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The Modelling of Volume and Percent Duration of Vehicle Parking for Shopping Stores in Surabaya, Indonesia

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***Abstract*— Both parking revenue and parking tax are the potential income for most local authorities in Indonesia since they are considered as part of their revenue. However, currently, many local authorities in Indonesia, including Surabaya, have a problem determining the target of annual parking revenue. Meanwhile, there are growing public and private facilities in many capital cities in which many parking spaces will be provided to support their activities later. Therefore, the providing of new parking spaces will potentially contribute to the local authorities' revenue as the consequences. The main variable to contribute to the parking revenue is the number of parked vehicles and the parking duration (progressive tariff is applied). This paper discusses parking modeling of shopping stores in Surabaya. The parking volume model is based on the following variables; accumulation, turnover, dynamic capacity, parking index, and average duration, while the model of duration is based on these following variables; accumulation, turnover, dynamic capacity, parking index, and parking volume. Since all variables has a multicollinearity problem, the model principal component regression is then used. This paper proposes the model of volume as well as percent duration of parking facility for shopping stores based on data in Surabaya.**

***Keywords*— off-street parking; principal component regression; shopping stores; Surabaya.**

I. INTRODUCTION

Currently, parking supply and parking restriction are commonly used as the vehicle movement restriction [1,2]. On the other hand, parking activity is one of the potential local government's revenues, especially for high car ownership and high economic activity. Compared to other local tax components, in Surabaya, parking revenue is not the biggest share [3].

However, most local governments in Indonesia, including Jakarta and Surabaya, has the parking management of both on-street and off-street. The revenue collected indicated less than supposed to be obtained due to the absence of collecting system methods, especially parking revenue prediction tools. Surabaya's target for annual parking revenue in 2014 is IDR 80 billion, while the real income is only IDR 48 billion, which is only 60% of the targeted revenue [4]. This under-targeted realization parking revenue has lasted for a long time period, it is can be proved by following records; the realization percentage of on-street parking revenue in 2009 and 2010 are 65.5% and 51.73%, respectively [5]. Meanwhile, it is found that the loss of parking revenue is 40%[6]. Moreover, from 2008 to 2011, the realization of total parking tax is always below the target [3].

The absence of system to estimate the potential parking revenue due to some reasons, as follows:

- The real number of the parked vehicle is not yet recorded entirely.
- In the site, the parking charge per vehicle is not applied consistently (a higher parking fee is found).
- The progressive tariff is applied in some facilities which make parking duration is important.
- There is no guidance regarding the collecting parking tax for both on-street and off-street parking.
- The variation of land use influencing parking characteristics.
- The numerous non-registered parking facilities are identified due to the development of the city.
- Many free-parking facilities in both government office and private facility still charge parking fee to users.

Therefore, this paper proposes the model of the parking volume and percent parking duration for shopping stores type land uses within the city to be used as the input to predict the parking revenue of local authority. This parking model is expected to support the parking system revenue collecting of local authorities since the revenue prediction is important during the feasibility study of parking facilities [7].

By the existence of a parking system collecting method, the parking operator and investor can make their financial planning more accurately. Simultaneously, the local authority can easily predict their future income based on the existing and future parking facilities. The concept of modeling parking volume and parking duration for several land use types in Surabaya has been proposed [8]. Therefore, this paper discusses more in-depth about such models for only the shopping stores. Moreover, local authorities can eliminate or at least minimize the parking lost revenue (parking fee and parking tax) to achieve more local income funds.

This paper aims to propose the model of parking volume as well as the parking duration of vehicles of shopping stores related to the parking indicator performances. The parking indicators performance includes turnover, accumulation, parking index, dynamic capacity [9] and operational characteristic (operational duration), and physical variables, including the number of parking spaces and parking areas. The sample of the shopping stores are consist of randomly selected shopping stores within Surabaya city. The locations are including shopping stores of Central Business Park (Ir. Sukarno Street), shopping stores of Sentra Fortuna (Jagung Suprapto Street), shopping stores of Darmo Galeria (Mayjen Sungkono Street)**.**

II. Materials and Methods

The proposed concept to create parking volume model as well as percent duration model for various type of land uses is already proposed [8]. the model was proposed by using the following variables; for volume model the independent variable will be accumulation, turnover, dynamic capacity, parking index and average duration. The physical variable (number of parking space and the area of building) and operational variable (operational hours) will be needed to obtained those variables.

The duration will be in form of percentage of duration of each group of duration as the dependent variable. It is subject to accommodate the progressive tariff that may occur, while the independent variable will be as follow; accumulation, turnover, dynamic capacity, parking index and volume.

A. Parking Performance Indicator

Parking performance indicators consist of several items: dynamic capacity, parking volume, parking accumulation, parking duration, parking index, and turnover. [10,11].

B. Multiple Linear Regression

Since all independent variables are suspected related, then the multicollinearity phenomenon is predicted occurred. In order to check whether multicollinearity does exist, VIF (Variance Inflation Factor) need to be checked if the VIF is bigger than 10 (VIF>10), it means the multicollinearity does exist. If this condition occurs, one of the analysis solutions is by using the regression of principal component [12].

C. Principal Component Regression

Principal component analysis (PCA) as part of principal component regression, can also reduce high dimensional data. In this case, they are combined with other reduction techniques, minimum noise fraction (MNF), resulting in an increase of image classification accuracy to 80.77%. In comparison, both PCA alone and MNF alone produce an accuracy of 40.37% and 77,21%, respectively [13]. Additionally, PCA plays the main role in reducing number of variables influencing metabolic change into 65% of total variables. Furthermore, PCA is used to explaining a group of samples based on every chemical constituent, including all of 56 compounds detected in mango wine [14].

