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THE SIGNIFICANCE OF TRANSIT-ORIENTED DEVELOPMENT (TOD) TOWARDS THE ENHANCEMENT OF PUBLIC TRANSPORTATION RIDERSHIP

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Abstract

Transit-oriented development (TOD) emerges as a strategic urban planning approach that aims to create well-connected, pedestrian-friendly communities centred around transit nodes. Despite the increasing use of public transportation, many people still rely on single-occupancy vehicles. Several TOD guidelines have been developed to enhance its implementation in Malaysia; however, the current policy context on housing and TOD practices does not adequately reflect the reality that public transport is the preferred mode of transportation for many people. Thus, this study aims to identify the most significant attributes of TOD that can improve public transportation (PT) ridership. Primary data was gathered from 284 respondents using a self-administered questionnaire distributed through simple random sampling. The chi-square test was used to determine the significant relationship between TOD and PT ridership. The findings indicated that eleven TOD attributes and eleven PT ridership attributes had a significant relationship, whilst the remaining relationships were considered null. More than half of the findings were significant, indicating that both TOD and PT ridership were related. In conclusion, a well-designed transit-oriented community can attract and retain public transportation users, making it a catalyst for creating transit-friendly environments.

Keywords: Transit-Oriented Development (TOD), Public Transportation Ridership

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INTRODUCTION

Transit-oriented development (TOD) is a crucial concept in urban planning that promotes sustainable and efficient transportation systems. It addresses urban challenges like congestion and pollution by shifting from highway-based zoning to transit-based zoning. Cities in Asia, such as Kuala Lumpur, Toyama, and Jakarta, have successfully implemented TOD, investing heavily in mass transit networks (Kidokoro, 2020). TOD optimizes land use around transit stations, enhancing mobility, productivity, and local businesses, thus making neighborhoods vibrant and maximizing public transport ridership (Khalid and Samsudin, 2023).

The Land Public Transport Commission (SPAD) aims for 40% of Malaysian commuters to use public transport by 2030. However, many single-occupancy vehicles still congest roads, and connectivity within regions like Klang Valley remains underdeveloped (Ravindran, 2021). Public awareness of TOD is low, and existing policies do not effectively promote public transport as the preferred travel mode (Yap & Goh, 2017). The 12th Malaysia Plan (12MP) acknowledges the need for better connectivity and reliability in public transport (Choong, 2021).

Countries like the US, UK, China, and Singapore are shifting towards transit-based zoning. In Malaysia, TOD guidelines focus on preserving the city's image through transit design but lack in promoting public transport connectivity (Azmi et al., 2021). Housing policies emphasize affordable housing and urban design more than connectivity. Thus, this research examines the significance of TOD towards public transportation ridership in the Klang Valley region. It aims to achieve two objectives, namely: (1) to identify the attributes of TOD to enhance public transportation ridership and (2) to analyse the significance of the relationship between TOD attributes towards public transportation ridership.

LITERATURE REVIEW

Transit-Oriented Development (TOD)

Transit-oriented development (TOD) refers to the idea of a mixed-use community within walking distance of a transportation node. The concept was first introduced by Peter Calthorpe in 1993 to develop metropolitan cities in the United States on undeveloped sites, held high potential for redevelopment or reuse, and could initiate more urban growth areas (Calthorpe, 1993). It later gained popularity as a sustainable form of urbanism with a broader array found across the country (Calthrope, 1993; Cervero, 2004). Calthorpe (1993) believes that TOD can create sustainable urban communities that can reduce the reliance on cars and promote public transportation. The community, in this context, comprises various amenities such as residential, retail, office, open space, and

public utilities for the convenience of its residents and employees to travel by foot, transit, bicycle, or automobile vehicles. The definition of TOD varies according to different guidelines published by different states and countries. The Planning Guidelines for TOD by PLANMalaysia (2018) describes TOD as a well-planned development network, particularly in areas near the transit station. Development in the transit area focuses on high-density, mixed-use, residential, commercial, business, and office buildings that are readily accessible by public transport. Meanwhile, other researchers defined TOD as a vibrant development concept that promotes seamless connectivity within transit distance with the compactness of land activities (Patnala et al., 2020). TOD is believed to be a planning approach that incorporates land use with public transportation, which considers the development surrounding the stations (Yen et al., 2023). The past few decades have witnessed the emergence of many TOD projects in the United States, The United Kingdom, Australia, and various Asian countries, which is vital for the development of cities in providing a basis for the citizens' faith (Ali et al., 2021; Arina Rahmat et al., 2016). This indicates that TOD-related studies are becoming internationally widespread and have become the agenda of state and local governments, stemming from concerns about the sustainability of urban mobility and environmental responsiveness (Doulet et al., 2017).

