# Understanding contextual attractiveness factors of transit orientated shopping mall developments (TOSMDs) and shopper passenger ridership on the Dubai Metro Redline

#### Abstract

Shopping mall studies reveal variable attractiveness factors and patronage. Transit Oriented Development (TOD) studies focus on TOD's impact on transit ridership. However, there is limited research on the area of Transit Oriented Shopping Mall Developments (TOSMDs) and the impact of the attractiveness of TOSMDs on the ridership of nearby stations. This study focused on explaining the impact of the contextual factors of TOSMDs on shopper-passenger ridership. Structural modelling indicated that contextual factors were related to shopper passenger ridership preferences to stations nearby shopping malls. This result can assist passenger forecasting models in optimising TOSMD planning and sustainability of transit networks. (100)

**Keywords:** station ridership preference; station boarding factors; Transit Oriented Development; shopping mall attractiveness; passenger forecasting models

### 1. Introduction

The physical context of Transit Oriented Development (TOD) is about concentrating and integrating both transit and development to encourage people to walk, cycle and use public transit instead of cars (Milakis & Vafeiadis, 2014; Singh *et al.*, 2017). Context refers to the layout and configuration of urban form; including blocks, parcels, buildings, street networks, pedestrian-oriented attributes, and property land uses (Lee, 2013). TOD benefits include increased access to public transportation and efficient land use, typically in the form of denser, mixed-use, and pedestrian-friendly development oriented to transit

(Higgins & Kanaroglou, 2016; Singh *et al.*, 2017). A mixed-use shopping mall (i.e. retail, commercial, residential and social) can be developed as a TOD, where shoppers drive their cars less and, instead ride nearby mass transit (Bernick & Cervero, 1997) and therefore can result in increased transit ridership (Singh *et al.*, 2017).

However, the potential benefits of coordinated transportation and land use planning through TOD are sometimes not well considered (Higgins & Kanaroglou, 2016), particularly in the case of a Transit Oriented Shopping Mall Development (TOSMD), which refers to a shopping mall (SM) nearby a transit station in a TOD context. Shopping malls are often considered to be the retail, social, and community centres of their communities (Feinberg & Meoli, 1991). Rydin (2019) recently highlighted the social importance of shopping areas and the need for planning to engage further with this feature of urban lifestyle. Hence, there is a need to explore the effect of TOSMD context in order to better understand the number of passengers using a nearby transit station and its capacity to serve shopper passengers. A transit station nearby a TOSMD can reach its capacity in a short time as a result of the level of people congestion of a nearby shopping mall (Kok, 2007), resulting in costly upgrades, and disruption to the rail service and travellers. Moreover, the population growth in cities, as well as visiting tourists, can exacerbate this problem.

Several scholars have studied TOD design principles (Mingqiao *et al.*, 2014; Newman, 2009; Thomas & Bertolini, 2014), rail ridership (Taylor & Fink, 2003; Chu, 2004; Boyle, 2006; Choi et al., 2012), and the relationship between them (Acheampong & Silva, 2015; Cervero, 1994; Sung & Oh, 2011). The majority of these studies focused on analysing the impact of transit systems, stations, land use, and value creation. Studies have also considered the transit service level and Origin-Destination (O-D) trip analysis (Cervero & Duncan, 2002; Chen *et al.*, 2011; Du & Mulley, 2007; Gutiérrez *et al.*, 2011; Zhao *et al.*, 2007). Other studies focused on shopping mall characteristics, and analysed shopping mall patronage within the shopping mall context, with no mention of the reverse impact of the specific mall contextual impact on the forecasting models of the ridership in a nearby transit station (De Juan, 2004; Mundell, 2013; Telci, 2013; Thang & Tan, 2003). A number of researchers have identified the need for more detailed analysis of station environments, to better understand the connection between station use and its context (Cardozo *et al.*, 2012; Zemp *et al.*, 2011), based on land use and transport developments often being poorly aligned with each other (Chorus, 2012).