The principal component's forming is based on the correlation matrices since the range of value among independent variables is quite big [12]. The obtained principal component is W_i which the i^{th} principal component is based on standardized value $Z'=(Z_1, Z_2, Z_3,\dots,Z_p)$ as well as $\mathrm{cov}(\mathbf{Z})=\boldsymbol{\rho}$ can be written as follow:

$$W_i = e_{i1}Z_1 + e_{i2}Z_2 + \dots + e_{ip}Z_p \qquad i = 1,2,\dots, p \tag{1}$$

Meanwhile, the proportion of total variance explained by kth principal component based on the standardized independent variable is as follow:

$$\begin{pmatrix}\text{Total Proportion of population's variance}\\ \text{explainned by the k}^{\text{th}}\text{principal component}\end{pmatrix} = \frac{\lambda_k}{tr(\boldsymbol{\rho})} = \frac{\lambda_k}{\mathrm{p}} \tag{2}$$

Where, λ_k is the eigenvalue of $\boldsymbol{\rho}$ and k=1, 2, …., p

One of the purpose principal component analysis is to reduce the number of the independent variable, the previous number of independent variable *p* can be consolidated into *k* number of principal components. The selection of principal component can be based on several methods, one of them is that the total cumulative variation of source data can be explained by 80% of *k* number of principal component[15] while other research mentioned that the total cumulative variation of source data can be explained is 75%[16].

The principal component regression based on the the correlation matrices is as follow:

$$\mathbf{Y}=\alpha_0 \mathrm{l}+\mathbf{W}_k\boldsymbol{\alpha}_k+\boldsymbol{\varepsilon} \tag{3}$$

Where $\mathbf{Y}$ is dependent variable, α_0 is intercept, l is vector in which its elements are 1 with the size of *nxl*. W_k is the matrices with the size of *nxk* which have a principal component in its element where $\mathbf{W}_k=\mathbf{ZP}_k$, while $\boldsymbol{\alpha}_k$ is a vector of principal component coefficient with the size of *kxl*, and $\boldsymbol{\varepsilon}$ is an error.

1) Prediction of Principal Component Regression Coefficient: Supposed a0, a1, ..., ap is predictor principal component regression of coefficienta0, a1, …, ap. The prediction by using maximum likelihood produces equal prediction with least square method. However, to fulfill normal assumption, the prediction of coefficient use maximum likehood. The predicting procedure of a'=(a0, a1, …,ap) is by using maximum likelihood which multiplying density function of f(ei), taking logarithmic value (ln) and differentiated to a'=(a0, a1, ...,ap), then equalized with zero. The prediction of principal component regression coefficient by using maximum likelihood is explained with this following equation:

$$\frac{\partial \ln L(\varepsilon_1,\varepsilon_2,\dots,\varepsilon_n;\sigma^2)}{\partial a} = \frac{\partial}{\partial a}\ln\left(\prod_{i=1}^{n}\frac{1}{\sqrt{2\pi\sigma}}e^{(-1/2\sigma^2)[(\mathbf{Y}-\mathbf{Wa})'(\mathbf{Y}-\mathbf{Wa})]}\right) = 0 \tag{4}$$

Having said that, the prediction of coefficient a is as follows:

$$\mathbf{a}_k=\mathbf{\Lambda}_k^{-1}\left((\mathbf{ZP}_k)'\mathbf{Y}\right) \text{ and } \mathbf{a}_o=\bar{Y} \quad (5)$$

Where $\mathbf{\Lambda}_k^{-1}$ is a diagonal matrices which has main diagonal element of $((n-1)\lambda_1)^{-1}$, $((n-1)\lambda_2)^{-1}$,., $((n-1)\lambda_k)^{-1}$ and $\mathbf{P}_k$ is matrices with size of *kxl* which its elements are eigen vector. Each eigen vector $\mathbf{e}_1$, $\mathbf{e}_2$, …., $\mathbf{e}_k$ has *kxl* in size [12]. This equation should be free from multicollinearity problem. Minitab is used during the analysis of principal component regression.

2) Prediction of Principal Component Regression Coefficient: The principal component W in principal component regression equation will be re-transformed into original X variable. The transformation will need two step, firstly transformation from W to Z and then continued with transformation from Z to X. Transformation procedure of variable W into variable Z which has regression coefficient β* is as follow:

$$f: W\rightarrow Z$$
$$\mathbf{Y}=\alpha_0\mathbf{1}+\mathbf{Z}\boldsymbol{\beta}^*+\boldsymbol{\varepsilon} \quad (6)$$

Transformation converts variable Z into original variable X, which has a regression coefficient of γ is as follow:

$$f: Z\rightarrow X$$
$$\boldsymbol{\gamma}=\mathbf{V}^{1/2}\boldsymbol{\beta}^* \quad \text{and} \quad \gamma_0=\overline{Y}-\boldsymbol{\beta}^*\mathbf{V}^{1/2}\overline{\mathbf{X}} \quad (7)$$

D. Vehicle Parking Study

Mostly, the parking study discusses the performance indicators of the parking facility. They mostly finished calculating duration, turnover, accumulation, parking index and dynamic capacity with no further research to utilize the obtained parking performance indicators [9,11,17]. However, some researches related to the behavior of parking user have been conducted at the on-street parking facility. First, the needs of parking lots from the perceptual-behavioral approach connected with economic and financial analysis is simulated in Verona, Italy [7]. Second, the parking demand modelling related to the public transit accessibility of both supermarket and shopping centre in China. The relation of parking demand and public transit accessibility in this paper are as follow:[18]

$$\alpha_{shopping\ \ centre}=28.61AI^{-0.53} \quad (8)$$

$$\alpha_{supermarket}=3.11AI^{-0.40} \quad (9)$$

Where AI is the public transport accessibility index, additionally, vehicle parking research is conducted to determine the probability model of a motorcycle in Surabaya to choose using a lot of parking, garage parking, or on-street parking facility [19]. Nonetheless, there is still no research in predicting the parking volume and the duration based on the obtained parking performance indicators for specific land, uses. However, this paper is only working on shopping stores only.

E. Data

Data collected for four days representing two working days and two weekend days. In this paper, data are collected from three samples of shopping stores in Surabaya. They are collected during the operational time of the parking facility. With the parking demand data, the parking supply is also collected, including the number of parking spaces and the parking facility's service time. The demand for parking data covers both car and motorcycles.

F. Methodology

The methodology of this paper is summarized in Fig. 1.