Transit-Oriented Development (TOD) in Malaysia

The concept of Transit-Oriented Development (TOD) is being implemented in Malaysia, with a focus on the Klang Valley region. This is due to the region's steady growth rate, which is higher than any other region. Currently, there are 24 TOD projects planned along the 31 stations of the Mass Rapid Transit (MRT) Sungai Buloh-Kajang (SBK) line, with two more projects in the pipeline. In the future, more rail transit infrastructures are planned, including projects such as Mass Rapid Transit 2, Mass Rapid Transit 3, Light Rail Transit 3, High-Speed Rail, and East Coast Rail Line. The key to successful TOD development is the proximity of buildings to transit stations, as well as ensuring that the walking experience to and from the station is of high quality. This encourages more people to use public transportation, increasing ridership. A typical TOD neighbourhood has a diameter of a quarter to half a mile (400 to 800 metres), representing pedestrian scale distances of approximately five to ten-minute walk. To encourage TOD in the Kuala Lumpur metropolitan area, the Kuala Lumpur City Hall (DBKL) and surrounding municipalities have designated a Transit Planning Zone (TPZ) within 400 metres of a transit station.

Currently, there are several national policies related to the implementation of TOD in Malaysia, such as the National Physical Plans (NPP27 in 2005 and NPP32 in 2010), Selangor Structure Plan 2020, KL City Plan 2020, 10th Malaysia Plan (RMK-10), National Urbanisation Policy (NUP), and various

regional policies like the Iskandar Region's Comprehensive Development Plan (CDP). According to Buang (2018), the first successful and largest TOD hub in Malaysia is Kuala Lumpur Sentral, best known as KL Sentral. It contains all the major railway stations in Kuala Lumpur, and is considered the best mixed-use development in Malaysia, with luxury condominiums, 5-star international hotels, a shopping mall, corporate office towers, and business suites. The Malaysian government has introduced various plans, guidelines, policies and incentives to promote TOD, including Chapter 6 of the 10th Malaysian Plan (RMK-10), National Physical Plan 3 (NPP3), National Urbanisation Policies 2 (NUP2), and Draft Planning and Design Guidelines for Compact and Liveable Development. These policies and guidelines encourage the use of public transportation, walking, and cycling as alternative modes of transport for urban development. TOD is a key focus in state and local plans, such as the Selangor Structure Plan 2020 and Kuala Lumpur City Plan 2020, as well as regional plans like the Iskandar Region's Comprehensive Development Plan (CDP) (Gomez et al., 2019). Some local authorities provide incentives for developers to build within 400 metres of a transit station, usually by allowing higher plot ratios for commercial development and increased density for residential development.

Public Transportation Ridership

Public transportation ridership refers to the number of people using public transport instead of private vehicles (Taylor & Fink, 2003). In Malaysia, rail service ridership has been increasing annually, from 681,418 in 2017 to 865,713 in 2019 (Ministry of Transportation Malaysia, n.d). Factors affecting ridership are categorized as external (e.g., population, employment) and internal (e.g., fares, service levels) (Taylor & Fink, 2003). Public transportation is vital, especially in metropolitan areas, as it improves the quality of life and attracts businesses (Taylor & Fink, 2009; Weisbrod & Reno, 2009).

Mixed-development projects near transit stations can boost ridership (Buang, 2018; Soehodho, 2017). Studies show that TOD can increase ridership by 20-40% at single stations and up to 50% regionally (Arrington, 2005). Ensuring public transport is safe, fast, and convenient is key to increasing ridership (Calthorpe, 1993). Accessibility should be a priority in design, and TOD areas see higher public transport use due to urban congestion (Panse & Panse, 2019).

