbol of loop polarity	Example of loop polarity	The explanation for example loop polarity
		If the degree of road congestion increases (decreases), the allure of driving decreases (increases). However, as the appeal of driving increases, the degree of road congestion increases or decreases proportionally. As a result of the negative polarity link indicating an odd number, the causal loop is considered a balancing loop (B).
		The urban population has a positive relationship with travel demand and vice versa. If the urban population increase (decreases), then the travel demand increase (decreases), accordingly. If the travel demand decrease (increase), then the urban population also decrease (increase), as appropriate. Therefore, the causal loop is considered reinforcing (R) due to the negative polarity link being zero which indicates an even number.

Furthermore, in the development of CLD, endogenous and exogenous factors were identified. The endogenous variable is the factor that correlates with other factors within the system being studied. In contrast, the external factors related to road pricing management are called exogenous variables. In Table 4 below, identified factors in the development of the CLD model are listed.

Table 4. List of identified factors in the development of the causal loop diagram model for road pricing.

Variable	Description	Type of Variable
Urban Population	The total number of urban populations by years	Endogenous variable
Travel Demand	The total travel demand per year	Endogenous variable
Growth Rate of Vehicles	The growing number of vehicles per year	Endogenous variable
Number of Vehicles	The total rate of vehicles per year	Endogenous variable

Vehicle Sharing Rate	The total number of the vehicle-sharing rate	Exogenous variable
Private Vehicles Ownership	The total number of private vehicle	Endogenous variable
Degree of Road Congestion	The degree of road congestion	Endogenous variable
Pollution	The degree of pollution	Exogenous variable
Health Risks	The degree of health risks	Exogenous variable
Pressure of Government	The pressure on the government	Endogenous variable
Investment in Public Transport	The investment in public transport	Endogenous variable
Adequacy of Public Transport	The satisfaction level of public transport	Endogenous variable
Public Transport Users	The number of public transport users per year	Endogenous variable
Road Pricing Charge	The road pricing charging	Endogenous variable
Trips Cost	The cost for every trip made by the driver per day	Endogenous variable
Trips per Day	The number of a trip made by drivers per day	Endogenous variable
Traffic Volume	The number of vehicles in each traffic flow	Endogenous variable
Travel Time	The total time taken by a driver for every travel	Endogenous variable
New Road Construction	Construction of new road	Endogenous variable
Attractiveness of Driving	The attraction for users to drive their vehicle	Endogenous vehicle

EXPERIMENTAL RESULTS

The result of the cause-and-effect relationship between exogenous and endogenous variables as listed in Table 4 is connected through the link polarity within the CLD. The constructed CLD is illustrated in Figure 1 to conceptualize the related causes and effects within the road pricing system.