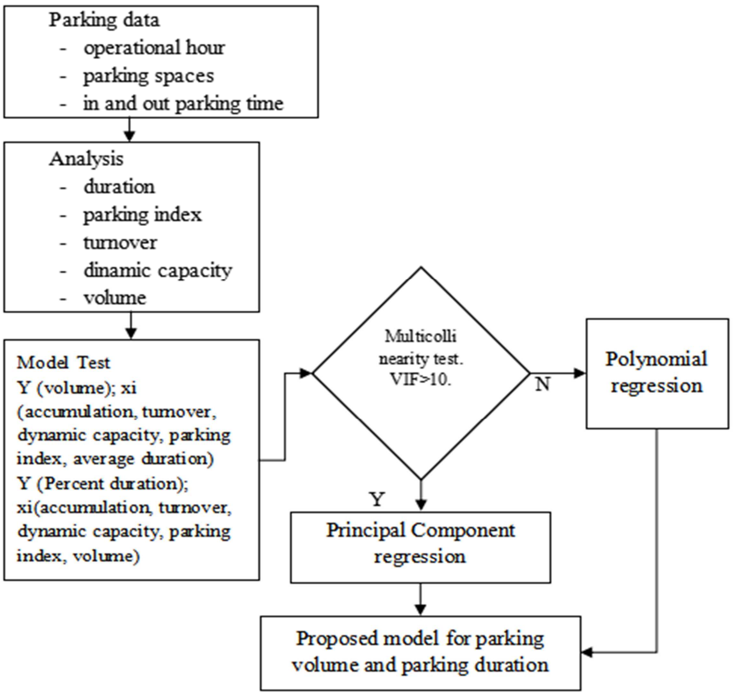

Fig. 1 Methodology of analysis

III. Results and Discussion

A. Results

1) Parking Performance Indicators: Shopping stores of Central Business Park, (Situated on Ir. Soekarno Street). The parking facility characteristic within this shopping stores is as follows: No. The parking spaces available are 43 for car and 57 rooms for motorcycle (MC) while the operational time of this shopping stores is 16 hours. Therefore, the percent duration, average parking duration and the parking volume are presented in Table 1.

TABLE I
Percent Duration, Average Parking Duration and The Parking Volume

Type of Veh.	Day	No. of vehicle and percentage	Duration (d) Group (Minute) and Mid value										Total (Parking Volume)	Average Duration (minute)
			a	b	c	d	e	f	g	h	i	j		
			5	35	90	150	210	270	330	390	450	480		
Car	Wednesday	No. of vehicle	0	8	27	15	20	5	6	2	14	7	104	
		Percentage (%)	0.00	7.69	25.96	14.42	19.23	4.81	5.77	1.92	13.46	6.73	1	220.481
	Thursday	No. of vehicle	0	2	7	30	28	18	18	21	8	6	138	
		Percentage (%)	0.00	1.45	5.07	21.74	20.29	13.04	13.04	15.22	5.80	4.35	1	264.855
	Saturday	No. of vehicle	0	1	4	8	10	16	9	18	8	10	84	
		Percentage (%)	0.00	1.19	4.76	9.52	11.90	19.05	10.71	21.43	9.52	11.90	1	314.345
	Sunday	No. of vehicle	0	5	34	26	8	2	0	0	0	0	75	
		Percentage (%)	0.00	6.67	45.33	34.67	10.67	2.67	0.00	0.00	0.00	0.00	1	124.733
MC	Wednesday	No. of vehicle	7	101	160	31	17	20	10	6	11	60	423	
		Percentage (%)	1.65	23.88	37.83	7.33	4.02	4.73	2.36	1.42	2.60	14.18	1	167.801
	Thursday	No. of vehicle	0	42	70	51	41	49	29	30	16	23	351	
		Percentage (%)	0.00	11.97	19.94	14.53	11.68	13.96	8.26	8.55	4.56	6.55	1	218.718
	Saturday	No. of vehicle	2	44	37	23	23	19	18	6	3	4	179	
		Percentage (%)	1.12	24.58	20.67	12.85	12.85	10.61	10.06	3.35	1.68	2.23	1	166.704
	Sunday	No. of vehicle	10	49	40	31	9	6	3	3	1	1	153	
		Percentage (%)	6.54	32.03	26.14	20.26	5.88	3.92	1.96	1.96	0.65	0.65	1	108.595

Note: a:<10, b: 10-60, c: 60-120 d: 120-180, e:180-240, f:240-300, g: 300-360, h: 360-420, i:420-480, j:>480

TABLE II
Accumulation, Turnover, Dynamic Capacity and Parking Index

Day	Accumulation		Turnover		Dynamic Capacity		Parking Index	
	Car	MC	Car	MC	Car	MC	Car	MC
Tuesday	47	149	2.42	7.42	0.73	1.27	1.09	2.61
Friday	67	146	3.21	6.16	0.81	1.30	1.56	2.56
Saturday	57	47	1.95	3.14	0.51	1.28	1.33	0.82
Sunday	26	37	1.74	2.68	1.29	1.97	0.60	0.65

Additionally, the other parking indicator, including accumulation, turnover, dynamic capacity, and parking index of these shopping stores are presented in Table 2. All the value above are summarized as the input for regression analysis later. All of the values above are summarized as the input for regression analysis later on. Shopping stores of Darmo Galeria (situated on Mayjend Sungkono Street). The parking facility characteristic within this shopping stores is as follows: No. Of parking spaces available are 41 for car and 55 spaces for motorcycle (MC) while this shopping store's operational time is 18 hours. Therefore, the percent duration, average parking duration and the parking volume are presented in Table 3.