In Kuala Lumpur, initiatives like an 11.86 km cycling lane aim to reduce car use and promote cycling (Nathan, 2018). Areas with a mix of commercial and residential uses have higher ridership, especially high-density developments near TOD stations (Abdullah et al., 2020). This aligns well with the theory of TOD, which advocates for high density and intensity of use for areas near TOD stations.

Tabulation of Attributes

Identifying and understanding the critical attributes of TOD is crucial for gauging its impact on enhancing public transportation ridership. These attributes provide insights into the factors that contribute to the success of TOD in promoting sustainable and transit-friendly urban environments. Table 1 shows the TOD attributes, while Table 2 illustrates the attributes of Public Transportation (PT) Ridership. To systematically analyze these attributes and develop outcomes, researchers will use the Matrix Frequency Analysis approach to transform the chosen attributes into variables. By quantifying these attributes, statistical tests can be used to determine whether the differences observed are statistically significant, providing a basis to conclude the relationships between variables.

Table 1: Tabulation of TOD Attributes

No.	Criteria/ Author	Yap & Goh (2017)	Moon-Miklaucic (2021)	Azmi et al. (2021)	Kidokoro (2020)	Gomez et al. (2019)	Thomas et al. (2018)	Ali et al. (2021)	Sohoni et al. (2017)	Pan et al. (2017)	Zhang et al. (2019)	Total
1	Location	x		x								2
2	Land Use Panning			x	x	x	x			x	x	6
3	Mixed-use Development				x		x	x	x	x		5
4	Future Value of Property	x	x		x			x			x	5
5	Density	x	x	x	x	x	x	x		x		8
6	Design			x			x					2
7	Affordability	x		x	x		x					4
8	Amenities	x	x	x	x		x					5
9	Walkability	x	x			x		x	x		x	6
10	Bikeability						x	x			x	3
11	Social		x								x	2
12	Job Opportunity			x				x	x	x	x	5
13	Pedestrian Friendly				x		x	x				3
14	Safety	x	x				x	x	x			5
15	Traffic Congestion	x					x	x	x	x	x	6
16	Travel Behaviour	x	x	x			x	x	x		x	7
17	Car Ownership	x	x							x	x	4
18	Accessibility	x	x	x	x	x	x	x		x	x	9
19	Feeder Bus						x		x	x		3
20	Parking			x	x	x	x		x	x		6
21	Convenience	x	x	x		x		x			x	6
22	Save Time	x								x		2
23	Cleaner							x	x		x	3

No.	Criteria/ Author	Yap & Goh (2017)	Moon-Miklaucic (2021)	Azmi et al. (2021)	Kidokoro (2020)	Gomez et al. (2019)	Thomas et al. (2018)	Ali et al. (2021)	Sohoni et al. (2017)	Pan et al. (2017)	Zhang et al. (2019)	Total
24	Environmentally Friendly Technology		x	x				x	x			4
25	Open Space							x	x			2
26	Economic Development		x		x	x		x			x	5

Table 2: Tabulation of Public Transportation Ridership Attributes

No.	Criteria/Author	Redman et al. (2013)	Chowdhury & Ceder (2013)	Ibrahim et al. (2021)	Sánchez-Atondo et al. (2021)	Azmi et al. (2018)	Total
1	Reliability	x	x		x	x	4
2	Frequency	x	x		x	x	4
3	Coverage		x	x			2
4	Speed	x	x	x			3
5	Accessibility	x				x	2
6	Ticketing Service			x	x		2
7	Facilities			x	x		2
8	Price	x	x		x		3
9	Information Provision	x	x	x		x	4
10	Transfer and Interchange	x	x				2
11	Staff Service			x			1
12	Comfort	x		x	x	x	4
13	Safety	x	x	x	x	x	5
14	Convenience	x				x	2
15	Aesthetic	x					1
16	Signage			x			1

A total of 19 TOD attributes, and 13 PT ridership attributes were selected as variables measured by the questionnaire due to their higher frequency. The remaining attributes analysed in the literature review were voided due to their low frequency from past researchers or incompatibility towards the overall research.

