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Development of Parking Demand Model for Private Hospital in Developing Country (Case Study of Denpasar City, Indonesia)

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Abstracts

Denpasar City is the capital of Bali Province and the center of activities in Bali, Indonesia. The population continue to increase with the annual growth rate of 2%. As the number of population increase, the number of facilities including health facility also continue to increase. The traffic volume is predominated by private motor vehicle (where 80% is motor cycle) as lack of public transport service available. The trip attraction to hospital increases, however parking spaces provided are very limited. As the results the visitors usually park their vehicles on street around the hospital. This has caused a significant reduction in the road capacity. Therefore, it is required to accurately estimate parking demand both for car and motor cycle. The objectives of this study are to analyze parking characteristics and to develop parking demand models for car and motor cycle. Five private hospitals were considered in this study. Parking data were collected and used to model parking demand based on simple and multiple liner regression models. The results of this study indicated that the parking index for all private hospitals has exceeded 1. The number of beds for room class 1 was found to be the main predictor for parking demand for car. However, the number of hospital's employees was found to be the best predictor for parking demand for motor cycle.

Keywords: parking characteristics, parking demand, simple regression, multiple regression

1. Introduction

Denpasar City is the capital of Bali Province and the center of activities in Bali. As the center of activities, Denpasar City experiences highest trip attraction and production compared to the other eight regencies. Parking demand in Denpasar City is increasing greatly due to the increase in the number of vehicles especially motor cycles and the trip attractions to the shopping centers, hospitals and other commercial buildings. According to Denpasar Bureau of Statistics (2016), the number of motor vehicles in Denpasar City reaches 1.2 million exceeding the number of population which is about 0.9 million. The number of motor vehicles continue to increase with the rate 10 percent per year. Similar condition has also been experienced in Beijing. By reviewing 40,000 residents in Beijing, Yao, et al. (2006) analyzed relationship between parking supply and private usage. They found that the vehicle ownership is influenced by income, family size, location, and parking fee.

Parking problems caused by large increases in the number of vehicles have become a serious traffic issue in urban cities including in Denpasar City. On-street parking, in particular, has resulted in the loss of local road function, interference with the movement of emergency vehicles, deterioration in the walking environment, conflicts among residents, and other problems. Due to the lack of proper parking facilities and strict regulations, on street parking has become a very common phenomenon in Denpasar City which decreases the roadway capacity and creates severe problems like congestion, delay, accident potentiality and some other relevant problems. Every car owner prefers to park their vehicle as close as possible to destination to minimize the walking distance, leading to overcrowded.

Parking is a basic type of requirement for any type of development. The areas with development of shopping centers, hospitals and other commercial buildings attract a lot of trips as well as increase the demand for parking. Due to the lack of adequate parking facility, unauthorized on-street parking is practiced which affects the roadway capacity greatly and creates some relevant problems. Banu and Rahman (2016) studied the effects of on street parking on roadway capacity in Dhaka City, Bangladesh. They stated that about 60% of activities do not have adequate parking facility. They found that the roadway capacity reduction varies from 43 to 60% and

creates severe problems like congestion, delay and accident potentiality. In similar study, Das, et al. (2016) studied on street parking demand using sensitivity analysis in Kolkata. The predicted demand was found to be three times higher than the supply. They suggested several actions to reduce on street parking such as to provide sufficient off-street parking spaces, increase on street parking fees, and improve public transport system. Therefore, it is required that every activity has to provide adequate parking spaces and proper parking management in order to reduce on-street parking.