TABLE III
Duration and Parking Volume

Type of Veh.	Day	No. of vehicle and percentage	Duration (d) Group (Minute) and Mid value										Total (Parking Volume)	Average Duration (minute)
			a	b	c	d	e	f	g	h	i	j		
			5	35	90	150	210	270	330	390	450	480		
Car	Wednesday	No. of vehicle	28	67	44	31	9	2	2	1	1	11	196	
		Percentage (%)	14.29	34.18	22.45	15.82	4.59	1.02	1.02	0.51	0.51	5.61	1	103.597
	Thursday	No. of vehicle	7	52	51	19	4	4	2	1	3	9	152	
		Percentage (%)	4.61	34.21	33.55	12.50	2.63	2.63	1.32	0.66	1.97	5.92	1	117.993
	Saturday	No. of vehicle	21	80	45	21	18	10	8	2	1	1	207	
		Percentage (%)	10.14	38.65	21.74	10.14	8.70	4.83	3.86	0.97	0.48	0.48	1	101.135
	Sunday	No. of vehicle	17	26	21	25	8	4	6	1	0	7	115	
		Percentage (%)	14.78	22.61	18.26	21.74	6.96	3.48	5.22	0.87	0.00	6.09	1	131.522
MC	Wednesday	No. of vehicle	70	172	100	34	13	7	2	3	12	35	448	
		Percentage (%)	15.63	38.39	22.32	7.59	2.90	1.56	0.45	0.67	2.68	7.81	1	109.643
	Thursday	No. of vehicle	20	107	61	21	8	10	4	12	18	50	311	
		Percentage (%)	6.43	34.41	19.61	6.75	2.57	3.22	1.29	3.86	5.79	16.08	1	176.736
	Saturday	No. of vehicle	36	102	76	37	31	28	27	17	12	19	385	
		Percentage (%)	9.35	26.49	19.74	9.61	8.05	7.27	7.01	4.42	3.12	4.94	1	156.545
	Sunday	No. of vehicle	24	28	38	37	20	11	4	1	1	2	166	
		Percentage (%)	14.46	16.87	22.89	22.29	12.05	6.63	2.41	0.60	0.60	1.20	1	122.651

Note: a:<10, b: 10-60, c: 60-120 d: 120-180, e:180-240, f:240-300, g: 300-360, h: 360-420, i:420-480, j:>480. Additionally, the other parking indicator, including accumulation, turnover, dynamic capacity and parking index of these shopping stores, is presented in Table 4. Shopping stores of Sentra Fortuna (Situated on Jaksa Agung Suprapto Street). The parking facility characteristic within this shopping store is as follows: No. The parking spaces available are 37 for car and 45 spaces for motorcycle (MC) while the operational time of this shopping stores is 18 hours. Therefore, the percent duration, average parking duration, and the parking volume are presented in Table 5. Additionally, the other parking indicator, including accumulation, turnover, dynamic capacity, and parking index of these shopping stores, are presented in Table 6.

TABLE IV
ACCUMULATION, TURNOVER, DYNAMIC CAPACITY AND PARKING INDEX

Day	Accumulation		Turnover		Dynamic Capacity		Parking Index	
	Car	MC	Car	MC	Car	MC	Car	MC
Wednesday	51	120	4.78	8.15	1.48	1.88	1.24	2.18
Thursday	46	114	3.71	5.65	1.30	1.17	1.12	2.07
Saturday	44	159	5.05	7.00	1.35	1.17	1.07	2.89
Sunday	28	41	2.80	3.02	1.04	1.49	0.68	0.75

All of the value above are summarized as the input for regression analysis later on.

TABLE V
DURATION AND PARKING VOLUME

Type of Veh.	Day	No. of vehicle and percentage	Duration (d) Group (Minute) and Mid value										Total (Parking Volume)	Average Duration (minute)
			a	b	c	d	e	f	g	h	i	j		
			5	35	90	150	210	270	330	390	450	480		
Car	Wednesday	No. of vehicle	7	30	11	7	2	2	1	0	0	24	84	
		Percentage (%)	8.33	35.71	13.10	8.33	2.38	2.38	1.19	0.00	0.00	28.57	1	189.702
	Thursday	No. of vehicle	5	40	14	8	4	1	0	0	0	21	93	
		Percentage (%)	5.38	43.01	15.05	8.60	4.30	1.08	0.00	0.00	0.00	22.58	1	162.097
	Saturday	No. of vehicle	2	18	23	18	3	9	4	0	1	2	80	
		Percentage (%)	2.50	22.50	28.75	22.50	3.75	11.25	5.00	0.00	1.25	2.50	1	140.000
	Sunday	No. of vehicle	5	5	8	6	4	7	2	3	6	4	50	
		Percentage (%)	10.00	10.00	16.00	12.00	8.00	14.00	4.00	6.00	12.00	8.00	1	220.000
MC	Wednesday	No. of vehicle	0	2	14	26	18	16	14	19	28	26	163	
		Percentage (%)	0.00	1.23	8.59	15.95	11.04	9.82	8.59	11.66	17.18	15.95	1	309.448
	Thursday	No. of vehicle	1	1	15	34	18	12	10	13	23	25	152	
		Percentage (%)	0.66	0.66	9.87	22.37	11.84	7.89	6.58	8.55	15.13	16.45	1	290.987
	Saturday	No. of vehicle	1	10	26	16	2	6	3	1	0	3	68	
		Percentage (%)	1.47	14.71	38.24	23.53	2.94	8.82	4.41	1.47	0.00	4.41	1	146.397
	Sunday	No. of vehicle	5	20	37	11	3	1	1	0	0	3	81	
		Percentage (%)	6.17	24.69	45.68	13.58	3.70	1.23	1.23	0.00	0.00	3.70	1	103.395

Note: a:<10, b: 10-60, c: 60-120 d: 120-180, e:180-240, f:240-300, g: 300-360, h: 360-420, i:420-480, j:>480

TABLE VI
ACCUMULATION, TURNOVER, DYNAMIC CAPACITY AND PARKING INDEX

Day	Accumulation		Turnover		Dynamic Capacity		Parking Index	
	Car	MC	Car	MC	Car	MC	Car	MC
Tuesday	34	115	2.27	3.62	0.65	0.48	0.92	2.56
Wednesday	39	85	2.51	3.38	0.76	0.52	1.05	1.89
Saturday	21	16	2.16	1.51	0.88	1.02	0.57	0.36
Sunday	21	22	1.35	1.80	0.56	1.45	0.57	0.49

The parking volume model's input data for regression analysis are summarized in Table 7 and Table 8. Table 7 show independent variables, including accumulation, turnover, dynamic capacity, parking index and average duration. This table is prepared for parking volume of both car and motorcycles for week day. Meanwhile, input data for weekend is presented in Table 8.

