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Potential Study of Applying Traffic Congestion Index to Simulate Property Price Changes

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Abstract

Urban traffic congestion is widely recognized as a critical issue affecting both urban development and quality of life. One significant consequence is the depreciation of property values due to decreased accessibility and environmental quality. This study investigates the potential to simulate changes in property prices under varying traffic congestion conditions. First, the paper discusses the current lack of analytical tools for assessing the relationship between traffic congestion and fluctuations in urban property values. Second, it aims to develop a simulation and modeling framework to address this gap, thereby validating the applicability of the proposed tool in analyzing the implications of urban traffic congestion on property prices. The research integrates traffic congestion data and property price data using the Overlay Mapping Method with reference to the i-PLAN platform. Correlation analysis and hypothesis testing are then employed to evaluate the outcomes. The simulation results, presented in index format, are expected to serve as a practical guideline for developers in making property acquisition decisions.

Keywords

Traffic Congestion, Property Prices, Place of Interest, Simulation Index

Introduction

Traffic congestion in urban areas is a persistent and complex issue, not only degrading the quality of life but also contributing to inefficient land use and reduced urban productivity. Numerous studies have examined the relationship between traffic congestion and urban development. Sethi (2018) notes that rapid urbanization often leads to increased traffic congestion, which disrupts surrounding developments. As city populations grow, so too does the demand for private vehicle use, which directly contributes to traffic congestion.

Transport infrastructure generates both positive and negative externalities (Guijarro, 2019). While proximity to road networks may provide better access to public transportation

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and amenities—considered positive externalities—negative externalities include traffic congestion, air pollution, and noise. When determining property prices, both types of externalities are evaluated. Guijarro's (2019) study of Madrid, Spain, reveals that while proximity to amenities positively affects residential property values, higher daily traffic volumes have a negative impact.

In contrast, the influence of traffic congestion on commercial property values can differ. Alliyu et al. (2015), in a study conducted in Bauchi, Nigeria, found that traffic congestion often has a positive impact on commercial property values due to increased business activity in congested areas. Negative impacts, such as pollution, were less significant when choosing business locations.

Several other studies support the notion that traffic congestion negatively affects residential property values, as many residents prefer to avoid high-traffic areas due to health and convenience concerns. However, there is a lack of comprehensive studies examining the relationship between traffic congestion and commercial property prices. Further research is required to determine whether congestion influences commercial property values positively or negatively.

To address these gaps, this paper explores the possibility of integrating traffic congestion and property value data to develop a comprehensive modeling framework. This framework is intended to validate the application of a simulation tool that could assist stakeholders in optimizing urban development strategies.

Methodology

In addition to changes in property prices caused by demand and supply dynamics, other important factors influencing property values include predicted pollution levels and commuting time. These two factors, travel time delay and environmental degradation (i.e., air and noise pollution), are closely linked to traffic congestion and directly affect the desirability of residential areas.

A case study conducted in suburban cities in Texas, USA, by Wen et al. (2013) found that each additional minute of average commuting time is associated with a decrease of $1.90 in housing prices per square foot ($p = .038$). Similarly, Li (2020), in a study in Shanghai, China, found that residents in areas with poor air quality are more willing to pay for improved air conditions. Morano et al. (2021), studying the city of Bari, Italy, reported that residential buildings located in high-noise areas suffer a decline in market value. These factors are incorporated into the proposed simulation framework.

Impact due to Travel Time

Travel time is one of the major components of road user costs and is largely influenced by traffic speed. A study on traffic outflow from Klang Valley, Malaysia, by Nik Mustapha et al. (2016), compared traffic speed and congestion levels, finding that roads with higher speeds generally experienced lower congestion. Additionally, research by Chang et al. (2018) reported that in cities with populations exceeding five million, a 1% increase in population leads to a 0.338% to 0.424% increase in congestion levels.

To assess travel time implications for specific properties, a transportation mode survey is necessary to determine the proportion of residents affected by congestion. Properties located near transit stations may experience less negative impact compared to those that depend heavily on road networks. The study must also account for socio-economic factors: for instance, motorcyclists often from lower-income groups tend to tolerate congestion more than private car users. A study by Mohammed et al. (2015) demonstrated that transportation mode choice is linked to income and education levels. These factors must be considered in the modeling process to ensure accurate simulation of congestion impacts on property values.

Impact due to the Environment

Another significant factor influenced by traffic congestion is environmental degradation, particularly due to noise and air pollution. Congestion slows down traffic flow, which in turn increases air pollution in affected areas. A study by Hwang et al. (2020) found that vehicle emissions were highest when vehicles were idle and lowest when traveling at an average speed of 65 km/h. Similarly, Yu et al. (2021) conducted a case study measuring air quality in congested areas, such as the Hsuehshan Tunnel and the Toucheng Interchange in Taiwan, and reported peak emission levels during rush hour.

Regarding noise pollution, a study by Herni Halim et al. (2014) on the Sungai Besi Expressway and DUKE Highway in Klang Valley, Malaysia, revealed that highways with higher traffic volumes recorded significantly higher noise levels compared to highways with lower traffic flow.