There are a number of parking demand studies that have been conducted. Several researches focused on central city parking demand study. Tiexin, et al. (2012) developed parking demand model for the Central Commercial District in Tianjin, China. Several factors were considered include parking turnover, parking space occupation, service level, parking fees and growth rate of motor vehicles. They suggested that the parking spaces should be provided by considering the road capacity limitation in order to avoid the parking demand exceeds the road capacity. Qin, et al. (2010), analyzed the parking demand of the shopping center and supermarkets in Beijing. They also analyzed the relationship between the parking demand and the accessibility to public transport services. They found that the parking demand tend to decrease with the increase of the accessibility to the public transport services. Bu and Pershouse (2015) developed a parking choice model based on a logit model, for remote parking behavior in Queensland, Australia. Variables considered include parking cost and availability of parking spaces. The model provided information for further analysis on trip generation, distribution and mode choice in Brisbane's city center.

Other studies focused on parking demand for campus. Chalermpong and Ampansirirat (2011) studied parking demand for Chulalongkorn University in Bangkok, Thailand. Based on the interview data of 130 students, they applied a binary logit model to analyze the trip characteristics. They found that the parking choice was significantly influenced by the arrival and departure times. Other factors are parking facilities, security, cover, parking spaces availability and tariff. Tembhurkar and Khobragade (2015) developed a parking demand model for Visvesvaraya National Institute of Technology in Nagpur, India. Several independent variables considered include trip attraction, trip characteristics, facilities, turn over and utilization rate.

Other land use activities that attract a large number of vehicle trips is hospital. Naser, et al. (2015) developed trip generation model for hospitals in Amman, Jordan based on several methods such as simple linier regression, multivariate regression and MLP algorithms. They found that the trip generation is significantly influenced by number of beds and the gross floor area ratio. High trip generation of the hospital will require large amount of parking spaces. Based on parking demand study for hospital in New Zealand and UK, Douglass and Abley (2011) stated that the design parking demand (spaces/100m^2 GFA) for hospital is influenced by the gross floor area ratio (GFA). For GFA 1-500 m^2, the average parking demand is 3.89 spaces/100m^2 GFA (New Zealand) and 4.73 spaces/100 m^2 GFA (UK). For GFA 501-1000 m^2, the average parking demand is 5.87 spaces/100 m^2 GFA (New Zealand) and 4.23 spaces/100 m^2 GFA (UK). For GFA >1000 m^2, the average parking demand is 2.46 spaces/100 m^2 GFA (New Zealand) and 2.09 spaces/100 m^2 GFA (UK). Khan, et al. (2015) observed a limited parking facilities in most hospitals in Punjab. They developed parking demand model for hospitals in Punjab by incorporating four public and two private hospitals. They found that the number of beds is a more significant independent variable than area of hospitals. They suggested that a separate parking demand model for private and public hospitals needs to be developed.

Parking supply has become an important issue that needs a serious attention, especially in the city with lack of public transport services like Denpasar City. The citizen are highly dependent on using private motor vehicle for their daily mobility which needs to be accommodated by providing sufficient parking spaces to reduce on street parking. An accurate forecast on parking demand requirement for certain land use activities such as hospital is required. There are 13 private hospitals available in Denpasar City. The number of private hospitals is predicted to continue to increase following the increase in the number of population. However, as the land price is quite high, almost all private hospitals do not provide sufficient parking spaces. The visitors usually park their vehicles on street around hospital. This condition has reduced the road capacity significantly. According to the Indonesian Government standard for parking facilities (Department of Transport, 1998), the parking demand standard for hospital in Indonesia is 0.2-1.3 parking spaces per bed. However, the standard does not separate parking space requirement for motor cycle and car. The proportion of motor cycle is approximately 80% of total motor vehicles on the road in Denpasar City. Therefore, a more accurate prediction of the parking spaces for motor cycle and car is required in order to provide information for future hospital development. This study applied simple and multiple linier regression methods to model parking demand for private hospital in Denpasar City. Separated parking demand models for motor cycle and car were developed. The model developed can be used to predict the parking space requirement and as an input to the decision makers in deciding the building permit to be granted

for private hospital development in Denpasar City.

