THE CRITICAL SUCCESS FACTORS FOR TRANSIT-ORIENTED DEVELOPMENT OF RAILWAY STATIONS IN MALAYSIA

Badariah Haji Din[1], Halimah Abdul Manaf[2], Rohafiz Sabar[3], Nur Khairiel Anuar[4] Azim Azuan Osman[5],

[1,2] School of Government, [3-5]School of Technology Management and Logistics

Universiti Utara Malaysia
06010 Sintok, Kedah
Peninsular Malaysia
Email: badariahdin@uum.edu.my

Abstract

Transit-Oriented Development (TOD) is gaining wide acceptance by many state's governments in Malaysia due to its potential to create a liveable neighbourhood with enhanced mobility. Therefore, the present study to examine criteria that are considered critical for the success of TOD adoptions based on integrated perceptions from residents and retail operators who live nearby or work at the selected northern KTM commuter stations in Malaysia. The data for this study were gathered from a survey on 360 residents who used the Northern KTM commuter train service and 33 respondents were business owners and operators (retailers) that run their business at or nearby the railway station. Descriptive and inferential technique was performed to analyse the data and produce the findings. The findings of this study shown that there were significant differences in travel behaviour patterns with respect to respondents' travel purposes. Moreover, it was revealed that land-use diversity and walkable design as important TOD principles that contribute to their quality of life. Besides residents' perspectives, the present study also considered the retail operators' viewpoints in estimating the impact of TOD adoption on quality of life. Unlike residents' perspectives, retail operators' quality of life was assessed in terms of business performance and business well-being. "Density" principle showed positive impacts on both retailers' business performance and business well-being. The findings of this research would serve as a base but critical information to direct future National Estate Development Plan.

Keyword: Transit-Oriented Development, Quality of Life, 5Ds Principles, northern Malaysia, PLS-SEM

[1] Associate Professor at University Utara Malaysia. Email: badariahdin@uum.edu.my
[2] Associate Professor at University Utara Malaysia. Email: imah@uum.edu.my
[3] Associate Professor at University Utara Malaysia. Email: rohafiz@uum.edu.my
[4] Senior Lecturer at University Utara Malaysia. Email: nurkhairiel@uum.edu.my
[5] Senior Lecturer at University Malaysia Pahang. Email azimazuan.osman@gmail.com

INTRODUCTION

Transit-oriented development (TOD) is an urban planning concept that emphasised on integrating transport and land use planning in a way that promotes the use of public and active transportation over the use of the private motor vehicles (Curtis, Renne, & Bertolini, 2009; van Lierop, Maat, & El-Geneidy, 2017). Most of the TOD studies in local context are devoted to railway stations in urban areas (for example see Ramlan et al. (2021), Yap et al. (2021), Gomez et al. (2019) and Woo (2020)), while suburban and rural stations are poorly investigated locally and even globally (Staricco & Vitale Brovarone, 2020). Although foreign studies have shown TOD adoption in suburban regions demonstrated a greater leap in the status quo as compared to its adoption in city centres (Sohoni, Thomas, & Rao, 2017), none of the local researcher attempt to focus on suburban or rural stations in studying TOD adoption. Therefore, this study aims to fill this research gap by assessing the potential of suburban railway stations such as Padang Besar, Bukit Ketri, Arau and Anak Bukit KTM commuter stations to be developed as full-fledged TOD locations.

Although transit-oriented development (TOD) has recently emerged as a trending topic in both urban development policies and academic studies (Azmi et al., 2021; PLANMalaysia, 2021), most studies have not assessed the success of TOD adoption in a comprehensive manner. For instance, a recent study conducted by Ramlan et al. (2021) solely focussed on "land-use diversity" principle in assessing the success of TOD adoptions. Meanwhile, Meng, Li, Taylor, and Scrafton (2021), Huang, Parker, and Minaker (2021) and Dong (2021) studies primarily emphasised on "demand management" principle. Therefore, a comprehensive study that evaluates a wider range of TOD principles is needed to assist urban planners and policy-makers in making inclusive decisions regarding TOD strategic planning and policies. Hence, the present study intends to include not just land-use diversity and demand management principles, but also population and employment density, walkable design as well as destination accessibility in evaluating the success of TOD adoptions at northern KTM commuter stations.