The percentage duration model input data for regression analysis is summarized in Table 9 and Table 10. Table 9 show independent variables, including accumulation, turnover, dynamic capacity, parking index, and parking volume. These table are prepared for the parking volume of both car and motorcycles for weekend. Meanwhile, input data for weekday are presented in Table 10. The y value including y_1, y_2,y_3, y_4, y_5, y_6, y_7, y_8, y_9, y_{10} represents duration (d) for d<10 min, 10-60 min, 60-120 min, 120-180 min, 180-240 min, 240-300 min, 300-360 min, 360-420 min, 420-480 min and >480 min, respectively.

TABLE VII
INPUT DATA OF PARKING VOLUME MODEL FOR BOTH CAR AND MOTORCYCLE (MC) DURING THE WEEKDAY

Type of Vehicle	Parking Volume (vehicle)	Independent Variable				
		Accumulation (Vehicle)	Turnover	Dynamic Capacity (vehicle)	Parking Index	Average Duration (min)
Car	y	x1	x2	x3	x4	x5
	138	67	3.21	0.81	1.56	264.86
	104	47	2.42	0.73	1.09	220.48
	152	46	3.71	1.30	1.12	117.99
	196	51	4.78	1.48	1.24	103.60
	93	39	2.51	0.76	1.05	162.10
	84	34	2.27	0.65	0.92	189.70
MC	351	146	6.16	1.30	2.56	218.72
	423	149	7.42	1.27	2.61	167.80
	311	114	5.65	1.17	2.07	176.74
	448	120	8.15	1.88	2.18	109.64
	152	85	3.38	0.52	1.89	290.99
	163	115	3.62	0.48	2.56	309.45

TABLE VIII
INPUT DATA OF PARKING VOLUME MODEL FOR BOTH CAR AND MOTORCYCLE DURING THE WEEKEND

Type of Vehicle	Parking Volume (vehicle)	Independent Variable				
		Accumulation (Vehicle)	Turnover	Dynamic Capacity (vehicle)	Parking Index	Average Duration (min)
Car	y	x1	x2	x3	x4	x5
	75	26	1.74	1.29	0.60	124.73
	84	57	1.95	0.51	1.33	314.35
	115	28	2.80	1.04	0.68	131.52
	207	44	5.05	1.35	1.07	101.14
	50	21	1.35	0.56	0.57	220.00
	80	21	2.16	0.88	0.57	140.00
MC	153	37	2.68	1.97	0.65	108.59
	179	47	3.14	1.28	0.82	166.70
	166	41	3.02	1.49	0.75	122.65
	385	159	7.00	1.17	2.89	156.55
	81	22	1.80	1.45	0.49	103.40
	68	16	1.51	1.02	0.36	146.40

TABLE IX
INPUT DATA OF PARKING PERCENT DURATION FOR CAR AND MOTORCYCLE (MC) DURING THE WEEKEND

% of duration		Accumulation		Turnover		Dynamic Capacity		Parking Index		Parking Volume	
Car	MC	Car	MC	Car	MC	Car	MC	Car	MC	Car	MC
Y1		x1		x2		x3		x4		x5	
0.00	0.07	26	37	1.74	2.68	1.29	1.97	0.60	0.65	75	153
0.00	0.01	57	47	1.95	3.14	0.51	1.28	1.33	0.82	84	179
0.15	0.14	28	41	2.80	3.02	1.04	1.49	0.68	0.75	115	166
0.10	0.09	44	159	5.05	7.00	1.35	1.17	1.07	2.89	207	385
0.10	0.06	21	22	1.35	1.80	0.56	1.45	0.57	0.49	50	81
0.03	0.01	21	16	2.16	1.51	0.88	1.02	0.57	0.36	80	68
Y2		x1		x2		x3		x4		x5	
0.07	0.32	26	37	1.74	2.68	1.29	1.97	0.60	0.65	75	153
0.01	0.25	57	47	1.95	3.14	0.51	1.28	1.33	0.82	84	179
0.23	0.17	28	41	2.80	3.02	1.04	1.49	0.68	0.75	115	166
0.39	0.26	44	159	5.05	7.00	1.35	1.17	1.07	2.89	207	385
0.10	0.25	21	22	1.35	1.80	0.56	1.45	0.57	0.49	50	81
0.23	0.15	21	16	2.16	1.51	0.88	1.02	0.57	0.36	80	68
Y3		x1		x2		x3		x4		x5	
0.45	0.26	26	37	1.74	2.68	1.29	1.97	0.60	0.65	75	153
0.05	0.21	57	47	1.95	3.14	0.51	1.28	1.33	0.82	84	179
0.18	0.23	28	41	2.80	3.02	1.04	1.49	0.68	0.75	115	166
0.22	0.20	44	159	5.05	7.00	1.35	1.17	1.07	2.89	207	385
0.16	0.46	21	22	1.35	1.80	0.56	1.45	0.57	0.49	50	81
0.29	0.38	21	16	2.16	1.51	0.88	1.02	0.57	0.36	80	68
Y4		x1		x2		x3		x4		x5	
0.35	0.20	26	37	1.74	2.68	1.29	1.97	0.60	0.65	75	153
0.10	0.13	57	47	1.95	3.14	0.51	1.28	1.33	0.82	84	179