2. Method

Denpasar City is the capital of Bali Province and the center of activities location. Denpasar City has become a metropolitan city which is called Metropolitan Sarbagita (agglomeration of Denpasar, Badung, Gianyar and Tabanan regency) with total population reaches about 2 million. The main transport mode used by residents in Metropolitan Sarbagita for their daily mobility is private transport as lack of public transport service available. The number of motor vehicles registered in Denpasar City is about 1.2 million and predominated by motor cycle with composition of about 80% (Denpasar Bureau of Statistics, 2016). The total road length is 584.8 km. The average number of road traffic accidents is about 400 accidents per year. There are 18 hospitals in Denpasar City which consists of 5 public and 13 private hospitals. The parking demand model developed in this study is focused on the private hospital. From 13 private hospitals, eight of them are hospital class D (with less than 100 beds) and only five hospitals are hospital class C (with the number of bed over 100 beds). Five hospitals class C were considered in this study, include Prima Medika, Surya Husada, Bali Med, Kasih Ibu and Bali Royal Hospital. Figure 1 shows the location of the hospitals. The primary data collected for this study were parking survey and inventory of the hospital facility.

Figure 1. Location of the private hospitals in Denpasar City, Bali

Table 1 shows variables considered in this study. Dependent variables considered were parking demand for car and parking demand for motor cycle. There were 11 independent variables included.

Table 1. Variables

Dependent variables		Independent variables	
Code	Variable	Code	Variable
Y1	Parking demand for car	X1	gross floor area (m^2)
Y2	Parking demand for motor cycle	X2	number of VIP room beds
		X3	number of class 1 room beds
		X4	number of class 2 room beds
		X5	number of ICU and NICU beds
		X6	number of general practitioner
		X7	number of specialist
		X8	number of paramedic
		X9	number of employees
		X10	number of doctor (morning shift)
		X11	number of doctor (afternoon shift)

The analyses comprise three sequential steps. Firstly, parking characteristics include parking volume, accumulation, duration, turn over, parking index and parking demand were analyzed based on the parking data. Secondly, the parking demand model was developed by using a simple linier regression model. Finally, the parking demand model was also developed by using a multiple linier regression model.

3. Results and Discussion

3.1 Parking Characteristics

Table 2 shows parking volume based on 13 hours parking survey. The parking volume for car varies from 306 to 553 vehicles per 13 hours or 24 to 43 vehicles per hour. The parking volume for motor cycles varies between 694 and 1,018 vehicles per 13 hours or between 53 and 78 vehicles per hour. The larger the gross floor area, the parking volume tend to be higher.

Table 2. Parking volume

No	Hospital	Gross floor area (m^2)	Car		Motor cycle	
			Volume (Vehicles)	Avg. Volume (Veh/hour)	Volume (Vehicles)	Avg. Volume (Veh/hour)
1	Prima Medika	2,900	527	41	936	72
2	Surya Husada	3,823	491	38	868	67
3	Bali Med	5,300	553	43	1,018	78
4	Kasih Ibu	2,694	306	24	731	56
5	Bali Royal Hospital	3,500	327	25	694	53
	Average		441	34	849	65

Accumulation is the sum of the overall vehicles parking in the parking lot during a certain time period. Table 3 presents the maximum and average parking accumulation for every hospital. Maximum parking accumulation for car tends to occur between 18.00 and 20.00. This is an indication of high vehicle trip attraction from the visitor using car tend to occur during that period. The maximum parking accumulation for car varies between 61 and 100 vehicles per hour, while the average varies between 51 and 74 vehicles per hour. Different case is found for motor cycle. The maximum parking accumulation for motor cycle tend to occur between 11.00 and 14.00. The maximum parking accumulation for motor cycle varies from 173 to 307 vehicles per hour, while the average varies from 130 to 234 vehicle per hour. The higher the gross floor area, the parking accumulation tend to be higher.