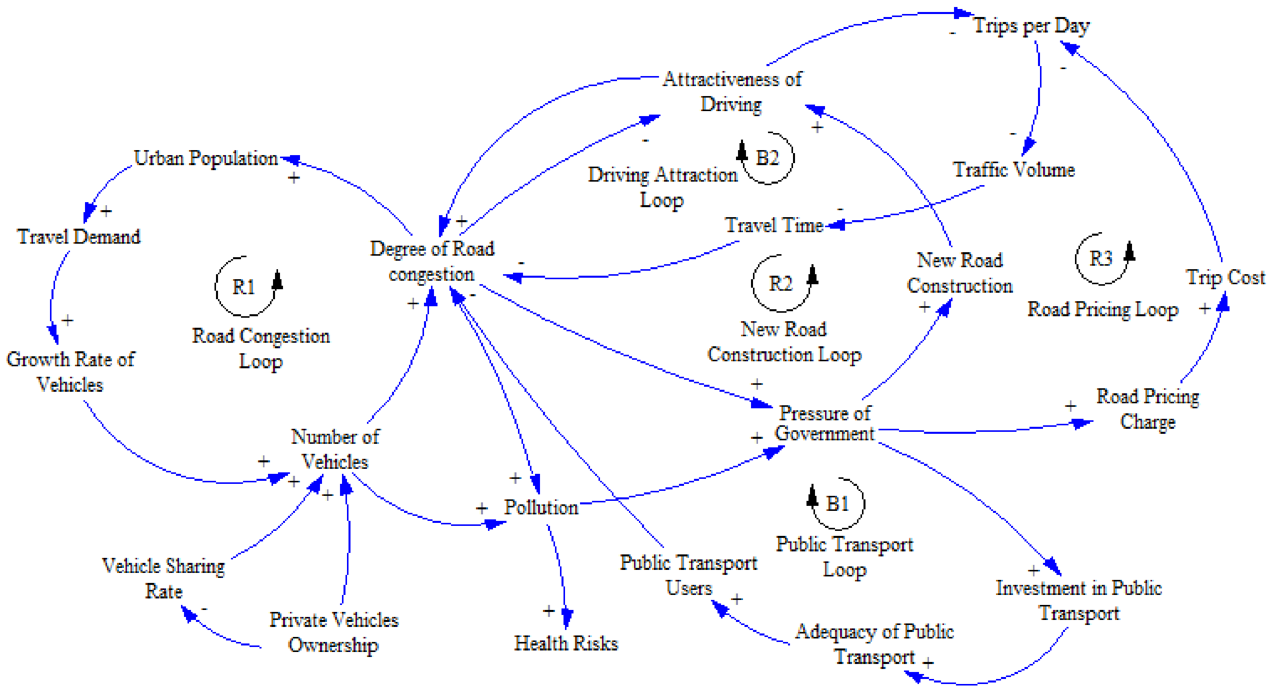


Figure 1. Causal loop diagram of main variables of road pricing system.

The developed CLD incorporates five loops: congestion, public transportation, road pricing, new road construction, and driving attraction. Each of the loops contains identified variables, such as those that should be prioritized when managing road pricing.

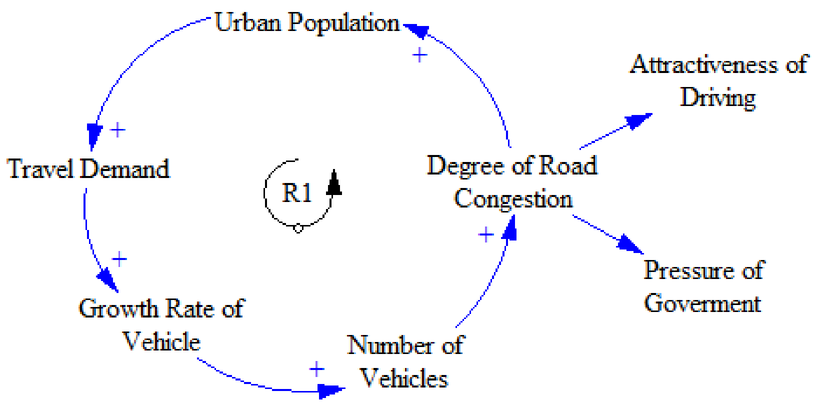


Figure 2. Road congestion subsystem.

Loop R1: Road Congestion.

As illustrated in Figure 2, Loop R1 is categorized as a reinforcing loop due to the even number of negative polarities. The related variables are urban population, degree of road congestion, the attractiveness of driving, pressure of the government, number of vehicles, growth rate of the vehicle, and travel demand. Congestion increases in severity as the number of vehicles on the road increases. Thus, the variables included in this loop should be scrutinized more closely, as they will result in unanticipated changes. The increased vehicle count can be attributed to a lower vehicle sharing rate, a high rate of private vehicle ownership, and a vehicle growth rate. Vehicle growth rates also increased in response to the increase in travel demand. Additionally, travel demand will increase as the urban population grows. Additionally, an increase in the degree of road congestion will affect the attractiveness of driving and the government's pressure.

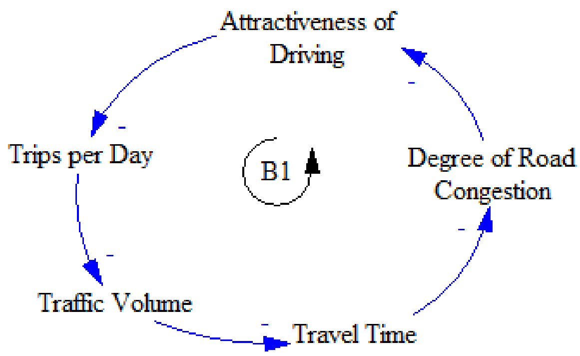


Figure 3. Driving attraction subsystem.