Against this background, this study examines transit shopper passengers that comprise part of total ridership at a metro station close to a TOSMD. Specifically, it attempts to clarify TOSMDs' related contextual attractiveness factors that affect the ridership of shopper passengers using a transit station associated with a nearby TOSMD on the Dubai Metro Redline in the UAE. Shopper passenger ridership is considered to be impacted by the location, space, and store's contextual attractiveness factors of TOSMDs. The study examines shopper passenger ridership preferences and associates it with the existence of a nearby TOSMD context. To understand this relationship, the study reviews the location, stores, and space contextual attributes of TOSMDs, and Station Boarding Factors (SBF). It then investigates how the ridership preferences of shopper passengers boarding at a station near a TOSMD is associated with these contextual attractiveness factors.

This study is structured and organised as follows. Section two presents the review of the existing literature relevant to contextual attractiveness factors of TOSMDs and Station Boarding Factors (SBFs) for transit stations. Section three presents the methodology and data analysis techniques. Section four discusses the results of the study, and finally, the last section concludes with the implications of the findings, limitations, and proposed

further research.

#### 2. Literature review

# 2.1 Transit Oriented Development (TOD)

Transit Oriented Development (TOD) is widely defined as a compact, mixed-use community, centred around a transit station that, by design, invites residents, workers, and shoppers to drive their cars less and ride mass transit more (Bernick & Cervero, 1997; Cervero, 2004). It links mixed-use developments to frequent, accessible rail transit services to stimulate decreased expansion of land use and improve transport integration. The majority of research that has applied TOD elements analyse the surrounding context of a transit network, i.e. city context such as Melbourne, Sydney, Brisbane - Australia (Searle *et al.*, 2014); Seoul - South Korea (Taehyun *et al.*, 2016); Beijing - China (Sun *et al.*, 2016); Brisbane - Australia (Kamruzzaman *et al.*, 2014); New York – USA and Hong Kong - China (Loo *et al.*, 2010) but often do not adequately address all of the salient factors impacting transit station ridership. Specifically, current studies do not consider the impact of the contextual factors (namely location, space, and stores) of attractiveness of TOSMDs on shopper passengers ridership using a transit station in a TOD context. The term TOSMD was only recently mentioned in literature and explained as a shopping mall (SM) near a transit station in a TOD context (Abutaleb *et al.*, 2019).

Therefore, since TOD can cause increased transit ridership (Singh *et al.*, 2017), analysing the attractiveness of a shopping mall within a TOD context and station boarding factors is considered crucial to ensure a transit station is continuing to offer accessibility to shopper passengers arriving at a station from a nearby TOSMD. However, the relationship between the extent of usage of a transit station and the existence of a nearby TOSMD within a TOD context has not been adequately investigated.

# 2.2 Contextual attractiveness of Transit Oriented Shopping Mall Developments (TOSMDs)

Shopping malls often consist of a mix of stores, food courts, restaurants, cinemas, children's play areas, interactive entertainment, social use areas, relaxation spaces and promotional areas (Farrag *et al.*, 2010). The level of the shopping malls' attractiveness to people and people congestion is likely to be greater with a wider assortment of services and products provided by shopping malls (Rajagopal, 2009). As a result, the growth patterns of shopping malls in some cities has become a significant element in the urban landscape as better mobility can improve cities' economies and tourism intensity (Albalate & Bel, 2010). Attractiveness factors of shopping malls have been studied for different reasons, such as predicting and optimising mall patronage (Arslan *et al.*, 2010; Wei Khong & Sim Ong, 2014), identifying the optimal mix of activities in shopping malls, developing retailing strategies (Dahsh & Dasa, 2014; El-Adly, 2007; Kushwaha *et al.*, 2017; Tandon *et al.*, 2016), understanding socio-spatial dynamics (Erkip, 2005), and determining malls' rent (Ke & Wang, 2016). The attractiveness factors of shopping malls can change from one context to another. Different TOSMD contexts can contribute to varying levels of nearby station use (Cervero, 2004; Rajagopal, 2009).