0.22	0.22	28	41	2.80	3.02	1.04	1.49	0.68	0.75	115	166
0.10	0.10	44	159	5.05	7.00	1.35	1.17	1.07	2.89	207	385
0.12	0.14	21	22	1.35	1.80	0.56	1.45	0.57	0.49	50	81
0.23	0.24	21	16	2.16	1.51	0.88	1.02	0.57	0.36	80	68
Y5		x1		x2		x3		x4		x5	
0.11	0.06	26	37	1.74	2.68	1.29	1.97	0.60	0.65	75	153
0.12	0.13	57	47	1.95	3.14	0.51	1.28	1.33	0.82	84	179
0.07	0.12	28	41	2.80	3.02	1.04	1.49	0.68	0.75	115	166
0.09	0.08	44	159	5.05	7.00	1.35	1.17	1.07	2.89	207	385
0.08	0.04	21	22	1.35	1.80	0.56	1.45	0.57	0.49	50	81
0.04	0.03	21	16	2.16	1.51	0.88	1.02	0.57	0.36	80	68
Y6		x1		x2		x3		x4		x5	
0.03	0.04	26	37	1.74	2.68	1.29	1.97	0.60	0.65	75	153
0.19	0.11	57	47	1.95	3.14	0.51	1.28	1.33	0.82	84	179
0.03	0.07	28	41	2.80	3.02	1.04	1.49	0.68	0.75	115	166
0.05	0.07	44	159	5.05	7.00	1.35	1.17	1.07	2.89	207	385
0.14	0.01	21	22	1.35	1.80	0.56	1.45	0.57	0.49	50	81
0.11	0.09	21	16	2.16	1.51	0.88	1.02	0.57	0.36	80	68
Y7		x1		x2		x3		x4		x5	
0.00	0.02	26	37	1.74	2.68	1.29	1.97	0.60	0.65	75	153
0.11	0.10	57	47	1.95	3.14	0.51	1.28	1.33	0.82	84	179
0.05	0.02	28	41	2.80	3.02	1.04	1.49	0.68	0.75	115	166
0.04	0.07	44	159	5.05	7.00	1.35	1.17	1.07	2.89	207	385
0.04	0.01	21	22	1.35	1.80	0.56	1.45	0.57	0.49	50	81
0.05	0.04	21	16	2.16	1.51	0.88	1.02	0.57	0.36	80	68
Y8		x1		x2		x3		x4		x5	
0.00	0.02	26	37	1.74	2.68	1.29	1.97	0.60	0.65	75	153
0.21	0.03	57	47	1.95	3.14	0.51	1.28	1.33	0.82	84	179
0.01	0.01	28	41	2.80	3.02	1.04	1.49	0.68	0.75	115	166
0.01	0.04	44	159	5.05	7.00	1.35	1.17	1.07	2.89	207	385
0.06	0.00	21	22	1.35	1.80	0.56	1.45	0.57	0.49	50	81
0.00	0.01	21	16	2.16	1.51	0.88	1.02	0.57	0.36	80	68
Y9		x1		x2		x3		x4		x5	
0.00	0.01	26	37	1.74	2.68	1.29	1.97	0.60	0.65	75	153
0.10	0.02	57	47	1.95	3.14	0.51	1.28	1.33	0.82	84	179
0.00	0.01	28	41	2.80	3.02	1.04	1.49	0.68	0.75	115	166
0.00	0.03	44	159	5.05	7.00	1.35	1.17	1.07	2.89	207	385
0.12	0.00	21	22	1.35	1.80	0.56	1.45	0.57	0.49	50	81
0.01	0.00	21	16	2.16	1.51	0.88	1.02	0.57	0.36	80	68
Y10		x1		x2		x3		x4		x5	
0.00	0.01	26	37	1.74	2.68	1.29	1.97	0.60	0.65	75	153
0.12	0.02	57	47	1.95	3.14	0.51	1.28	1.33	0.82	84	179
0.06	0.01	28	41	2.80	3.02	1.04	1.49	0.68	0.75	115	166
0.00	0.05	44	159	5.05	7.00	1.35	1.17	1.07	2.89	207	385
0.08	0.04	21	22	1.35	1.80	0.56	1.45	0.57	0.49	50	81
0.03	0.04	21	16	2.16	1.51	0.88	1.02	0.57	0.36	80	68

TABLE X
INPUT DATA OF PARKING PERCENT DURATION FOR CAR AND MOTORCYCLE (MC) DURING THE WEEKDAY

% of duration		**Accumulation**		**Turnover**		**Dynamic Capacity**		**Parking Index**		**Parking Volume**	
Car	**MC**	**Car**	**MC**	**Car**	**MC**	**Car**	**MC**	**Car**	**MC**	**Car**	**MC**
Y1		x1		x2		x3		x4		x5	
0.00	0.07	26	37	1.74	2.68	1.29	1.97	0.60	0.65	75	153
0.00	0.01	57	47	1.95	3.14	0.51	1.28	1.33	0.82	84	179
0.15	0.14	28	41	2.80	3.02	1.04	1.49	0.68	0.75	115	166
0.10	0.09	44	159	5.05	7.00	1.35	1.17	1.07	2.89	207	385
0.10	0.06	21	22	1.35	1.80	0.56	1.45	0.57	0.49	50	81
0.03	0.01	21	16	2.16	1.51	0.88	1.02	0.57	0.36	80	68
Y2		x1		x2		x3		x4		x5	
0.07	0.32	26	37	1.74	2.68	1.29	1.97	0.60	0.65	75	153
0.01	0.25	57	47	1.95	3.14	0.51	1.28	1.33	0.82	84	179
0.23	0.17	28	41	2.80	3.02	1.04	1.49	0.68	0.75	115	166
0.39	0.26	44	159	5.05	7.00	1.35	1.17	1.07	2.89	207	385
0.10	0.25	21	22	1.35	1.80	0.56	1.45	0.57	0.49	50	81
0.23	0.15	21	16	2.16	1.51	0.88	1.02	0.57	0.36	80	68
Y3		x1		x2		x3		x4		x5	
0.45	0.26	26	37	1.74	2.68	1.29	1.97	0.60	0.65	75	153
0.05	0.21	57	47	1.95	3.14	0.51	1.28	1.33	0.82	84	179
0.18	0.23	28	41	2.80	3.02	1.04	1.49	0.68	0.75	115	166
0.22	0.20	44	159	5.05	7.00	1.35	1.17	1.07	2.89	207	385
0.16	0.46	21	22	1.35	1.80	0.56	1.45	0.57	0.49	50	81
0.29	0.38	21	16	2.16	1.51	0.88	1.02	0.57	0.36	80	68
Y4		x1		x2		x3		x4		x5	
0.35	0.20	26	37	1.74	2.68	1.29	1.97	0.60	0.65	75	153
0.10	0.13	57	47	1.95	3.14	0.51	1.28	1.33	0.82	84	179
0.22	0.22	28	41	2.80	3.02	1.04	1.49	0.68	0.75	115	166
0.10	0.10	44	159	5.05	7.00	1.35	1.17	1.07	2.89	207	385
0.12	0.14	21	22	1.35	1.80	0.56	1.45	0.57	0.49	50	81
0.23	0.24	21	16	2.16	1.51	0.88	1.02	0.57	0.36	80	68
Y5		x1		x2		x3		x4		x5	