Loop B1: Driving Attraction.

As illustrated in Figure 3, when the level of road congestion increases, the allure of driving diminishes. Consequently, the number of trips per day decreases as the attractiveness of driving declines. The number of trips made per day affects the volume of traffic. A decrease in daily trips equates to a decrease in traffic volume. As a result, travel times have decreased. As travel time decreases, the degree of road congestion decreases as well. The driving attraction loop is considered a balancing loop. The balancing loop has the effect of stabilizing the variables. Thus, all variables will contribute to changes in their effect on the suit condition (increase or decrease).

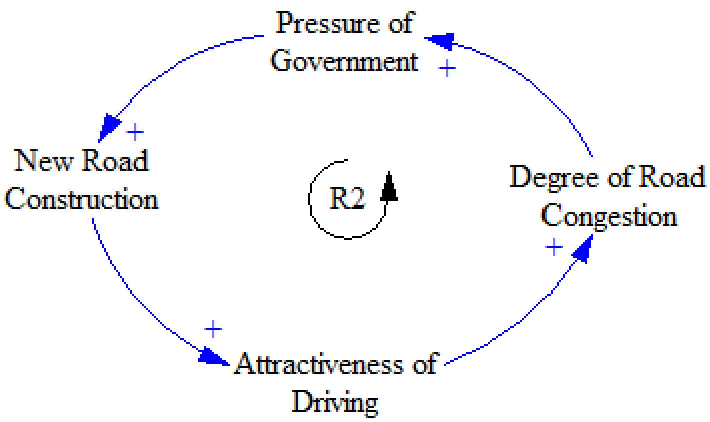


Figure 4. New road construction subsystem.

Loop R2: New Road Construction.

In contrast, Figure 4 shows that the government faces increased pressure as the degree of road congestion and pollution increases. Increased pressure on the government prompted the government to consider three strategies: new road construction, public transportation investment, and road pricing charging. However, when a new road is constructed, it attracts more people, which increases the appeal of driving. As a result, the degree of road congestion increases.

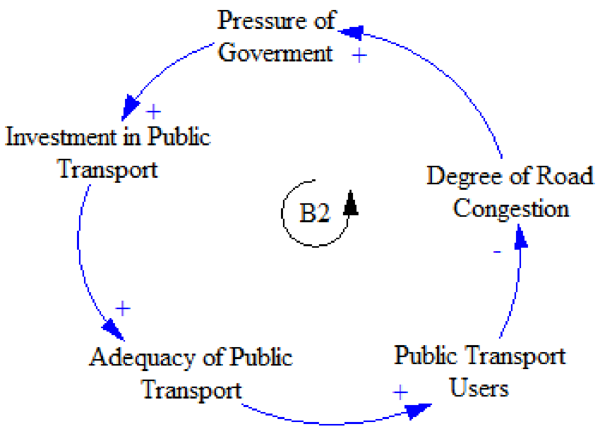


Figure 5. Public transport subsystem.

Loop B2: Public Transport.

The public transport loop in Figure 5 shows when the government invests more in public transportation, the system's adequacy improves. As a result, the number of people using public transportation will increase, thereby decreasing the degree of road congestion. Furthermore, this loop shows positive feedback as the number of negative polarities is even.

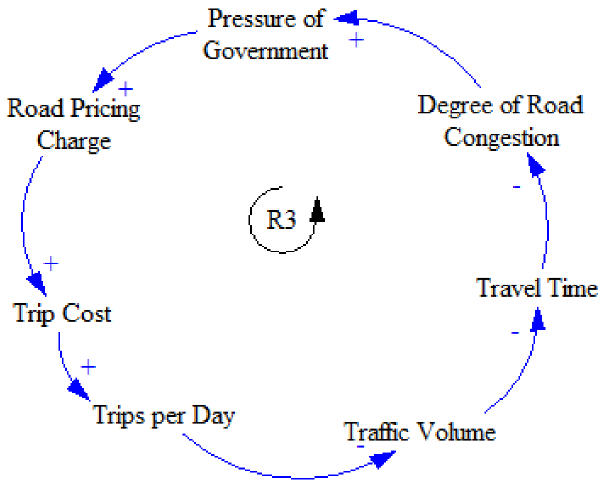


Figure 6. Road pricing subsystem.