Table 3. Parking accumulation

No	Hospital	Gross floor area (m^2)	Car			Motor cycle		
			Time	Accumulation		Time	Accumulation	
				Max	Avg		Max	Avg
1	Prima Medika	2,900	19.00-20.00	83	60	13.00-14.00	258	208
2	Surya Husada	3,823	19.00-20.00	88	66	11.00-12.00	173	130
3	Bali Med	5,300	18.00-19.00	100	74	13.00-14.00	307	234
4	Kasih Ibu	2,694	18.00-19.00	65	51	11.00-12.00	186	132
5	Bali Royal Hospital	3,500	19.00-20.00	61	33	13.00-14.00	203	166
	Average			79	57		225	174

Table 4 shows the average parking duration. The parking duration for car varies between 1.78 and 2.42 hours per vehicle with the average of 2.06 hours per vehicle. The parking duration for motor cycle varies between 2.11 and 2.56 hours per vehicle with the average of 2.34 hours per vehicle.

Table 4. Parking duration

No	Hospital	Average parking duration	
		Car	Motor cycle
		(Hours/veh)	(Hours/veh)
1	Prima Medika	2.42	2.56
2	Surya Husada	2.36	2.54
3	Bali Med	1.78	2.22
4	Kasih Ibu	1.93	2.26
5	Bali Royal Hospital	1.82	2.11
	Average	2.06	2.34

Table 5 presents the parking turn over for car. The parking turn over varies between 0.45 and 0.55 with the average of 0.50. Table 6 shows the parking turn over for motor cycle which varies between 0.27 and 0.35 with the average of 0.31.

Table 5. Parking turn over for car

No	Hospital	Volume	Stall	Period	Parking turn over
		(Veh)		(hours)	(Veh/Stall)
1	Prima Medika	527	91	13	0.45
2	Surya Husada	491	77	13	0.49
3	Bali Med	553	80	13	0.53
4	Kasih Ibu	306	51	13	0.46
5	Bali Royal Hospital	327	46	13	0.55
				Average	0.50

Table 6. Parking turn over for motor cycle

No	Hospital	Volume	Stall	Period	Parking turn over
		(Veh)		(hours)	(Veh/Stall)
1	Prima Medika	936	269	13	0.27
2	Surya Husada	868	221	13	0.30
3	Bali Med	1,018	232	13	0.34
4	Kasih Ibu	731	159	13	0.35
5	Bali Royal Hospital	694	171	13	0.31
				Average	0.31

The parking index can portrait of whether the capacity of existing parking spaces are still able to accommodate the demand for vehicle parking. The parking index is determined by dividing the parking accumulation and capacity. Table 7 shows that the parking index for car for the maximum accumulation varies between 2.18 and 2.67 with the average of 2.40. If the average accumulation is used, the average parking index is 1.70. The parking index exceeds 1 indicates that the parking demand over the supply. Table 8 shows the parking index for motor cycle. The average parking index based on the maximum accumulation is 2.51 and the average based on the average accumulation is 1.93.

Table 7. Parking index for car

No	Hospital	Accumulation (veh/hr)		Capacity	Parking Index	
		Max	Avg	(veh/hr)	Max	Avg
1	Prima Medika	83	60	38	2.18	1.58
2	Surya Husada	88	66	33	2.67	2.00
3	Bali Med	100	74	45	2.22	1.64
4	Kasih Ibu	65	51	26	2.50	1.96
5	Bali Royal Hospital	61	33	25	2.44	1.32
				Average	2.40	1.70

Table 8. Parking index for motor cycle

No	Hospital	Accumulation (veh/hr)		Capacity	Parking Index	
		Max	Avg	(veh/hr)	Max	Avg
1	Prima Medika	258	208	105	2.46	1.98
2	Surya Husada	173	130	87	1.99	1.49
3	Bali Med	307	234	105	2.92	2.23
4	Kasih Ibu	186	132	70	2.66	1.89
5	Bali Royal Hospital	203	166	81	2.51	2.05
				Average	2.51	1.93

The number of parking space requirements are influenced by the average accumulation of the vehicle and the average parking duration. The current parking space requirements for each hospital can be seen in Table 9. The average difference between demand and supply of parking spaces for car is 49 stalls. The average difference between demand and supply of parking space for motor cycle is 195 stalls.