0.11	0.06	26	37	1.74	2.68	1.29	1.97	0.60	0.65	75	153
0.12	0.13	57	47	1.95	3.14	0.51	1.28	1.33	0.82	84	179
0.07	0.12	28	41	2.80	3.02	1.04	1.49	0.68	0.75	115	166
0.09	0.08	44	159	5.05	7.00	1.35	1.17	1.07	2.89	207	385
0.08	0.04	21	22	1.35	1.80	0.56	1.45	0.57	0.49	50	81
0.04	0.03	21	16	2.16	1.51	0.88	1.02	0.57	0.36	80	68
Y6		x1		x2		x3		x4		x5	
0.03	0.04	26	37	1.74	2.68	1.29	1.97	0.60	0.65	75	153
0.19	0.11	57	47	1.95	3.14	0.51	1.28	1.33	0.82	84	179
0.03	0.07	28	41	2.80	3.02	1.04	1.49	0.68	0.75	115	166
0.05	0.07	44	159	5.05	7.00	1.35	1.17	1.07	2.89	207	385
0.14	0.01	21	22	1.35	1.80	0.56	1.45	0.57	0.49	50	81
0.11	0.09	21	16	2.16	1.51	0.88	1.02	0.57	0.36	80	68
Y7		x1		x2		x3		x4		x5	
0.00	0.02	26	37	1.74	2.68	1.29	1.97	0.60	0.65	75	153
0.11	0.10	57	47	1.95	3.14	0.51	1.28	1.33	0.82	84	179
0.05	0.02	28	41	2.80	3.02	1.04	1.49	0.68	0.75	115	166
0.04	0.07	44	159	5.05	7.00	1.35	1.17	1.07	2.89	207	385
0.04	0.01	21	22	1.35	1.80	0.56	1.45	0.57	0.49	50	81
0.05	0.04	21	16	2.16	1.51	0.88	1.02	0.57	0.36	80	68
Y8		x1		x2		x3		x4		x5	
0.00	0.02	26	37	1.74	2.68	1.29	1.97	0.60	0.65	75	153
0.21	0.03	57	47	1.95	3.14	0.51	1.28	1.33	0.82	84	179
0.01	0.01	28	41	2.80	3.02	1.04	1.49	0.68	0.75	115	166
0.01	0.04	44	159	5.05	7.00	1.35	1.17	1.07	2.89	207	385
0.06	0.00	21	22	1.35	1.80	0.56	1.45	0.57	0.49	50	81
0.00	0.01	21	16	2.16	1.51	0.88	1.02	0.57	0.36	80	68
Y9		x1		x2		x3		x4		x5	
0.00	0.01	26	37	1.74	2.68	1.29	1.97	0.60	0.65	75	153
0.10	0.02	57	47	1.95	3.14	0.51	1.28	1.33	0.82	84	179
0.00	0.01	28	41	2.80	3.02	1.04	1.49	0.68	0.75	115	166
0.00	0.03	44	159	5.05	7.00	1.35	1.17	1.07	2.89	207	385
0.12	0.00	21	22	1.35	1.80	0.56	1.45	0.57	0.49	50	81
0.01	0.00	21	16	2.16	1.51	0.88	1.02	0.57	0.36	80	68
Y10		x1		x2		x3		x4		x5	
0.00	0.01	26	37	1.74	2.68	1.29	1.97	0.60	0.65	75	153
0.12	0.02	57	47	1.95	3.14	0.51	1.28	1.33	0.82	84	179
0.06	0.01	28	41	2.80	3.02	1.04	1.49	0.68	0.75	115	166
0.00	0.05	44	159	5.05	7.00	1.35	1.17	1.07	2.89	207	385
0.08	0.04	21	22	1.35	1.80	0.56	1.45	0.57	0.49	50	81
0.03	0.04	21	16	2.16	1.51	0.88	1.02	0.57	0.36	80	68

2) *Regression*

The example polynomial regression analysis for car parking volume during the weekend is presented below: (output of Minitab)

```
Y = 5.223 + 2.505 x1 + 41.16 x2 - 3.124 x3 -
102.0 x4 - 0.02148 x5
Coefficients
Term          Coef SE Coef  T-Value  P-Value     VIF
Constant     5.223       *        *        *
x1           2.505       *        *        *  316.98
x2           41.16       *        *        *   52.41
x3          -3.124       *        *        *  235.08
x4          -102.0       *        *        *  157.16
x5        -0.02148       *        *        *  134.55
```

The VIF shows the value of much greater than ten, while when VIF>10, it is concluded that there is multicollinearity among independent variables. In this case, the common polynomial regression can not be used to use the principal component regression. Moreover, the result of the principal component regression is as follow:

```
Model Summary
      S    R-sq  R-sq(adj)  R-sq(pred)
7.43496  98.16%     96.94%      88.56%
Coefficients
Term         Coef  SE Coef  T-Value  P-Value   VIF
Constant   127.83     3.04    42.12    0.000
W1          25.53     2.02    12.65    0.001  1.00
W2           1.60     2.23     0.72    0.525  1.00
Regression Equation
Y = 127.83 + 25.53 W1 + 1.60 W2
```

The regression equation obtained is free of multicollinearity problem since the VIF value of new variable ‘W’ is 1.00 and 1.00 for W1 and W2, respectively which all are less than 10 (VIF<10). These ‘W’ value is then transformed to original independent ‘x’ value, therefore the all ‘x’ values are presented in Table 11, Table 12 and Table 13 below.