Loop R3: Road Pricing.

In Figure 6, increases in the road pricing charge will result in an increase in the trip cost on the R3 loop. When the cost of a trip increases, people tend to make fewer trips per day to save money. Reduced daily trips result in decreased traffic volume and improved travel time. As a result, road congestion will also decrease. Consequently, the reduction in traffic volume will increase workers' productivity, road safety, and local air quality.

Due to the even number of negative polarities, traffic congestion, new road construction, and road pricing loops are reinforcing. Since the loop is self-reinforcing, it leads to the exponential growth of traffic congestion, the pressure of the government, new road building, road pricing charge, and travel time. As a result, this loop must be more concerned with unexpected changes.

CONCLUSION AND FUTURE WORK

Congestion is a global obstacle to the development of a resilient and sustainable traffic management system. Given that nearly one-fourth of energy-related global greenhouse gas emissions come from the transport sector and that these emissions are projected to increase substantially in the coming decades, the transport sector will play a crucial role in achieving the goals of the Paris Agreement. In this paper, five subsystems were created during the development of CLD to develop a conceptual model for road pricing management. Three reinforcing loops and two balancing loops are included. According to this analysis, authorities should closely monitor with high integrity and ethics the road congestion loop, the road pricing charge loop, and the new road construction loop in the road pricing system, as these loops are mutually reinforcing (R). The authorities should devise a proper and formal policy (McGuffog, 2018). Values, morals, ethics, and integrity should be added and highlighted in the policy (Azizul & Kamarudin, 2021, Haron et al., 2020, Wan Husain, 2020). When one variable in this loop increases, another variable typically increases as well.

On the other hand, the research's balancing loop is the driving attraction loop and public transport. This is due to the unusually high number of negative links. Hence, this loop will have a balancing effect on the associated variables. As a result, all of the factors involved will increase or decrease to achieve equilibrium between the related factors. Moreover, this finding is appropriate to be suited to other big cities in Malaysia such as Johor Bahru and Georgetown in Penang since the nature of the road congestion is almost identical. CLD is found to be an appropriate guide when developing a conceptual model for road pricing management. Additionally, CLD can help identify the primary factors underlying the problem being studied by incorporating holistic perspectives from previous works and experts in the field. For future work, the developed CLD should be extended to the next stage of the SD model which is the SFD model. Furthermore, other potential variables that should be considered in the development of the road pricing model are private parking charges and the fee of public transport such as the light rail transit system.

In this paper, the proposed cause-and-effect model of road pricing shows that some variables need to be given full attention to reducing congestion problems. However, this will not be possible without action from the authorities because this study is done as a stepping stone in addressing the problem of congestion. Therefore, those in charge should carry out their duties with full integrity so that this congestion problem can be tackled and controlled.

ACKNOWLEDGEMENT

This research work is supported by the Sustainable Research Collaboration Grant IIUM UMP UiTM via an internal grant from Universiti Malaysia Pahang (RDU200720).

REFERENCES

Abulibdeh, A. (2020). *Traffic congestion pricing: methodologies and equity implications*. https://doi.org/10.5772/66569

Ahmarofi, A. A., Abidin, N. Z., & Ishak, M. K. (2021). Simulating the effect of the raw material preparation on the production completion time through a system dynamics model. *Intelligent Manufacturing and Mechatronics*, 1257–1266.

Ahmarofi, A. A., Kamaruzzaman, Z. A., Rahman, H. A., Masri, K. A., Rahim, N. A., Shariff, S. S. R., … Ahmad, A. B. (2021). Development of A Computer Simulation on Road Pricing Strategy to Reduce Congestion and Carbon Dioxide Emission: A System Dynamics Approach. *2021 6th IEEE International Conference on Recent Advances and Innovations in Engineering, ICRAIE 2021*, *2021*. https://doi.org/10.1109/ICRAIE52900.2021.9703987

Ahmarofi, A. A., Zainal Abidin, N., & Mahadzir, N. H. (2022). Simulating the Cycle Time Based on a Manpower Performance Through a System Dynamics Model: A Case Company in the Automotive Sector. *Human-Centered Technology for a Better Tomorrow* (pp. 515-523). Springer, Singapore.