Table 9. Parking demand estimation

No	Hospital	Car stall			Motor cycle stall		
		Required	Available	Difference	Required	Available	Difference
1	Prima Medika	145	91	54	532	269	263
2	Surya Husada	155	77	78	330	221	109
3	Bali Med	132	80	52	519	232	287
4	Kasih Ibu	98	51	47	298	159	139
5	Bali Royal Hospital	59	46	13	350	171	179
			Average	49			195

3.2 Parking Demand Model

Table 10 shows the results of a simple linier regression model for the car parking demand for private hospital. It can be seen that from 11 variables considered, the number of bed for class 1 hospital is found to have the highest relationship with the car parking demand as indicated by the coefficient of determination (R^2) of 0.774. The next variable is the number of bed for VIP room with R^2 value of 0.711. As the patients who occupy Class 1 room and VIP room are usually people with income higher than the average, therefore their family and visitors tend to use car to reach the hospital.

Table 10. Simple linier regression model for the car parking demand for private hospital

Statistic	Floor area	No of bed for VIP room	No of bed for class 1 room	No of bed for class 2 room	No of bed for Icu, Nicu	No of general practitioner	No of specialist doctor	No of paramedic	No of staff	No of doctor (morning shift)	No of doctor (aft. shift)
	(X1)	(X2)	(X3)	(X4)	(X5)	(X6)	(X7)	(X8)	(X9)	(X10)	(X11)
r	0,23	0,843	0,88	0,47	0,024	0,357	0,718	0,218	0,199	0,823	0,419
R^2	0,053	0,711	0,774	0,221	0,001	0,128	0,516	0,048	0,04	0,677	0,176
F	0,167	7,371	10,268	0,851	0,002	0,439	3,195	0,15	0,124	6,301	0,639
Sig. F	0,71	0,073	0,049	0,424	0,969	0,555	0,172	0,724	0,748	0,087	0,483
Constant	85,906	-10,805	9,224	216,038	115,229	141,02	4,006	72,379	96,112	-55,057	150,745
Un. Coef	0,009	6,183	3,27	-2,839	0,102	-0,726	1,853	0,301	0,073	17,286	-1,81
t	0,409	2,715	3,204	-0,922	0,042	-0,663	1,788	0,387	0,353	2,51	-0,799
Sig. t	0,71	0,073	0,049	0,424	0,969	0,555	0,172	0,724	0,748	0,087	0,483

Table 11 shows the simple linier regression model for the motor cycle parking demand. Unlike the parking demand model for car, the number of staff is found to have the highest relationship with the motor cycle parking demand as indicated by the R^2 value of 0.838. This may be caused by the majority of the hospital's staff using motor bike to reach the hospital. Other variable is the number of bed for class 2 room with R^2 value of 0.74. Class 2 room is mainly occupied by the patients with income below the average, therefore their family and visitors tend to use motor bike also to reach the hospital.

Table 11. Simple linier regression model for the motor cycle parking demand for private hospital

Statistic	Floor area	No of bed for VIP room	No of bed for class 1 room	No of bed for class 2 room	No of bed for Icu, Nicu	No of general practitioner	No of specialist doctor	No of paramedic	No of staff	No of doctor (morning shift)	No of doctor (aft. shift)
	(X1)	(X2)	(X3)	(X4)	(X5)	(X6)	(X7)	(X8)	(X9)	(X10)	(X11)
r	0,416	0,742	0,435	0,86	0,514	0,397	0,697	0,142	0,916	0,383	0,69
R^2	0,173	0,551	0,189	0,74	0,264	0,158	0,485	0,02	0,838	0,147	0,476
F	0,629	3,675	0,701	8,536	1,076	0,563	2,827	0,062	15,536	0,516	2,728
Sig. F	0,486	0,151	0,464	0,061	0,376	0,508	0,191	0,819	0,029	0,524	0,197
Constant	242,583	86,226	254,126	913,43	253,293	332,892	94,204	322,164	124,801	178,657	559,015
Un. Coef	0,045	15,364	4,568	-14,671	6,052	2,278	5,075	0,554	0,94	22,714	-8,418
t	0,793	1,917	0,837	-2,922	1,037	0,75	1,681	0,249	3,942	0,718	-1,652
Sig. t	0,486	0,151	0,464	0,061	0,376	0,508	0,191	0,819	0,029	0,524	0,197