Moreover, TOD studies focused on examining the success and performance of TOD adoptions are most often based on experts viewpoints (Gomez et al., 2019; Searle, Darchen, & Huston, 2014; Tan, Janssen-Jansen, & Bertolini, 2014; van Lierop et al., 2017) or spatial data (Khare et al., 2021; Nyunt & Wongchavalidkul, 2020; Rahmat, Endot, Ahmad, Ishak, & Ibrahim, 2016; Wey, Zhang, & Chang, 2016). However, it is also imperative to solicit community perceptions regarding this matter, since they are the major stakeholders that will be benefitted in terms of quality of life from the successful TOD adoptions (Abdullah & Mazlan, 2016; Appleyard, Frost, & Allen, 2019; Parker, McKeever, Arrington, Smith-Heimer, & Brinckerhoff, 2002). On that account, the present study attempted to examine criteria that are considered critical factors for the success of TOD adoptions based on integrated perceptions from residents and retail operators who live nearby or work at the selected northern KTM commuter stations and also to measure the impact of these critical success factors on residents and retailers' quality of life.

LITERATURE REVIEW

TOD Principles

The fundamental principles of TOD are diversity, density and design, shortly known as "3Ds" (Calthorpe, 1993). Later, another two Ds namely destination accessibility and demand management were introduced (Cervero & Kockelman, 1997; Ogra & Ndebele, 2014). Table 1 summarises the principles of TOD studied in 20 different academic publications. From these publications it is evident that global TOD's adoption revolves around 5Ds principles which include; 1. Land-use diversity, 2. Population and employment density, 3. Walkable design, 4. Destination accessibility, and 5. Demand management.

Table 1: Common principles of TOD adoption from the literature

No	Authors	Settings	DLU	DST	DSG	DAC	DMG
1.	Yap, Chua, and Skitmore (2021)	Malaysia	X	X	X	X	X
2.	Tamakloe et al. (2021)	Korea	X	X	X		
3.	Ramlan et al. (2021)	Malaysia	X				
4.	Meng et al. (2021)	Australia					X
5.	Khare et al. (2021)	India	X	X	X	X	X
6.	Huang et al. (2021)	Canada					X
7.	Dong (2021)	USA					X
8.	Azmi et al. (2021)	Malaysia	X	X	X	X	X
9.	Staricco and Vitale Brovarone (2020)	Italy	X	X	X		
10.	Sinaga et al. (2020)	Indonesia	X			X	
11.	Nyunt and Wongchavalidkul (2020)	Thailand	X	X	X		X
12.	Jones (2020)	Canada		X			
13.	Jaafar Sidek et al. (2020)	Malaysia				X	X
14.	Ganning and Miller (2020)	USA	X	X	X		
15.	Abutaleb, McDougall, Basson, Hassan, and Mahmood (2020)	UAE	X	X	X	X	
16.	Pongprasert and Kubota (2019)	Thailand			X	X	
17.	Gomez, Omar, and Nallusamy (2019)	Malaysia	X	X	X		X
18.	Appleyard, Frost, and Allen (2019)	USA	X	X	X	X	
19.	Al Saeed and Furlan (2019)	Qatar	X	X	X	X	
20.	Abutaleb, McDougall, Basson, Hassan, and Mahmood (2019)	UAE	X	X	X	X	

*Note. DLU = Land-Use Diversity, DST = Density, DSG = Design, DAC = Destination Accessibility, DMG = Demand Management

Quality of Life

A better quality of life (QoL) is one of the paramount objectives of TOD adoption. A higher density may cause overcrowding and negatively affect the QoL, while mixed land use development may provide conveniences to residents and improve their QoL. Thus, there may be a trade-off between physical efficiency and QoL. Thus, a successful TOD adoption would not compromise the residents' QoL (Abdullah & Mazlan, 2016). In general, QoL can be viewed as the subjective aspects of well-being (Salvador-Carulla, Lucas, Ayuso-Mateos, & Miret, 2014). Felce and Perry (1995) introduced five domains of well-being namely; 1. physical, 2. material, 3. social, 4. emotional and 5. developmental activity. Each domain encompassed several sub-domains. For example, the physical well-being domain comprised health, fitness, personal safety and mobility. Meanwhile, material well-being domain includes housing quality, privacy, security and neighbourhood. Cross-examination with TOD literatures (Abdullah & Mazlan, 2016; Appleyard et al., 2019; Renne, 2007) revealed that only "neighbourhood" and "mobility" are matched with indicators that reflect benefits of TOD adoption for the residents. Thus, the present study assessed the impact of TOD adoptions on residents' QoL in terms of "neighbourhood" and "mobility".