Akbari, F., & Mahpour, A. (2020). Evaluation of Energy Consumption and CO2 Emission Reduction Policies for Urban Transport with System Dynamics Approach. *Environmental Modeling & Assessment*, Vol. 25, 505–520

Azizul, F. B., & Kamaruddin, D. B. (2021). An Empirical View of Business Ethics on Press Freedom: A Case Study. *Journal of Governance and Integrity*, *4*(2), 125–134. https://doi.org/10.15282/jgi.4.2.2021.5865

Baranzini, A., Carattini, S., & Tesauro, L. (2021). *Designing Effective and Acceptable Road Pricing Schemes: Evidence from the Geneva Congestion Charge*. *Environmental and Resource Economics* (Vol. 79). Springer Netherlands. https://doi.org/10.1007/s10640-021-00564-y

Bernama. (2022). Congestion charges in KL, are we ready? Retrieved from https://www.thesundaily.my/local/congestion-charges-in-kl-are-we-ready-YX9275634

Croci, E. (2016). Urban road pricing : a comparative study on the experiences of London, Stockholm and Milan. *Transportation Research Procedia*, *14*, 253–262. https://doi.org/10.1016/j.trpro.2016.05.062

Eliasson, J. (2009). Lessons from the Stockholm congestion charging trial, *15*, 395–404. https://doi.org/10.1016/j.tranpol.2008.12.004 Federal Highway Administration. (2022). Congestion pricing: environmental benefits, 20590.

Ganesh, L. (2019). Can everyday traffic affect our mental health? Retrieved at 30 September 2022 from https://www.whiteswanfoundation.org/mental-health-matters/understanding-mental-health/can-everyday-traffic-affect-our-mental-health

Goh, M. (2002). Congestion management and electronic road pricing in Singapore. *Journal of Transport Geography*, *10*(1), 29–38. https://doi.org/10.1016/S0966-6923(01)00036-9

Haron, H., Jamil, N. N., & Ramli, N. M. (2020). Western and Islamic Values and Ethics: Are They Different?. *Journal of Governance and Integrity*, *4*(1), 12–28. https://doi.org/10.15282/jgi.4.1.2020.5609

Hong, D., & Wong, L. W. (2017). A study on smart mobility in Kuala Lumpur. *Proceedings of the 2017 2nd International Conference on Computing and Communications Technologies, ICCCT 2017*, 27–32. https://doi.org/10.1109/ICCCT2.2017.7972241

Iqbal, M., & Tri Anggraini, A. (2019). Public Service Innovation for Public Transportation to Disabilities by Difa City Tour, Yogyakar City. *Journal of Governance and Integrity*, *3*(1), 44–49. https://doi.org/10.15282/jgi.3.1.2019.5421

Jayaraman, K., Leow, N. X., Asirvatham, D., & Chan, H. R. (2020). Conceptualization of an urban travel behavior model to mitigate air pollution for sustainable environmental development in Malaysia. *Management of Environmental Quality: An International Journal*, Vol. 31 No. 3, 785-799.

Khan, A. M. (2001). Reducing traffic density: The experience of Hong Kong and Singapore. *Journal of Urban Technology*, 8(1), 69–87. https://doi.org/10.1080/10630730120052181

Khosravi, S., Haghshenas, H., & Salehi, V. (2020). Macro-Scale Evaluation of Urban Transportation Demand Management Policies in CBD by Using System Dynamics Case Study : Isfahan CBD. *Transportation Research Procedia*, 48(2018), 2671–2689. https://doi.org/10.1016/j.trpro.2020.08.246

Knight, F. H. (1924). Some fallacies in the interpretation of social cost. *The Quarterly Journal of Economics*, 38(4), 582-606. https://doi.org/10.2307/1884592

Maria, B., Eliasson, J., Hugosson, M. B., & Brundell-freij, K. (2012). The Stockholm congestion charges — 5 years on . Effects , acceptability and lessons learnt, Transport Policy, Vol. 20, 1–12. https://doi.org/10.1016/j.tranpol.2011.11.001

Moyer, J. D., & Hedden, S. (2020). Are we on the right path to achieve the sustainable development goals?. *World Development*, *127*, 104749.