The parking demand is also modelled by using a multiple regression model. Table 12 shows the results of the multiple regression model. All of the eleven variables considered were entered into the model. However, based on the stepwise method, it was found that only the number of bed for class 1 room (X3) was included in the model. The model indicates that the increase of one bed for room class 1 will require about 3 parking spaces for car. The coefficient of determination (R^2) is 0.774 which means that the number of bed for class 1 room variable can explain about 77.4% of variation in the car parking demand estimation. The relationship is significant with the significance value of 0.049 (< 0.05) and the standard error of estimate 21.57. The model can be written as : Y = 9.224 + 3.27(X3).

Table 12. Multiple regression model for car parking demand

No	Variable	Unstandardized Coeff.	Standardized Coeff. (beta)	t	Sig.
	Constant	9.224		0.262	0.810
1	Class 1	3.270	0.880	3.204	0.049
R = 0.880					
R^2 = 0.774					
Adj. R^2 = 0.699					
Std. Error of Estimate = 21.57					
F = 10.27					
Sig = 0.049					

Table 13 shows the results of the multiple regression model for motor cycle parking demand. All of the eleven variables considered were entered into the model. However, based on the stepwise method, it was found that only the number of staff (X9) was included in the model. The model indicates that the increase of one staff will require about 1 parking space for motor cycle. The coefficient of determination (R^2) is 0.838 which means that the number of staff variable can explain 83.8% of variation in motor cycle parking demand estimation. The relationship is significant with the significance value of 0.029 (< 0.05) and the standard error of estimate 51.53. The model can be written as: Y = 124.801 + 0.940(X9).

Table 13. Multiple regression model for motor cycle parking demand

No	Variable	Unstandardized Coeff.	Standardized Coeff. (beta)	t	Sig.
	Constant	124.801		1.666	0.194
1	No of staff	0.940	0.916	3.942	0.029
R = 0.916					
R^2 = 0.838					
Adj. R^2 = 0.784					
Std. Error of Estimate = 51.53					
F = 15.54					
Sig = 0.029					

4. Conclusion

Parking space requirement is one of the central city facilities that has to be given more attention. Parking demand seems continue to increase in Denpasar City as there is lack of public transport service available. Most of the hospitals in Denpasar City do not provide sufficient parking spaces and they tend to use the road surrounding the hospital. This has caused significant reduction in the road capacity and contributed to traffic congestion. By analyzing the parking characteristics of 5 private hospitals, it was found that the higher the gross floor area of the hospital the higher the parking volume. Maximum parking accumulation for car tended to occur between 18.00 and 20.00, however for motor cycle between 11.00 and 14.00. The average parking duration for car was 2.06

hours/vehicle and for motor cycle was 2.34 hours/vehicle. The parking turn over rate for car was 0.5 and for motor cycle was 0.31. The parking index for both car and motor cycle exceeded 1 which indicates that more parking spaces is required. As the parking characteristics between car and motor cycle different, separate parking demand models were constructed. The parking demand model indicated that the main predictor for car parking demand was the number of bed for room class 1, while the main predictor for motor cycle parking demand was the number of employees. The results of this study can be used by the decision makers in preparing parking demand standard for future private hospital development in Denpasar City.

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