Contextual factors refer to the context of TOSMDs attractiveness, measured by both TOD and shopping mall attractiveness attributes. The majority of researchers distinguish between attractiveness factors of shopping malls and design factors of TODs (Abutaleb *et al.*, 2019). They are studied separately in retail and urban planning literature, respectively. However, the contextual factors of attractiveness of TOSMDs, that have been identified in the literature, can be classified into three general categories: TOSMD location context related factors such as the ease of reaching the mall and the crowdedness of buildings around the mall, TOSMD space related factors such as the size and carpark of the mall, and TOSMD stores related factors such as the number of stores inside and around the mall (see Table 1 for a summary of studies on contextual attractiveness factors of TOSMDs).

		Contextual	
Author(s)/year	Country	attractiveness	Attributes
		factors of	
		TOSMDs	
El-Adly (2007); Farrag et al.	UAE; Egypt		Ease of reaching mall (e.g. directions)
(2010)			
Jacobson & Forsyth (2008);	USA; China	Location	Crowdedness and compactness of
Li et al. (2016)		context	buildings around mall
Pacheco-Raguz (2010)	Philippine	(Loc_cont)	Car traffic congestion around
			shopping mall
Taehyun et al. (2016)	South Korea		Proximity of a metro station
González-Hernández &	Mexico		Size of mall
Orozco-Gómez (2012)			
Rajagopal (2011)	Mexico	Space	Average size of shops in mall
Rajagopal (2011)	Mexico	context	Number of shops in mall
van Lierop et al. (2017)	America,	(Spa_cont)	Availability of parking facilities
	Canada, and the		
	Netherlands		
Khare (2011)	India		Grocery store present (e.g.
			Carrefour)
Ahmad (2012); El-Adly	Saudi Arabia;		Availability of cinema
(2007)	UAE	Stores	
Farrag et al. (2010)	Egypt	context	Ease of finding desired store inside
		(Sto_cont)	mall (i.e. Virgin store)
van Lierop et al. (2017)	America,		Extent of shops surrounding shopping
	Canada, and the		mall
	Netherlands		
Kamruzzaman et al. (2014)	Australia		Station walkable distance from mall
Pacheco-Raguz (2010)	Philippine	TOSMDs	Car traffic congestion in area of mall
Jacobson & Forsyth (2008)	USA	attractiveness	Lacking enough number of car
		(Att cont)	parking spaces in area of the mall
Lund (2006)	USA	(AIL_COIII)	Walking access from station to mall

Table 1. Summary of studies on contextual attractiveness factors of TOSMDs.

From the literature review, it was concluded that the effect of shopping malls' attractiveness factors is mainly captured in the mall patronage but has not been considered in relationship to the ridership at nearby transit stations.

Although researchers, such as Castillo-Manzano & López-Valpuesta (2009) and Zemp *et al.* (2011) indicated that there was a relationship between railway stations and their context, it is not clear to what extent the contextual location, space, and stores attributes of attractiveness of TOSMDs impact nearby transit station ridership.

#### 2.3 Station Boarding Factors (SBFs)

Sohn & Shim (2010) aggregated the factors affecting Metro demand into three categories, including 1) built environment, 2) external connectivity, and 3) intermodal connection. These three categories contained 24 metro boarding independent variables identified in previous studies (Boyle, 2006; Cao *et al.*, 2009; Cervero, 2006; Chu, 2004; Estupiñán & Rodríguez, 2008; Khattak & Rodriguez, 2005; Kim *et al.*, 2007; Kuby *et al.*, 2004; Quade, 1996; Yao, 2007). Among the identified metro boarding variables, the study showed "*commercial floor area*" as significantly associated with station boarding. However, the study did not capture the impact of the variability in "*commercial floor area*" particularly in the case of TOSMD context although researchers such as Gutiérrez *et al.* (2011); Rajagopal (2011); Khare (2011) indicated that location, space, and stores of a shopping mall might limit the effect of its attractiveness and therefore presumably its impact on the number of shopper passengers intending to use a nearby transit station.

In conclusion, although researchers, such as Castillo-Manzano & López-Valpuesta (2009) and Zemp et al. (2011), indicated that there is a relationship between railway stations usage and their context, it is not clear to what extent the contextual location, space, and stores attributes of attractiveness of TOSMDs impact nearby transit station ridership.