RESEARCH METHODOLOGY

This research adopted a quantitative approach and used simple random sampling to determine the sample. The pilot study involved ten (10) respondents from the private sector, academia, and MRT commuters. According to Johanson and Brooks (2010), a pilot study should have a minimum of ten (10) to fifteen (15) individuals to make the questionnaire feasible and provide practical benefits. To determine the accuracy and reliability of the research, reliability tests were conducted using Cronbach's Alpha. Tavakol and Dennick (2011) suggest that the alpha value should be between 0.70 and 0.95 to be acceptable, and this research

was categorized as excellent and reliable, with an alpha value of 0.851. The MRT Kajang Line was chosen as it is a significant transit hub attracting diverse commuters. The sample was selected based on the average statistics of public transportation ridership for MRT Kajang Line in Q1 of 2018, 2019, and 2020, as shown in Table 3.

Table 3: Average Statistic of Public Transportation Ridership for MRT Kajang Line in Q1 of 2018, 2019, and 2020

Year	2018	2019	2020
Average ridership	11,333,252	14,918,332	13,973,715

Source: Ministry of Transportation (2020)

According to Krejcie and Morgan's (1970) table, in order to have a representative sample of a population of one million or more, a sample size of 384 is required. Therefore, 384 self-administered questionnaires were distributed to the public who used the MRT Kajang Line over a period of two months. A total of 284 questionnaires were returned, resulting in a 74% return rate, which is considered sufficient to provide accurate results for confident judgments based on research findings. Morton et al. (2012) justify that a return rate of 70-85% is excellent, and a response rate of 74% is therefore satisfactory and acceptable. The chi-square test was used for variable selection to determine the significant relationship between TOD and PT Ridership. The researcher identified the critical attributes to be used as the main variables through matrix frequency table analysis and established the significance of TOD in enhancing PT ridership. All data was analysed using the Statistical Package for Social Sciences (SPSS) version 27 by comparing each variable's mean average score, finding the squared difference between actual and expected data values, and dividing that difference by the expected data values. A p-value of less than or equal to 0.05 was considered statistically significant. Therefore, variables that significantly contribute to the association with the dependent variable may be retained in the outcome while those with non-significant associations may be considered for removal.

ANALYSIS

A Pearson Chi-square Test of Independence was conducted to determine whether there is a significant relationship between attributes of Transit-Oriented Development (TOD) that can increase public transportation (PT) ridership and an understanding of TOD and PT ridership. This test is frequently used in empirical research to identify whether two categorical or nominal variables are related. In this study, the two categorical variables were the TOD attributes that could increase PT ridership and a significant understanding of TOD and PT ridership.

The test assessed whether the variables were related to the null hypothesis (H0) or alternative hypothesis (H1). The Ho was that TOD attributes have no effect on PT ridership, and there is no relationship between understanding TOD and PT ridership. The H1 was that TOD attributes enhance PT ridership, and there is a significant relationship between understanding TOD and PT ridership. The alpha level of significance was set at $\alpha = 0.05$. The chi-square (x^2) value was used to determine the significance of any observed differences, as well as to identify precisely which categories accounted for any differences found. A low chi-square value indicates a high correlation between two variables. A p-value was used to determine whether the test results were significant. The results were recorded and analysed in Tables 4 and 5 for further understanding.

Table 4: TOD Attribute Relationship Between the Significant Understanding of the Concept of TOD

TOD Attribute Relationship Code	Chi-square Test				Significance Understanding of TOD
	Value of x^2 (Observe Value)	df	Value of x^2 in Critical Value Table (Expected Value)	Value of p	
TOD1	12.421	6	12.59	0.053	X
TOD2	25.690	9	16.92	0.002	/
TOD3	14.927	9	16.92	0.093	X
TOD4	10.458	9	16.92	0.315	X
TOD5	25.867	9	16.92	0.002	/
TOD6	20.766	9	16.92	0.014	/
TOD7	17.147	9	16.92	0.046	/
TOD8	18.091	6	12.59	0.006	/
TOD9	19.568	9	16.92	0.021	/
TOD10	23.394	6	12.59	0.001	/
TOD11	17.057	6	12.59	0.009	/
TOD12	16.388	9	16.92	0.059	X
TOD13	23.331	6	12.59	0.001	/
TOD14	23.222	9	16.92	0.006	/
TOD15	12.087	9	16.92	0.208	X
TOD16	12.470	9	16.92	0.188	X
TOD17	6.411	9	16.92	0.698	X
TOD18	13.538	9	16.92	0.140	X
TOD19	19.729	9	16.92	0.020	/