Neighbourhood. In this study, quality of life from the neighbourhood aspect is perceived as residents' well-being with regards to living conditions and atmosphere in their residential areas that are located nearby railway stations. Indicators such as well-maintained neighbourhood, provision of adequate public facilities, pollution-free, crime-free, less traffic congestion, cost of living and affordable housing were adapted from several previous studies (Abdullah & Mazlan, 2016; Appleyard et al., 2019; Niles & Nelson, 1999; Yap & Goh, 2017) especially from Renne's (2007) work.

Mobility. On the other hand, quality of life in terms of "mobility" is viewed as ease for residents who lived nearby railway stations to move within the neighbourhood and reach other destinations outside of the neighbourhood. Indicators including walkability, safety, well-served public transport, incurred travel expenses and travel time consumption adapted from the same sources as "neighbourhood" aspect were used to measure the mobility dimension.

METHODOLOGY

This study conducted a cross-sectional survey to gather the research data. The survey targeted residents who used KTM Commuter Northern Sector train service. There are 20 railway stations under the management of KTM Commuter Northern Sector. The survey was conducted using self-completed questionnaire forms. There are two separate population involved in the survey study namely; 1. residents who use KTM Commuter Northern Sector service and 2. retailers who operate their business within 800-m buffer area from the railway station. On the other hand, the population for case study are 20 railway stations under the management of KTM Commuter Northern Sector (see Table 2).

Table 2: KTM Commuter Northern Sector Stations

No.	Station Names	No.	Station Names
1.	Padang Besar	11.	Bukit Mertajam
2.	Bukit Ketri	12.	Bukit Tengah
3.	Arau	13.	Butterworth
4.	Kodiang	14.	Simpang Ampat
5.	Anak Bukit	15.	Nibong Tebal
6.	Alor Setar	16.	Parit Buntar
7.	Kobah	17.	Bagan Serai
8.	Gurun	18.	Kamunting
9.	Sungai Petani	19.	Taiping
10.	Tasek Gelugor	20.	Padang Rengas

ANALYSES AND FINDINGS

This study had gathered a total of 440 responses within a week of data collection period. From these 440 responses, 407 were from residents who used the KTM Commuter Northern Sector train service, while the remaining 33 respondents were business owners and operators (retailers) that run their business at or nearby the railway station (within 800-m from the station). However, some of the respondents were excluded from the analysis due to incomplete responses and straight-lining responses. All related information about the survey responses was summarised in Table 3.

Table 3: Survey responses information

No	Information	Residents	Retailers	Total
1.	All responses	407	33	440
2.	Incomplete responses	4	-	4
3.	Straight-lining responses	43	-	43
4.	Total eligible responses	360	33	393

Critical Success Factors: TOD Indicators

In order to identify the critical success factors, mean scores from the ratings given by the respondents for all TOD indicators in the survey questionnaire were computed (Figure 1 and Figure 2). Next, the computed mean scores were compared with thresholds indicated by Darusalam and Hussin (2018) whereby mean scores ranged from 1.00 to 2.33 are categorised as "low", 2.34 to 3.67 are "medium" and 3.68 to 5.00 are "high".