#### 3. Methods

The research was designed to provide an insight into the shopper passenger ridership at Dubai Metro Redline stations in relation to a nearby shopping mall development or TOSMD and was non-experimentally designed using a survey questionnaire (Fowler Jr, 2013; Phillips & Burbules, 2000). The study measured the association between the contextual factors of TOSMDs' attractiveness (the independent factors), and the ridership preference factors of shopper passengers using TOSMDs' nearby stations (the dependent factor). Shopper passengers (individuals) boarding at seven metro stations nearby TOSMDs were surveyed to understand their perspectives on shopping mall attractiveness and ridership preferences.

# 3.1 Study area

Dubai Metro Redline (Figure 1) has two stations connected to Dubai airport (T1, T3) and the seven stations (circled) that are either connected to, or within a walkable distance of around 0.8 km of a shopping mall. These malls are typically in high density, mixed communities along Sheikh Zaid Road, and the old Deira area. The Dubai Metro stations include urban designed walkways which connect the mall and a nearby metro station. The Dubai Metro Redline is 52.1 kilometres long and was opened in 2009.



Figure 1. Dubai Metro Redline route map and stations within 0.8km (circled) of a shopping mall

The percentage of checking-in passengers at Dubai Metro Redline stations in the period from 2013 to 2018 (the period when there was no major change in the line services) is depicted in Figure 2.



Figure 2. Percentage of checking-in passengers at stations of Dubai Metro Redline in the period 2013 to 2018. (Source: Rail Operations Department (RTA).

As can be seen in Figure 2, Dubai Metro Redline stations near TOSMDs generally have a higher percentage of checking-in passengers.

#### 3.2 Data collection

The data used to examine the extent of station use by shopper passengers (unit of analysis) and the contextual attractiveness factors (location, space, and stores) of TOSMDs and variables in the modelling, were collected from various sources. TOSMDs were identified using the public internet, GIS and Google maps based on a walkable distance around 0.8km (Gutiérrez *et al.*, 2011; Kuby *et al.*, 2004; O'Neill *et al.*, 1992; Zhao *et al.*, 2003). The initial list of independent contextual attractiveness factors of TOSMDs was synthesised from the literature review summarised earlier. The study used data collected from a 72-question survey. The survey questionnaire was divided into six sections (see Table 2).

Section	Number of questions	Details
Section A	11	Demographic characteristics
Section B	7	Mall visit behavioural characteristics
Section C	28	Mall internal characteristics impacting choice to visit it
Section D	20	Mall external neighbourhood characteristics impacting choice to visit it
Section E	4	Level of agreement to potentially use a metro station nearby the mall
Section F	2	Respondents voluntary comments and email details

Table 2. Study survey summary sections.

The survey uses closed questions designed for easy and prompt response (El-Adly, 2007), with sections C, D, and E using a 5-point Likert scale (Kamruzzaman *et al.*, 2016).

The survey questionnaire was pre-tested using a collaborative participant pretesting method (Cooper, 2011) with a sample of 10 shopper passengers. Data for the main study was collected during April and May 2019 via sampling conducted at the seven metro stations nearby shopping malls, as shown in Figure 2. Participants were purposively selected by first determining the shopping mall passengers that had come to board the metro at the nearby station (Guarte & Barrios, 2006). Shopper passengers were given the option to complete the survey within two days, using a web link to the survey. Out of 700 surveys distributed, 400 survey responses were received (response rate of 57%); including 168 survey responses completed online (42%), and 232 station completed (58%).

The data from the 400 surveyed shopper passengers were used to explore the principal list of contextual attractiveness factors of TOSMDs used to construct the SEM model explaining the volume of shopper passengers using Dubai metro Redline stations nearby TOSMDs.

# 3.3 Descriptive statistics

Table 3 presents a profile of the respondents in terms of the level of importance associated with items of space, location, and stores context of TOSMDs, and the level of desire to potentially use a metro station nearby a shopping mall. As can be seen in Table 3, more than half the respondents ranked the space context items as important (M=3.88; SD=0.72; including size of the mall (54%), average size of shops (59%), and number of shops (50%). A high percentage of respondents also ranked location context items as important (M=4.02; SD=0.62); including ease of reaching the mall (62%), ease of finding a desired store inside the mall (45%), and proximity of other modes of transport (35%). However, a high percentage of respondents ranked store context items as neutral (M=2.96; SD=0.84); including crowdedness and compactness of buildings around the mall (25%), car traffic congestion around the mall (22%), and high number of shops surrounding the shopping mall (39%). Nonetheless, a high percentage of respondents agreed on intending to use the metro station close to a mall (M=3.46; SD=0.76); mainly because the station is at a walkable distance from the mall, as explained by 52% of the respondents.