These environmental indicators are integrated into land-use patterns using the i-PLAN database. Through the application of the Overlay Mapping Method, data are graphically represented with assigned weightages to each component. A correlation analysis is then conducted to evaluate the validity of the model’s outputs. The conceptual model for the Congestion–Property Price Index is illustrated in Figure 1.

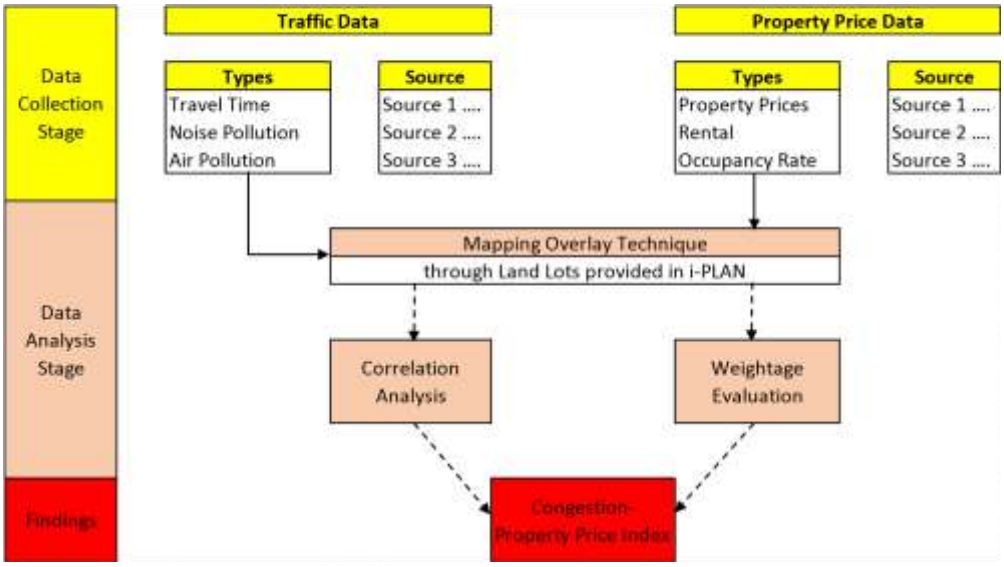

Figure 1. Modelling Framework of Congestion-Property Price Index

The model incorporates two primary data categories:

(i) **Traffic Data**, which includes

- Travel time
- Noise pollution levels
- Air pollution levels

(ii) **Property Price Data**, which includes

- Market property prices
- Rental rates
- Occupancy rates

These data are mapped to specific land lots based on proximity using the online i-PLAN platform. Parameters are standardized using average values or derived indices and spatially visualized across land lots, as shown in Figure 2.

Figure 2. Land Lot Information provided by i-PLAN

Correlations are then studied to match with each property's lots based on its usage and also location from the traffic. Appropriate weightage is given to classify the importance of each parameter using the approach of Analytical Hierarchy Process (AHP). The outcomes of the analysis are displayed in tabulation format based on the zoning and district identified as highlighted in Figure 3.

Zone		Traffic Data				Property Price Data			Index
	(1)	(2)	(3)	Total	(4)	(5)	(6)	Total	
1a-z …	=a*(1)	=b*(2)	=c*(3)	A	=d*(4)	=e*(5)	=f*(6)	B	A//B
2a-z…	…	…	…	…	…	…	…	…	…
3a-z…	…	…	…	…	…	…	…	…	…
4a-z…	…	…	…	…	…	…	…	…	…
5a-z…	…	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…	…

Figure 3. Prototype of the Traffic Congestion Index based on Property Price Changes

Weightage of evaluation are distributed to the six parameters based on AHP analysis as shown in Figure 3 labelled as (1), (2) …. (6). Each condition of the sub-zone, such as Zone 1a, 1b, 1c …. etc. are scaled accordingly such as a, b, c ….. Both the accumulated weightage of Traffic Data and Property Price Data by each sub-zone are obtained as shown in A and B, respectively. Each subzone is then compared to the relationship between A and B as stated in the final Index column. After this, all the indices of each sub-zone are identified. These values are further assessed and generate a composite index value for Zone 1, after conducting Hypothesis Testing to confirm its validity. This applies to other zones, such as Zone 2, 3, 4, etc. Finally, after all the composite index values of Zone 1, 2, 3, etc are obtained. Hypothesis tests are conducted once again to justify the validity of the index values for each of the different zones based on their traffic conditions and development status.

Results and Discussion

This model framework serves as a prototype, providing a gross projection to estimate the impact of traffic congestion on property prices. It also considers other environmental issues, such as traffic noise and pollution, as well as social and economic factors that may affect productivity and resource utilization. Through this prototype operation, a set of estimation standards with different index values for various development statuses and traffic conditions can be used as important inputs or references for developers to justify the potential of land development in specific locations and land lots.

Conclusion

In conclusion, it is possible to integrate the parameters relating to traffic congestion and property prices into a comprehensive framework towards the development of prototype modelling, which is beneficial for urban development planning.

Acknowledgements

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