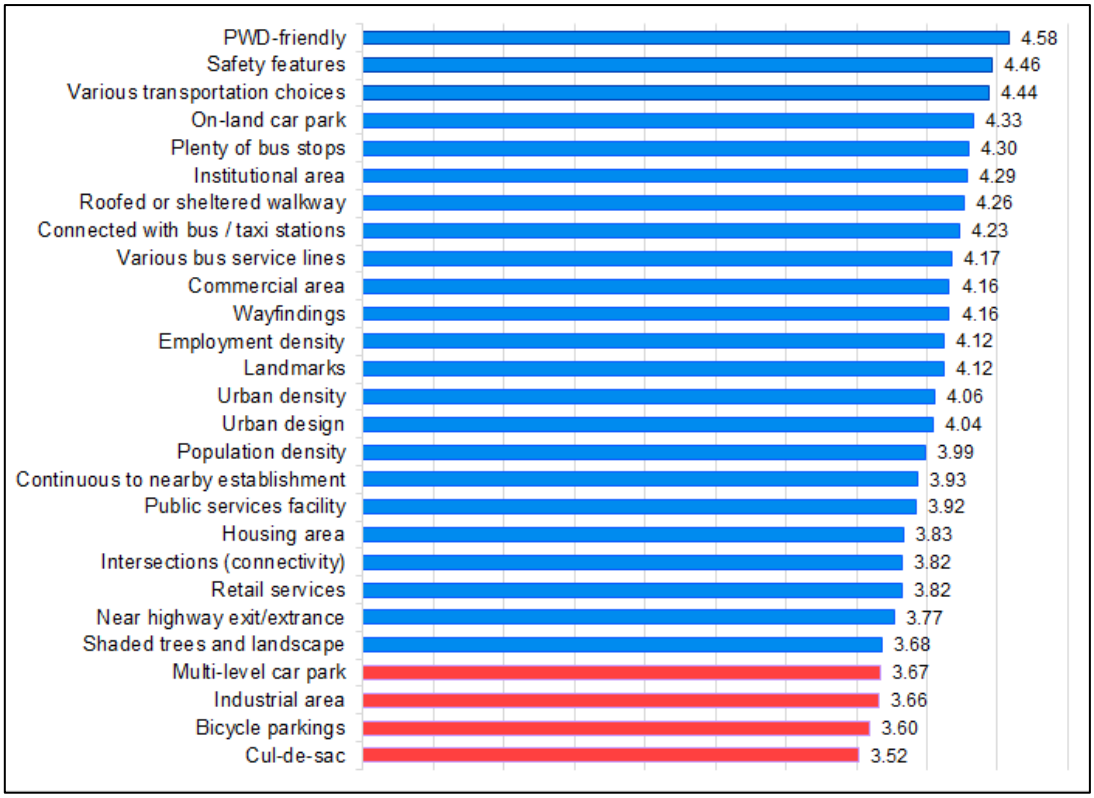

Figure 1: TOD indicators' mean scores (residents)

Figure 1 portrayed that people with disability (PWD) friendly walkway as the most important indicator in determining TOD adoption success. On the contrary, cul-de-sac (dead ends) as the least important indicator. Nevertheless, there were 23 indicators (except multi-level car park, industrial area land-use, bicycle parking and cul-de-sac) that could be categorised as "highly important" according to mean scores thresholds indicated by Darusalam and Hussin (2018).

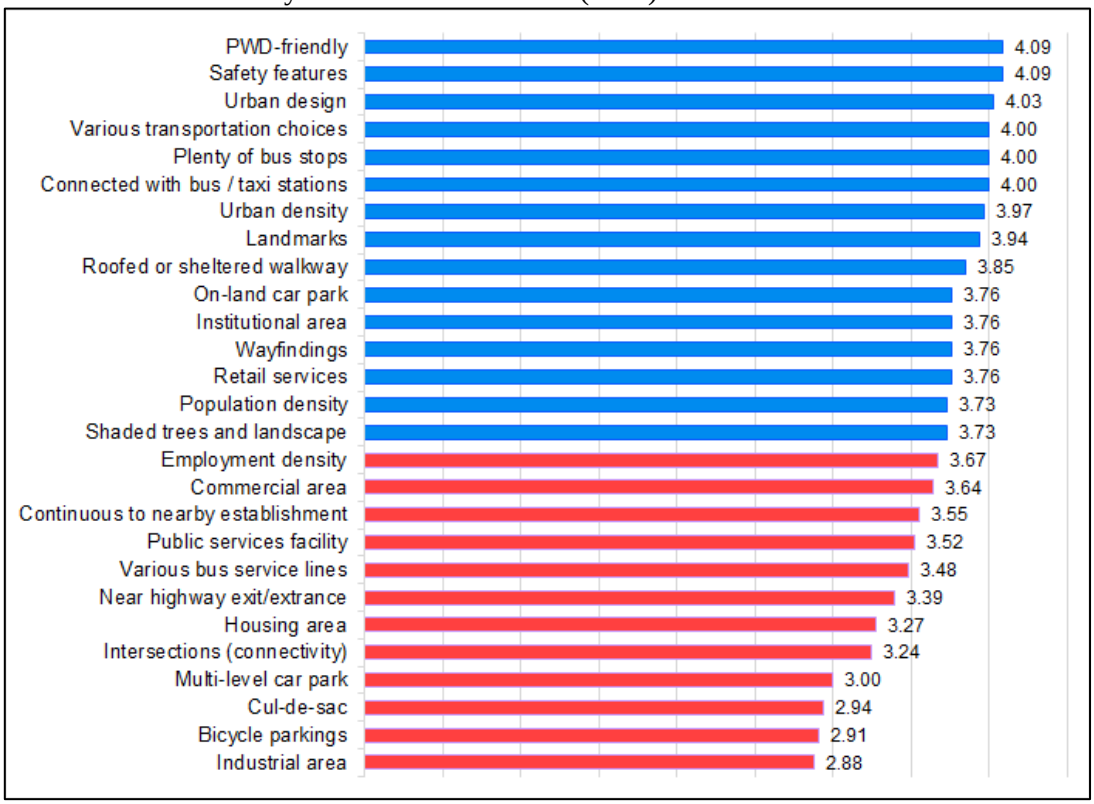

Figure 2: TOD indicators' mean scores (retailers)