Table 3. Attractiveness of TOSMDs contextual factors (n=400).

Scale=	No Impor	ot rtant	2	2	ŝ	}	4	4	Ve Impo	ery ortant		
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	М	SD
*Space context												
Size of the mall	6	2%	18	5%	31	8%	216	54%	129	32%	4.11	0.84
Average size of shops	3	1%	29	7%	72	18%	235	59%	61	15%	3.81	0.81
Number of shops	3	1%	34	9%	99	25%	200	50%	64	16%	3.72	0.86
(M=3.88; SD=0.72)												
*Location context												
Ease of reaching the mall (e.g. directions)	1	0%	3	1%	4	1%	249	62%	143	36%	4.33	0.56
Ease of finding a desired store inside the mall (e.g. Virgin store)	1	0%	2	1%	112	28%	181	45%	104	26%	3.96	0.76
Proximity of other modes of transport ( <i>M</i> =4.02; <i>SD</i> =0.62)	2	1%	49	12%	99	25%	141	35%	109	27%	3.77	1.00
*Store context												
Crowdedness and												
compactness of buildings	35	9%	126	32%	99	25%	118	30%	22	6%	2.92	1.08
Car traffic congestion around the shopping mall	24	6%	115	29%	87	22%	137	34%	37	9%	3.12	1.11
High number of shops surrounding the shopping	31	8%	116	29%	154	39%	83	21%	16	4%	2.84	0.97
maii ( <i>M=2.96; SD=0.84</i> )												
**Shopper passengers ride	rship pr	eferend	ces									
L intend to use the metro												
station close to the mall	6	2%	5	1%	5	1%	207	52%	177	44%	4 36	0.72
because; the station is at walkable distance	0	270	U	1,0	U	170	207	0270	1,,,	, o		0.72
I intend to use the metro												
station close to the mall	11	3%	125	31%	105	26%	76	19%	83	21%	3.24	1.18
congestion in the mall area												
I intend to use the metro												
station close to the mall because: there is lack of	28	7%	138	35%	155	39%	46	12%	33	8%	2.80	1.02
enough car parking spaces	_0	, /0	100	2270	100	2270	.0	12/0	20	070	2.00	1.02
in the mall area $(M=3.46: SD=0.76)$												

\* Scale values range from 1 ("Not important") to 5 (Very important");

\*\* Scale values range from 1 ("Strongly disagree") to 5 (Strongly agree"); the higher the mean, the higher the attractiveness with that particular aspect.; FM= mean, SD= standard deviation, Freq=frequency.

# 3.4 Analytical approach

This study explains the effect of TOSMD's attractiveness factors associated with location, store, and space context with the number of shopper passengers boarding-in at a nearby transit station. Similar studies such as El-Adly (2007) addressing the effect of shopping malls attractiveness factors on mall patronage used a Principal Component

Analysis (PCA) approach in measuring shopper attractiveness factors and also to assess the measurement validity. Therefore, location, stores, and space contextual attractiveness factors of TOSMDs were the independent constructs, and the ridership preference of shopper passengers boarding at nearby transit station was the dependent construct.

The statistical data, in the case for Dubai Metro Redline, indicated that stations next to shopping mall developments generally have higher ridership than many other stations. Therefore, the seven metro stations next to shopping malls (see Figure 2) were chosen for survey data collection from shopper passengers intending to use the metro stations close to malls. For further explanation, these shopper passengers were profiled according to the level of importance attracted to items of space, location, and stores context of TOSMDs, and their ridership preferences to use a metro station nearby a shopping mall.