To summarise, findings from Table 4 depict that eleven (11) TOD attribute relationships are considered significant, while the remaining eight (8) attribute relationships are null. The TOD relationship attribute codes that established a significant relationship with the respondents' understanding of TOD are TOD2, TOD5, TOD6, TOD7, TOD8, TOD9, TOD10, TOD11, TOD13, TOD14, and TOD19.

Table 5: TOD attribute relationships between the significant understanding of PT Ridership

PT Ridership Attribute Relationship Code	Chi-square Test				Significance Understanding of PT Ridership
	Value of x^2 (Observe Value)	df	Value of x^2 in Critical Value Table (Expected Value)	Value of p	
PTR1	18.123	6	12.59	0.006	/
PTR2	18.040	9	16.92	0.035	/
PTR3	16.687	9	16.92	0.540	X
PTR4	9.744	9	16.92	0.372	X
PTR5	19.578	9	16.92	0.021	/
PTR6	27.186	9	16.92	0.001	/
PTR7	11.125	9	16.92	0.267	X
PTR8	19.461	6	12.59	0.003	/
PTR9	37.823	9	16.92	0.000	/
PTR10	23.780	6	12.59	0.001	/
PTR11	16.583	6	12.59	0.011	/
PTR12	26.760	9	16.92	0.002	/
PTR13	13.574	6	12.59	0.035	/
PTR14	20.105	9	16.92	0.017	/
PTR15	11.606	9	16.92	0.236	X
PTR16	12.912	9	16.92	0.167	X
PTR17	12.582	9	16.92	0.182	X
PTR18	13.797	9	16.92	0.130	X
PTR19	12.897	9	16.92	0.167	X

According to Table 5, eleven (11) out of nineteen (19) PT ridership attribute relationships are considered significant, while the remaining eight (8) are considered null. The PT ridership relationship attribute that established a significant relationship with the respondents' understanding of PT ridership were coded as PTR1, PTR2, PTR5, PTR6, PTR8, PTR9, PTR10, PTR11, PTR12,

PTR13, and PTR14. It can be concluded that both variables tested using the chi-square test of independence have equal numbers of significant findings, which are eleven (11) out of nineteen (19) attribute relationships. Table 6 shows the relationship between two (2) variables, namely (1) TOD attributes to enhance PT ridership and (2) a significant understanding of TOD and PT ridership. The highest levels of significant understanding were coded as PTR9, TOD10, TOD13, PTR6, PTR10, TOD2, and TD5. Meanwhile, the average levels of significant understanding were coded as PTR12, PTR8, TOD8, TOD14, PTR1, TOD11, and PTR11. Lastly, the lowest levels of significant understanding were coded as TOD6, PTR14, TOD19, TOD9, PTR5, PTR2, PTR13, and TOD7.

Table 6: Relationship Ranking Summary of TOD attribute in Enhancing PT Ridership

Level of Significance	Rank	TOD/PT Ridership Attribute Relationship Code	Chi-square Test			
			Value of x^2 (Observe Value)	df	Value of x^2 in Critical Value Table (Expected Value)	Value of p
High	1	PTR9	37.823	9	16.92	0.000
	2	TOD10	23.394	6	12.59	0.001
	3	TOD13	23.331	6	12.59	0.001
	4	PTR6	27.186	9	16.92	0.001
	5	PTR10	23.78	6	12.59	0.001
	6	TOD2	25.69	9	16.92	0.002
	7	TOD5	25.867	9	16.92	0.002
Average	8	PTR12	26.76	9	16.92	0.002
	9	PTR8	19.461	6	12.59	0.003
	10	TOD8	18.091	6	12.59	0.006
	11	TOD14	23.222	9	16.92	0.006
	12	PTR1	18.123	6	12.59	0.006
	13	TOD11	17.057	6	12.59	0.009
	14	PTR11	16.583	6	12.59	0.011
Low	15	TOD6	20.766	9	16.92	0.014
	16	PTR14	20.105	9	16.92	0.017
	17	TOD19	19.729	9	16.92	0.020
	18	TOD9	19.568	9	16.92	0.021
	19	PTR5	19.578	9	16.92	0.021
	20	PTR2	18.04	9	16.92	0.035