On the other hand, both PWD-friendly walkway and walkway equipped with safety features (e.g., railings, bollards) topped the rank in Figure 2. Retailers viewed both indicators as equally important. Meanwhile, the least important indicator went to industrial area land-use. Contradict to residents' perceptions, retailers only perceived 12 indicators as "highly important" (critical) factors to determine success of TOD adoption. Nevertheless, both groups of respondents ranked multi-level car park, cul-de-sac, bicycle parking and industrial area land-use as the bottom four in the list (see Table 4). Although PWD-friendly walkway and walkway equipped with safety features top the rank in both residents and retailers' lists, residents viewed PWD-friendly walkway slightly more important than walkway with safety features. Overall, none of the indicator was classified as "low important" (mean ranged 1.00 to 2.33) by both respondents' groups.

Table Error! No text of specified style in document.**: The most and the least critical factors for TOD adoption success**

Indicators	Sample Sub-Groups			
	Residents	**Mean**	**Retailers**	**Mean**
Top 4	1. PWD-friendly	4.58	1. PWD-friendly	4.09
	2. Safety features	4.46	2. Safety features	4.09
	3. Various transportation choices	4.44	3. Urban design	4.03
	4. On-land car park	4.33	4. Various transportation choices	4.00
Bottom 4	1. Cul-de-sac	3.52	1. Industrial area	2.88
	2. Bicycle parking	3.60	2. Bicycle parking	2.91
	3. Industrial area	3.67	3. Cul-de-sac	2.94
	4. Multi-level car park	3.68	4. Multi-level car park	3.00

The Relationships between TOD Principles and QoL Dimensions

The relationships between TOD principles and QoL dimensions namely neighbourhood and mobility were assessed using PLS-SEM technique. PLS-SEM is a variance-based statistical analysis technique for estimating structural equation models (Hair et al., 2017). Typically, Malaysian researchers use SmartPLS software as a tool to conduct PLS-SEM analysis because there are lots of training and technical support available for this software. The research team of this study also used the same software, namely SmartPLS version 3.3.9 (Ringle, Wende, & Becker, 2015). This study used PLS-SEM technique to fulfil the second research objective because it is among the best statistical analyses to predict causal relationship between two or more latent variables (Hair, Ringle, & Sarstedt, 2011; Šiška, 2018).

In general, PLS-SEM analysis involves two stages of assessment namely; 1. measurement model, and 2. structural model. The purpose of measurement model assessment is to evaluate the validity and reliability of constructs (latent variables) being studied. Meanwhile, structural model is performed to test the significance of hypothesised relationships between constructs (Hair et al., 2019). Altogether, there were two sets of PLS-SEM models; 1. travel for working, and 2. travel for leisure, established to estimate the impact of TOD adoption on respondents' QoL. As discussed in the literature review section, QoL for residents' view was operationalised in terms of Neighbourhood (QLN) and Mobility (QLM) qualities, while TOD adoptions were operationalised in terms of 5Ds principles; 1. Land-Use Diversity (DLU), 2. Density (DST), 3. Walkable Design (DSG), 4. Destination Accessibility (DAC), and 5. Demand Management (DMG).

Structural Model Analysis

To assess the significance of relationships between constructs in the structural model, values such as *t*-statistics and *p*-values were observed (Mandhani, Nayak, & Parida, 2020; Zhang, Liu, Lu, & Xiao, 2019). Meanwhile, path coefficients, β were assessed to indicate the direction of the relationships being studied (negative or positive relationships). A significant relationship should demonstrate *t*-statistics

more than 1.65 (t > 1.65), for one-tailed test (Hair et al., 2019). All structural model results were illustrated in Figure 3 (work sample group) and Figure 4 (leisure sample group).