McGuffog, T. (2018). Insights: How to Calculate the Most Valuable Answers: Developing Added Value Arithmetic. *Journal of Governance and Integrity*, *2*(1), 1–3. https://doi.org/10.15282/jgi.2.1.2018.5532

Olszewski, P., & Xie, L. (2005). Modelling the effects of road pricing on traffic in Singapore. *Transportation Research Part A: Policy and Practice*. Vol. 39, Issues 7–9, 755-772. https://doi.org/10.1016/j.tra.2005.02.015

Pigou, A. C. (1920). *The economics of welfare*. Macmillan & Co, London.

Rajé, F., Tight, M., & Pope, F. D. (2018). Traffic pollution: A search for solutions for a city like Nairobi. *Cities*, 82, 100–107. https://doi.org/10.1016/j.cities.2018.05.008

Rez, L. (2019). Bottom-up modeling approach and mesoscopic simulations in traffic system dynamics models. https://doi.org/10.1177/0037549719869989

Richards, C. E., Lupton, R. C., & Allwood, J. M. (2021). Re-framing the threat of global warming: an empirical causal loop diagram of climate change, food insecurity and societal collapse. *Climatic Change*, 164(3), 1-19.

Rotaris, L., Danielis, R., Marcucci, E., & Massiani, J. (2010). The urban road pricing scheme to curb pollution in Milan , Italy : Description , impacts and preliminary cost – benefit analysis assessment. *Transportation Research Part A*, 44(5), 359–375. https://doi.org/10.1016/j.tra.2010.03.008

Salmon, P. M., Stanton, N. A., Walker, G. H., Hulme, A., Goode, N., Thompson, J., & Read, G. J. (2022). *Causal Loop Diagrams*

(CLDs). Handbook of Systems Thinking Methods, 157-180. CRC Press.
Sterman, J. D. (2000). *Business Dynamics*: *New Business Models for the Knowledge Economy*. Routledge, London. https://doi.org/10.4324/9781351152723-7
Suryani, E., Hendrawan, R. A., Adipraja, P. F. E., Wibisono, A., & Dewi, L. P. (2019). Urban mobility modeling to reduce traffic congestion in Surabaya: a system dynamics framework. *Journal of Modelling in Management*, 16(1), 37–69. https://doi.org/10.1108/JM2-03-2019-0055
Suryani, E., Hendrawan, R. A., Adipraja, P. F. E., Wibisono, A., Widodo, B., & Indraswari, R. (2020). Modelling and simulation of transportation system effectiveness to reduce traffic congestion: a system dynamics framework. *Transportation Planning and Technology*, 43(7), 670–697. https://doi.org/10.1080/03081060.2020.1805543
Suryani, E., Hendrawan, R. A., Mukti, F. A., & Zahra, A. A.-. (2020). System Dynamics Model To Decrease Congestion Cost Using Transit-Oriented Development. *MATTER: International Journal of Science and Technology*, 6(2), 74–89. https://doi.org/10.20319/mijst.2020.62.7489
United Nations. (2018). 2018 revision of world urbanization prospects. Retrieved at 30 September 2022 from https://www.un.org/development/desa/publications/2018-revision-of-world-urbanization-prospects.html
Vafa-Arani, H., Jahani, S., Dashti, H., Heydari, J., & Moazen, S. (2014). A system dynamics modeling for urban air pollution: A case study of Tehran, Iran. *Transportation Research Part D: Transport and Environment*, 31, 21–36. https://doi.org/10.1016/j.trd.2014.05.016
Verhoef, B. E., Nijkamp, P., & Rietveld, P. (1995). Second-best Regulation of Road Transport Externalities, *29*(2), 147–167.
Wan Husain, W. A. F. (2020). Insights: The Conceptual Framework for Building the World Class Good Governance Ethics. *Journal of Governance and Integrity*, *4(*1), 1–5. https://doi.org/10.15282/jgi.4.1.2020.5606
Xue, Y., Cheng, L., Wang, K., An, J., & Guan, H. (2020). System Dynamics Analysis of the Relationship between Transit Metropolis Construction and Sustainable Development of Urban Transportation — Case Study of Nanchang City, China. *MDPI*.
Yang, H., & Huang, H. (2005). *Mathematical and Economic Theory of Road Pricing*. http:// 10.1108/9780080456713.
Yearworth, M. (2014). *A Brief Introduction to System Dynamics Modelling.* Reader in Engineering Systems. University of Bristol, 1–15.
Zefreh, M. M., Esztergar-Kiss, D., & Torok, A. (2021). Implications of different road pricing schemes in urban areas: A case study for Budapest. *Proceedings of the Institution of Civil Engineers: Transport*, 174(7), 407–418. https://doi.org/10.1680/jtran.19.00094