The factors identified from the PCA were then subjected to confirmatory factor analysis to validate the outcome from this analysis following the empirical model presented by Sohn & Shim (2010) which examined on-boarding factors affecting demand at a station level (refer to section 2.3). This study also utilised a Structural Equation Modelling (SEM) approach used by Sohn & Shim (2010) to compare and determine the impact of contextual attractiveness factors of TOSMDs using the seven stations nearby TOSMDs. Finally, the study's explanatory model was examined for statistical goodness of fit.

#### 4. Results

# 4.1 Contextual attractiveness factors of TOSMDs

The result of the Principal Component Analysis (PCA) is shown in Table 4. It shows that 12 items explain 67.33% per cent of data variability. Only four items (namely, q0019:

Grocery store presence, q0020: Cinema presence, q0057: Availability of parking facilities, and q0070: Walking access from the station to the mall) were excluded from the analysis as they were not significantly loaded (less than 0.5) to any of the four revealed constructs (Lai & Chen, 2011), namely Space context (Spa\_cont), Location context (Loc\_cont), Stores context (Sto\_cont), and shopper passenger ridership preferences (Shopper\_Pass\_pref) at the station. Confirmatory Factor Analysis (CFA) was then used to relate variables and assess model fitness.

Table 4. TOSMD's contextual attractiveness impacting shopper passengers' ridership.

		Contextual attractiveness factors									
Code	Variable	Space context (Spa_cont)	Location context (Loc_cont)	Store context (Sto_cont)	Number of shopper passengers (Shopper_ Pass_pref)	Eigenvalue	Variance explained (%)	Cronbach α			
q0027	Size of the mall	0.846				3.38	28.13	0.82			
q0028	Average size of shops	0.897									
q0029	Number of shops	0.769									
q0043	Ease of reaching the mall (e.g. directions)		0.723			1.87	15.58	0.67			
q0044	Ease of finding a desired store inside the mall (e.g. Virgin store)		0.776								
q0066	Proximity of other modes of transport		0.760								
q0047	Crowdedness and compactness of buildings around the mall			0.771		1.78	14.80	0.70			
q0049	Car traffic congestion around the shopping mall			0.764							
q0050	High number of shops surrounding the shopping mall			0.817							
q0067	I intend to use the metro station close to the mall because; the station is at walkable distance from the mall				0.633	1.06	8.82	0.66			
q0068	I intend to use the metro station close to the mall because; there is car traffic congestion in the area of the mall				0.812						
q0069	I intend to use the metro station close to the mall because; there is lack of enough car parking spaces in the area of the mall	4 1 ·			0.786						

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 5 iterations.

n = 400, Cumulative % of variance explained = 67.33, Cronbach's Alpha = 0.75

# 4.2 Confirmatory factor analysis (CFA) and Structural Equation Model (SEM)

Applying the same approach of Sohn & Shim (2010), confirmatory factor analysis was

used to validate the identified contextual attractiveness factors of TOSMDs impacting the

shopper passenger ridership using TOSMD's nearby station. Figure 3 reveals relationships among the identified variables using the pooled measurement modelling (Afthanorhan *et al.*, 2014).



Figure 3. Links among TOSMD's contextual attractiveness factors impacting the shopper passenger ridership at a nearby transit station.

According to Lei & Wu (2007), SEM is well specified and valid if the model meets the following conditions: the sample is large enough, and the Normed Fit Index (NFI), Comparative Fit Index (CFI), and Goodness-of-Fit Index (GFI) are over 0.9 (Bentler, 1990; Bentler & Bonett, 1980). The above model in Figure 3 showed a reasonable fit (Rabbanee *et al.*, 2012): Chi-Square= 355.298 (p=0.00), degrees of freedom (df)= 163,

the Goodness-of-Fit Index (GFI)= 0.965, the Adjusted Goodness of Fit Index (AGFI)= 0.933, the Comparative Fit Index (CFI)= 0.968, the Normed Fit Index (NFI)=0.943, and the Root Mean Square Residual (RMR)=0.043.

SEM was then employed to test the relationships between the latent constructs. Table 5 shows location and stores contextual factors to be significantly associated with the shopper passengers' ridership using metro stations nearby TOSMDs. Space was not significantly associated with ridership of shopper passengers using metro stations nearby TOSMDs, but was significantly associated with the location and store contextual attractiveness factors of TOSMDs.