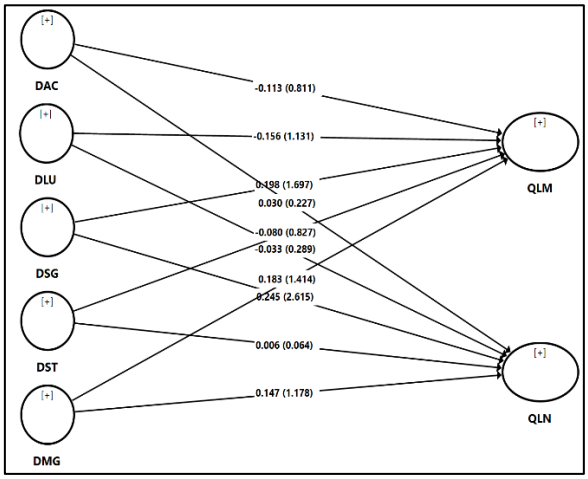

Figure 3: Structural model (work sample group, n = 192)

Note. DLU = Land-use diversity, DSG = Walkable design, DST = Density, DAC = Destination accessibility, DMG = Demand management, QLM = Quality of life: Mobility, QLN = Quality of life: Neighbourhood.

**Values inside brackets represent t-values. Values outside brackets represent path coefficients.*

Results presented in Figure 3 revealed that only two relationships were significant. DSG showed significant and positive relationships with both outcome variables, QLM (β = 0.198, t = 1.697) and QLN (β = 0.245, t = 2.615). The results were implying that only walkable design has a positive impact on residents' neighbourhood and mobility qualities from the viewpoints of respondents who rode the train for working purpose.

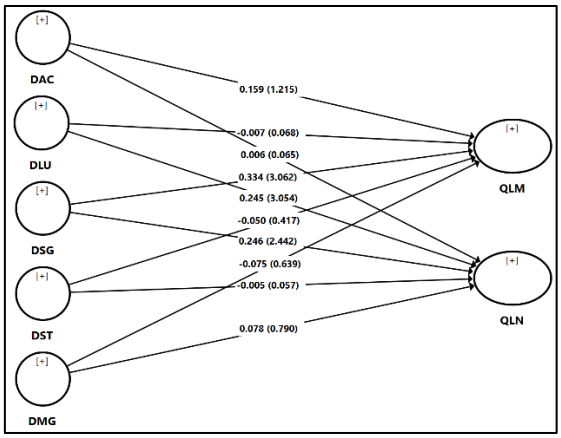

Figure 4: Structural model (leisure sample group, n = 168)

Note. DLU = Land-use diversity, DSG = Walkable design, DST = Density, DAC = Destination accessibility, DMG = Demand management, QLM = Quality of life: Mobility, QLN = Quality of life: Neighbourhood.

**Values inside brackets represent t-values. Values outside brackets represent path coefficients.*

Figure 4 portrays the structural model for residents who travel to work by train, which encompassed 10 relationships. In comparison to structural model of travel for working purpose, there were three significant relationships for leisure sample group structural model. In the same vein, DSG showed significant and positive relationships with both outcome variables, QLM (β = 0.334, t = 3.062) and QLN (β = 0.246, t = 2.442). Another significant relationship found in the leisure sample group structural model was between DLU and QLN (β = 0.245, t = 3.054). The results were implying that both land-use diversity and walkable design had a positive impact on residents' neighbourhood quality from the perspective of travel for leisure sample group. In addition, leisure sample group also demonstrated that walkable design had a positive impact on residents' mobility quality. All structural model results were summarised in Table 5.

Table 5: Significance of the relationships (work)

Relationships	Path Coefficients (β)	*t*-statistics	*p*-values
Demand → Mobility	.183	1.398	.081
Demand → Neighbourhood	.147	1.134	.128
Density → Mobility	-.080	.792	.214
Density → Neighbourhood	.006	.062	.475
Design → Mobility	.198	1.667	.048
Design → Neighbourhood	.245	2.585	.005
Destination → Mobility	-.113	.804	.211
Destination → Neighbourhood	.030	.228	.410
Diversity → Mobility	-.156	1.117	.132
Diversity → Neighbourhood	-.033	.287	.387

*Note. One-tailed test

Results presented in Table 5 revealed that only two relationships were significant. Design showed significant and positive relationships with both outcome variables, Neighbourhood (t = 2.585, p = 0.005) and Mobility (t = 1.667, p = 0.048). The results were implying that only walkable design has a positive impact on residents' neighbourhood and mobility quality from the viewpoints of respondents who rode the train for working purpose.

Meanwhile, the structural model assessment for retailers, two models were established to compensate with the limitation of sample size. According to Barclay et al. (1995), the minimum required sample size to estimate the causal relationship in the PLS structural model should at least follow the 10 times rule (i.e., 10 times the largest number of structural paths directed at a particular construct in the structural model). Since this study only obtained 33 samples for the retailers' group, only the maximum of three structural paths can be estimated in the retailers' structural model. On that account, the effect of five TOD success factors on the outcome variables need to be tested in two separate models to overcome this issue. Hence, one model consisted of three predictors namely Density, Diversity and Design (see Figure 5) and another model with two predictors that include Destination and Demand (see Figure 6) were established to appropriately determine the significance of relationship between TOD success factors and the retailers' business outcomes (performance and well-being).