Level of Significance	Rank	TOD/PT Ridership Attribute Relationship Code	Chi-square Test			
			Value of x^2 (Observe Value)	df	Value of x^2 in Critical Value Table (Expected Value)	Value of p
	21	PTR13	13.574	6	12.59	0.035
	22	TOD7	17.147	9	16.92	0.046

DISCUSSION

To assess the strength of each attribute relationship, the chi-square test of independence was tested in Tables 5 and 6 using the relationship between TOD and PT ridership to identify whether the data established a significant relationship. The results showed that twenty-two (22) relationship attributes created a significant result and were ranked in Table 4 as having high, average, and low levels of significant understanding. Further discussion on each significant relationship attribute is illustrated as follows.

According to the research, PTR9, which focuses on bikeability and signage, ranked the highest for every relationship attribute. This means that the respondents understood the importance of bikeable features and availability of signage in complementing public transportation (PT) ridership, thus improving passenger satisfaction. This finding is consistent with a study by Shelat et al. (2018), which emphasizes the need to focus on ridership growth through the combination of bicycle and transit modes. The research also showed that TOD10, which focuses on pedestrian-friendly developments and safety of PT services, was ranked as the second highest relationship attribute, indicating a high level of significance between pedestrian-friendly developments and the safety of PT services. This finding aligns with a study by Bossard et al. (2002), which highlights the importance of having walkways that connect various hubs to increase public transportation ridership. PTR12, which focuses on car ownership and information provision, and PTR8, which focuses on walkability and convenience, had a high average significance level. This suggests that respondents understood that reducing car ownership through adequate information provision on PT services would increase PT ridership. This finding is consistent with a study by Latif et al. (2016), which emphasizes the importance of reducing car ownership and changing public perception towards public transportation. PTR8, which focuses on walkability and convenience, had an average level of significant understanding, indicating that respondents moderately recognized the significance of understanding this relationship and its attribute to increase overall PT ridership. This finding aligns with a study by

Redman et al. (2013), which highlights the importance of ease of utilizing public services in increasing PT ridership. Finally, TOD6, which focuses on job opportunity and price, had a low level of significant understanding. The research indicates a weak relationship between TOD and increased job opportunities, but adjusting fare pricing for PT services may encourage higher passenger volume. This finding aligns with a study by Zimbabwe and Anderson (2011), which emphasizes the role of TOD in improving employment opportunities and driving innovation. Similarly, PTR14, which focuses on convenience and reliability, also showed a low level of significant understanding. This finding indicates that PT ridership leads to convenient travel and higher reliability on PT services, but with low significant results. This finding is consistent with a study by Gomez et al. (2019), which highlights the role of convenience and safety in increasing public transportation ridership.

CONCLUSION

In conclusion, this study identified the attributes of TOD and explored the significance of the relationship understanding between TOD attributes towards public transportation ridership. The results showed that eleven (11) TOD attribute relationships and eleven (11) PT ridership attribute relationships were significant, while the remaining relationships were considered null. More than half of the findings were considered significant, indicating that TOD attributes to enhance PT ridership and a significant understanding of TOD and PT ridership were indeed related. This advocates the symbiotic relationship between well-designed transit-oriented communities and increased ridership as catalysts for creating transit-friendly environments that can attract and retain public transportation users. As cities grapple with the complex challenges of the 21st century, adopting TOD is a pivotal strategy for fostering liveable, resilient, and environmentally conscious urban spaces. The lessons learned from successful TOD implementations serve as valuable guideposts for future urban planning endeavours, hence reinforcing the importance of prioritising public transportation as a cornerstone of sustainable urban development. By embracing the principles of TOD, cities can enhance public transportation ridership and pave the way for a more interconnected, equitable, and vibrant urban future.

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