Table 5. Estimation result of each weight in SEM.

			Estimate	S.E.	C.R.	Р
Ridership of shopper	<	Location_context	0.47	0.064	7.221	***
passengers Ridership of shopper	<	Store_context	0.143	0.088	2.156	0.031*
passengers Ridership of shopper	<	Space_context	-0.009	0.058	-0.158	0.88
passengers						

\*\*\* Highly significant (p < 0.001).

\* Significant (p < 0.05).

Not significant (p > 0.05).

The result of the study suggests that except for space, TOSMDs contextual attractiveness factors of location and stores associate significantly with the ridership of shopper passengers using transit stations nearby TOSMDs, as shown in Table 5. This finding is supportive of the earlier data which identified that stations near TOSMDs have a generally higher level of ridership in the case of Dubai Metro Redline stations. As a result, the impact of TOSMDs contextual attractiveness factors on transit stations use should be considered in station passenger forecasting models for optimal TOD and improving cities' shopping and transit network usage experience.

#### 5. Discussion

This study investigated the effect of shopping malls attractiveness on ridership at nearby transit stations in TOD contexts where residents, workers, and shoppers drive their cars less and ride mass transit more. Specifically, it tested the associated impact of location, stores, and space contextual attractiveness factors of TOSMDs and the ridership of shopper passengers using nearby transit stations in the case of Dubai Metro Redline. We constructed, in an earlier study (Abutaleb *et al.*, 2019), a conceptual framework that proposed a relationship between the latent construct of shopper passenger ridership at transit stations nearby a TOSMD and the independent constructs of contextual attractiveness factors of TOSMDs (Abutaleb *et al.*, 2019). This study has empirically supported this relationship in the case of Dubai Metro Redline.

This study evaluated and validated the associated effect of TOSMDs' contextual attractiveness factors of location, space, and stores and shopper passenger ridership of nearby transit stations shopper passengers. Most previous passenger forecasting models captured "*commercial floor area*" as significantly associated with station boarding. However, the impact of the variability in attractiveness of TOSMDs context was not captured. Therefore, there was a need to establish the relationship between metro station's shopper passenger ridership and TOSMDs' contextual attractiveness factors for optimal TOD planning practice. The study contributes to the transit and urban planning literature by demonstrating the effect of TOSMDs on ridership at nearby transit stations represented by shopper passengers.

The study investigated shopper passenger ridership at stations nearby TOSMDs (see Figure 1), while other factors of the level of service (such as punctuality, availability, public transport policies, and fare level) were neutralised by selecting the same geographical service context, namely Dubai Metro Redline–UAE. It further indicates a

significant relationship between TOSMDs contextual attractiveness factors and shopper passenger ridership preferences at nearby transit stations flowing into the station from the nearby shopping mall. The cumulative percentage of variance explained in this relationship is 67.33% (see Table 4). The study identifies that the contextual attractiveness factors of TOSMDs are contributing positively to nearby transit stations shopper passenger numbers.

The study results are in line with previous urban planning studies indicating that there is an interrelationship between railway stations and their context; i.e. TOSMDs (Castillo-Manzano & López-Valpuesta, 2009; Zemp *et al.*, 2011), and retail and marketing studies indicating that the level of people congestion is likely to be higher with the broader assortment of services and products provided by larger shopping malls (Rajagopal, 2009).

The study then presented a SEM model that explained the relationship between location, stores, and space contextual attractiveness factors of TOSMDs as independent constructs and the ridership of shopper passengers boarding at a nearby transit station as a dependent construct. The model in Figure 3 suggests location and stores contextual attractiveness factors of TOSMDs to be significantly associated with the shopper passengers' ridership preferences of using metro stations nearby TOSMDs. The space contextual attractiveness factor of TOSMDs was, however, not significantly associated with the ridership of shopper passengers using metro stations nearby TOSMDs but rather significantly associated with the location and stores contextual attractiveness factors of TOSMDs. Table 5 depicts the standardised total effects (estimate) of location (0.47), stores (0.143), and space (-0.009) factors of attractiveness of TOSMD context on the ridership of shopper passengers boarding at station level in the case of Dubai Metro Redline stations.