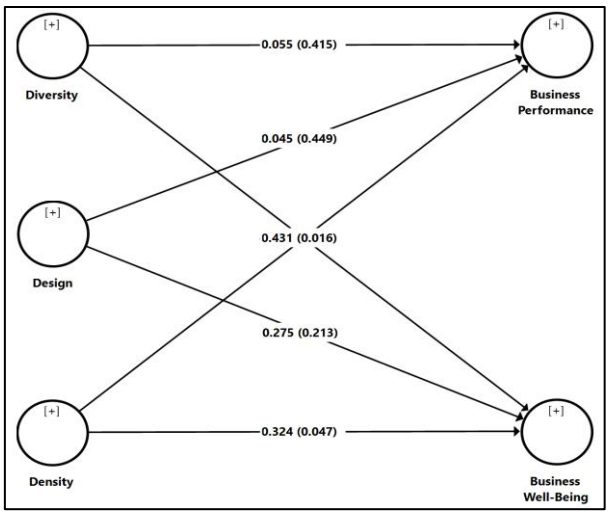

Figure 5: Structural model (retailers) 3Ds

*Note. Values inside brackets represent *p*-values. Values outside brackets represent path coefficients.

Figure 5 portrays the structural model for retailers' samples which comprised three predictor variables, two outcome variables and six relationships (i.e., three directed at Business Performance and three directed at Business Well-Being).

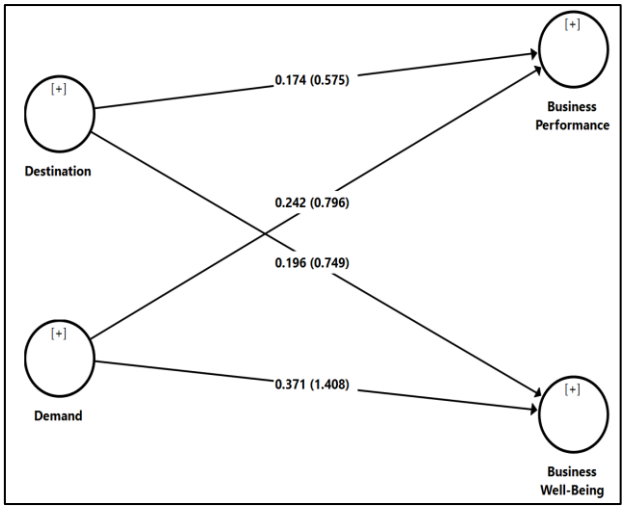

Figure 6: Structural model (retailers) 2Ds

*Note. Values inside brackets represent *p*-values. Values outside brackets represent path coefficients.

Figure 6 exhibits the structural model for retailers' samples with two predictor variables, two outcome variables and four relationships (i.e., two directed at Business Performance and two directed at Business Well-Being). Again, to assess the significance of relationships between constructs in the structural model, values such as *t*-statistics and *p*-values were observed (Mandhani et al., 2020; Zhang et al., 2019). Meanwhile, path coefficients, β were assessed to indicate the direction of the relationships being studied (negative or positive relationships). A significant relationship should demonstrate *t*-statistics more than 1.65 ($t > 1.65$), for one-tailed test and *p*-values less than 0.05 ($p < 0.05$) (Hair et al., 2019). All structural model results for retailers' data were summarised in Table 6.

Table 6: Significance of the relationships (retailers)

Relationships	**Path Coefficients (β)**	***t*-statistics**	***p*-values**
Density → Business Performance	.431	2.144	.016
Density → Business Well-Being	.324	1.674	.047
Design → Business Performance	.045	.128	.449
Design → Business Well-Being	.275	.797	.213
Diversity → Business Performance	.055	.214	.415
Diversity → Business Well-Being	-.132	.494	.311
Demand → Business Performance	.242	.796	.213
Demand → Business Well-Being	.371	1.408	.080
Destination → Business Performance	.174	.575	.283
Destination → Business Well-Being	.196	.749	.227

*Note. One-tailed test

As a result, only Density demonstrated significant relationships with both outcome variables at $t = 2.144$, $p = 0.016$ for Business Performance and $t = 1.674$, $p = 0.047$ for Business Well-Being. The results were implying that only density elements (population, employment and urbanisation) matters to the retailers in sustaining their business at the transit station areas.