AUTHORS' BIOGRAPHY

Author's Full Name: Masriah binti Mansur
Author's Email: maszreahrh@gmail.com
Author Professional Bio: Masriah graduated from Universiti Malaysia Pahang in 2020 with Bachelor's Degree in Business Engineering. In 2019, she completed her internship as an assistant in purchasing and sales departments at Eshan Engineering. In 2021, she is an apprentice at Pandit Sdn. Bhd. as a content creator for the JustFind company, while simultaneously studying Data Science with Python at Nexpert Academy, where she works on projects such as simple facial recognition, logistic regression in machine learning, polynomial regression, and multiple linear regression.

Author's Full Name: Zetty Ain binti Kamaruzzaman
Author's Email: zetty@ump.edu.my
Author Professional Bio: Zetty Ain is a Senior Lecturer and Head of Programme (Business Analytics) at the Faculty of Industrial Management, Universiti Malaysia Pahang. She is also a Research Fellow at Centre for Artificial Intelligence & Data Science (Data Science Centre), Universiti Malaysia Pahang. She has been teaching for almost five years and has five years of experience in the construction industry. Her research interests include Statistics, Quantitative Finance, Analytics, Data Science, and Business Management.

Author's Full Name: Ahmad Afif bin Ahmarofi
Author's Email: ahmadafif@uitm.edu.my
Author Professional Bio: Ahmad Afif bin Ahmarofi is a Senior Lecturer at the Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA (UiTM) Kedah Branch, Malaysia. His areas of expertise are computer simulation, artificial intelligence (AI), and optimization methods. Most recently, he is involved in a project related to big data analysis for E-Learning.

Author's Full Name: Cheng Jack Kie
Author's Email: jackkie@ump.edu.my
Author Professional Bio: Cheng Jack Kie is an Associate Professor at the Faculty of Industrial Management, Universiti Malaysia Pahang. She has been teaching for more than ten years and has vast experience in conducting a market study on employee engagement and customer satisfaction for numerous industries. Her research interests include System Dynamics Simulation, Discrete Event Simulation, Operation Research, Logistics, and Supply Chain Management.

Author's Full Name: Hamirahanim binti Abdul Rahman
Author's Email: hamirahanim@up.edu.my
Author Professional Bio: Hamimahrahim is a Senior Lecturer and Head of Programme (Business Engineering) at the Faculty of Industrial Management, Universiti Malaysia Pahang. She has been teaching for more than two years and has twelve years of experience in the telecommunication industry. Her research includes Artificial Intelligence and Information systems.

Author's Full Name: Khairil Azman bin Masri
Author's Email: khairilazman@ump.edu.my
Author Professional Bio: Dr. Khairil Azman Masri is a Senior Lecturer at the College of Engineering, Universiti Malaysia Pahang. He is an expert in highway and transportation engineering. His research interests are related to advance pavement material, advanced pavement design, and transport engineering. He has a particular interest in nanomaterial application toward asphalt pavement.

Author's Full Name: Nadirah binti Abdul Rahim
Author's Email: nadirahabdulrahim@iium.edu.my
Author Professional Bio: Nadirah is currently working as an Assistant Professor at International Islamic University Malaysia, under the Department of Electrical and Computer Engineering teaching Programming for Engineers and Python at the Undergraduate level. Her research interests include Satellite Communication Systems, Programming, and Engineering Management. Nadirah is a member of BEM and INCOSE.

Author's Full Name: S.Sarifah Radiah binti Shariff
Author's Email: radiah@tmsk.uitm.edu.my
Author Professional Bio: S. Sarifah Radiah Shariff is an Associate Professor in the Centre of Statistics and Decision Sciences Studies at the Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA (UiTM) Shah Alam. Her research interests include supply chain modeling, logistics modeling, multicriteria decision making, metaheuristics, and application of technology into statistical processes.