The fact that space context attractiveness of TOSMDs, although not significantly associated with the ridership of shopper passengers using metro stations nearby shopping malls, is significantly associated with location and stores contextual attractiveness factors of TOSMDs (see Table 6). This may be attributed to the respondents' limited understanding of the attractiveness of a shopping mall context based on looking solely at its internal characteristics. However, in line with our previous study (Abutaleb *et al.*, 2019), and the outcome of this study, location contextual attractiveness (example: ease of reaching the mall) and stores contextual attractiveness (example: high number of shops surrounding the shopping mall) also need to be considered in explaining the impact of TOSMDs attractiveness context on the number of shopper passengers boarding at nearby transit station level, as shown in the study analyses.

Table 6. Correlation estimates between the independent constructs of space, location, stores context in SEM.

			Estimate	S.E.	C.R.	Р
Space_context	<>	Location_context	0.301	0.057	5.244	***
Space_context	<>	Store_context	0.209	0.046	3.406	***

\*\*\* Highly significant (p < 0.001).

Consequently, this study provides urban planners, policymakers and rail transit urban planners with a basis to understand the ridership motivation of shopper passengers boarding at a transit station nearby a TOSMD by considering the contextual factors of attractiveness of TOSMDs. Ski Dubai (see Figure 4), is an illustrative example of a specific attraction that may influence shopper passenger ridership at Mall of Emirates metro station. Ski Dubai is a 20,000 square metres themed climate park inside the Mall of Emirates shopping centre. The mall is directly connected to the metro station (see Figure 5). Therefore, the attractiveness of venues such as this is contributing to the 'location context' and potentially increasing patronage at the shopping mall and use of its nearby station, in the form of mall shopper passengers.



Figure 4. Ski Dubai inside Mall of Emirates shopping centre (Source: Author)



Figure 5. Mall of Emirates shopping mall direct connection to the metro station (Source: Author)

The study outcomes also contribute to refining existing passenger forecasting models by understanding the impact of the contextual attractiveness of TOSMDs on passenger ridership at nearby transit stations through the SEM analysis. It can be used for cities with existing or growing network plans which would like to understand the expected impact of TOSMDs nearby its transit network stations, in the form of shopper passenger ridership at those stations. This understanding is considered useful for effective TOD approaches to rail networks and shopping mall patterns of development and in guiding private or government investment as to where the best results will be achieved when developing metro stations.

Although the study's causal relationships were only tested on a single case study using Dubai Metro Redline's seven stations near to TOSMDs, the approach could be extended to other cases. For a more comprehensive test of causality, the study could be repeated in a number of cities' transit networks. It is also noted that individual personality traits might have impacted shopper passengers' perception of TOSMDs contextual factors of attractiveness, and therefore, future studies could incorporate individual-level factors in the study design.

# 6. Conclusion

Shopping malls are considered the retail, social, and community centres of their communities. In this context, this study explained the relationship of transit station use in a TOSMD context. It empirically clarified the associated effect of location, space, and stores (contextual attractiveness factors) of TOSMDs with the ridership at nearby transit stations.

Confirmatory factor analysis found location and stores contextual factors to be significantly associated with the ridership of shopper passengers using metro stations nearby TOSMDs. Space was, however, not significantly associated with the number of shopper passengers using metro stations nearby TOSMDs but significantly associated with location and store contextual attractiveness factors of TOSMDs. Therefore, this study presented a statically fit SEM model that explains the relationship between location, stores, and space contextual attractiveness factors of TOSMDs and the ridership of shopper passengers boarding at a nearby transit station. It provides a basis for further research into the attractiveness of TOSMDs to be potentially captured as a variable in passenger forecasting models at the rail transit station level for optimal TOD planning and practice.

The findings of this study are expected to assist transit urban planners, public transport policymakers, to better guide public and private sector investment in regard to TOSMDs, and also to increase the economic sustainability of transit rail networks. It lays the foundation to potentially enhance the accuracy and comprehensiveness of existing transit station passenger forecasting models and to better align the transit service level with the demand pattern of shopper passengers and maximise the shopping mall experience in cities.

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