DISCUSSIONS AND CONCLUSION

The first research objective of the present study is; RO1: *To identify the critical factors to successfully integrate residential and retail areas at the Northern Malaysia railway stations using Transit Oriented Development (TOD) principles,* was accomplished by computing mean scores from the ratings given by the respondents for all TOD indicators in the survey questionnaire. Further, the computed mean scores were categorised according to thresholds introduced by Darusalam and Hussin (2018) as the following; 1.00 to 2.33 (low), 2.34 to 3.67 (medium) and 3.68 to 5.00 (high). Out of 27 indicators, residents' sample group rated 23 indicators as "high importance" while the rest as "medium importance". On the other hand, retailers' sample group only perceived 12 indicators as "high importance". Nevertheless, both sample groups did not rate any indicator as "low importance".

Also, both sample groups rated almost similar indicators as the top 4 and bottom 4 in the importance rank. Top 4 indicators that were critical from the residents' point of views were including; 1. PWD-friendly walkway, 2. walkway with safety features, 3. various public transportation choices, and 4. on-land car park. Meanwhile, top 4 indicators that were critical from retailers' perceptions were; 1. PWD-friendly walkway, 2. walkway with safety features, 3. urban design, and 4. various public transportation choices. For the bottom 4 indicators, both residents and retailers ranked multi-level car park as the least important indicator. The remaining less important indicators were cul-de-sac, bicycle parking and industrial areas land-use.

In comparison to other empirical findings that also studied TOD adoption based on community's perceptions (Abutaleb et al., 2020; Jaafar Sidek et al., 2020; Kamruzzaman et al., 2016; Meng et al., 2021; Pongprasert & Kubota, 2019), only Yap et al. (2021) assessed the level of importance for TOD criteria. Nevertheless, the present study assessed a wider range of TOD criteria compared to Yap et al. (2021). For instance, Yap et al. (2021) only assessed criteria under "diversity" principle in general as mixed land-use. On the contrary, this study had assessed "diversity" principle specific to four-types of land-use development namely, residential, commercial, institutional and industrial. Unlike Yap et al. (2021), the present study had gathered not only residents' perceptions, but also retailers' insights. Thus, this study did provide a more comprehensive assessment than previous studies.

Until recently, the impact of critical success factors of TOD adoption on communities' QoL was left untested in the academic studies. Existing studies had reported positive impact of TOD adoption on household transportation expenditures (Dong, 2021), positive impact of transit-oriented shopping mall developments on train ridership (Abutaleb et al., 2020) and positive relationship between TOD adoption and ridership demand (Nyunt & Wongchavalidkul, 2020). Although QoL was perceived as the benefit gained from TOD adoption in previous studies (Abdullah & Mazlan, 2016; Appleyard et al., 2019; Gomez et al., 2019; Yap et al., 2021), none of the study statistically test the relationship between TOD adoption and QoL.

On that account, the present study had produced a novel empirical evidence that portrayed the impact of critical success factors of TOD adoption on residents' QoL in the form of content neighbourhood and ease of mobility. PLS-SEM analysis performed in the present study demonstrated significant positive effects of "walkable design" principle on both QoL dimensions, for residents who travel to work. Additionally, residents who travel for leisure purpose also revealed a positive relationship between "land-use diversity" principle and neighbourhood. Besides residents' perspectives, the present study also considered the retail operators' viewpoints in estimating the impact of TOD adoption on QoL. Unlike residents' perspectives, retail operators' QoL was assessed in terms of business performance and business well-being. "Density" principle showed positive impacts on both retailers' business performance and business well-being.

To the best of our research team's knowledge, statistical results that verify the impact of critical success factors of TOD adoption on communities' QoL was reported for the first time in the present study. Though direct comparisons with previous empirical studies were not relevant due to differences in operationalisation of TOD success factors and QoL dimensions being studied, current finding offered a

novel empirical evidence by operationalising TOD adoption based on its development principles (i.e., 5Ds) and testing QoL as its outcome variable. Current finding also supported notions of prior scholars who viewed QoL as the benefit realised from TOD adoption (Abdullah & Mazlan, 2016; Appleyard et al., 2019; Gomez et al., 2019; Yap et al., 2021). Albeit statistical evidence from this study verified that not all TOD principles would affect QoL of the studied community, it highlighted factors that are truly critical (i.e., walkable design, land-use diversity and density) in ensuring TOD adoption brings benefits to the community.

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