TABLE XI
THE REGRESSION MODEL OF PARKING VOLUME

Type of Vehicle	**Day type**	**Coefficient of Principal Component Regression**					
		c	**x1**	**x2**	**x3**	**x4**	**x5**
Car	Weekend	-62.251594	1.323154	3.705282	59.809931	54.540470	0.065764
	Weekday	-130.138894	8.506790	6.997432	41.970970	3.057564	-37.998875
MC	Weekend	-21.367564	0.713814	19.422891	26.835867	39.589583	0.121098
	Weekday	65.074964	0.945896	19.301147	70.561611	18.380220	-0.485388

TABLE XII
THE REGRESSION MODEL OF PERCENT DURATION OF CAR

Type of Vehicle	Day type	Coefficient of Principal Component Regression					
		c	**x1**	**x2**	**x3**	**x4**	**x5**
Car	Weekend						
	y1	0.032362	-0.000458	0.005962	0.035025	-0.020813	0.000137
	y2	-0.056128	-0.000917	0.031163	0.144555	-0.041041	0.000732
	y3	0.302911	-0.003185	0.008085	0.114356	-0.145816	0.000155
	y4	0.294268	-0.002143	-0.001229	0.051114	-0.098307	-0.000055
	y5	0.061086	0.000539	-0.000326	-0.015321	0.024720	-0.000001
	y6	0.135481	0.001278	-0.011933	-0.079512	0.058207	-0.000269
	y7	0.029634	0.000897	-0.002702	-0.033845	0.041040	-0.000054
	y8	0.032791	0.002319	-0.010649	-0.101699	0.106014	-0.000226
	y9	0.091853	0.000749	-0.010207	-0.059050	0.034025	-0.000234
	y10	0.075990	0.000922	-0.008193	-0.055769	0.042034	-0.000184
	Weekday						
	y1	0.081498	-0.001457	0.014190	0.055130	-0.075764	0.000255
	y2	0.720315	-0.006572	0.025568	0.132460	-0.341572	0.000327
	y3	1.707104	-0.029133	0.172968	0.767411	-1.514157	0.002728
	y4	-0.777108	0.014756	-0.071048	-0.338633	0.766899	-0.001027
	y5	-0.113644	0.003233	-0.015270	-0.073301	0.168050	-0.000219
	y6	-0.101751	0.002018	-0.007601	-0.039912	0.104850	-0.000095
	y7	-0.124048	0.002219	-0.007951	-0.042665	0.115333	-0.000096
	y8	-0.184745	0.002714	-0.007673	-0.045978	0.141049	-0.000073
	y9	-0.006111	0.001050	-0.007637	-0.031902	0.054587	-0.000128
	y10	0.540557	-0.002601	-0.016722	-0.028715	-0.135138	-0.000445

TABLE XIII
THE REGRESSION MODEL OF PERCENT DURATION OF MOTORCYCLE

Type of Vehicle	Day type	Coefficient of Principal Component Regression					
		c	**x1**	**x2**	**x3**	**x4**	**x5**
MC	Weekend						
	y1	0.049176	0.000076	0.002031	-0.003410	0.004252	0.000035
	y2	0.214495	0.000085	0.002257	-0.003789	0.004724	0.000039
	y3	0.354382	-0.000311	-0.008300	0.013934	-0.017375	-0.000143
	y4	0.132810	0.000178	0.004739	-0.007956	0.009921	0.000081
	y5	0.063218	0.000060	0.001595	-0.002677	0.003339	0.000027
	y6	0.055931	0.000039	0.001048	-0.001760	0.002194	0.000018
	y7	0.028720	0.000078	0.002076	-0.003486	0.004346	0.000036
	y8	0.006534	0.000062	0.001665	-0.002795	0.003486	0.000029
	y9	-0.001187	0.000054	0.001428	-0.002397	0.002989	0.000025
	y10	0.021389	0.000034	0.000910	-0.001528	0.001905	0.000016
	Weekday	c	x1	x2	x3	x4	x5
	y1	0.171808	-0.000504	0.008753	0.042225	-0.088691	0.000125
	y2	0.190426	-0.000404	0.025556	0.111611	-0.147989	0.000374
	y3	-0.189782	0.000923	0.011507	0.038194	0.048041	0.000180
	y4	0.271520	-0.000298	-0.007932	-0.030019	0.001987	-0.000120
	y5	0.068068	0.000108	-0.006118	-0.026837	0.036558	-0.000090
	y6	-0.047747	0.000406	-0.005019	-0.025483	0.062958	-0.000070
	y7	-0.004211	0.000221	-0.005188	-0.024171	0.044425	-0.000075
	y8	0.061428	0.000094	-0.006935	-0.030124	0.038595	-0.000102
	y9	0.238723	-0.000300	-0.009992	-0.038646	0.010381	-0.000151
	y10	0.238076	-0.000242	-0.004609	-0.016700	-0.005929	-0.000071

B. Discussions

The parking indicators, including percent duration, average parking duration, and the parking volume, are presented in Table 1, Table 3, and Table 5. The percent duration is classified into ten class intervals: <10 minutes, 10-60 minutes, 60-120 minutes, 120-180 minutes, 180-240 minutes, 240-300 minutes, 300-360 minutes, 360-420, 420-480 minutes and >480 minutes. This classification is chosen since in Surabaya, some applied parking tariff schemes accommodate hourly base progressive tariff with maximal tariff applied is 8 hours (480minute) for a whole day as well as free charged will be applied when the duration is below 10 minutes. The percentage explain the percent of vehicle within the class interval of duration, the total of percentage should be 100%. The parking volume is the total number of vehicles counted parking in the facility during the service time. The other parking indicators including accumulation, turnover, dynamic capacity, and parking index.

The inputs of regression analysis of the parking volume model for both dependent and independent variables during the weekdays as well as weekends are summarized in Table 7 and Table 8, while the inputs of regression analysis of percent duration model are summarized in Table 9 and Table 10. These values are basically summarized from previous table (Table 1, Table 2, Table 3, Table 4, Table 5, Table 6). These tables are prepared for regression analysis.

Principal component analysis as well as principal component regression is used in this paper. This method is also widely used in reducing number of variables and when multicollinearity issue occurred [12–14,16]. Therefore, this method is quite reliable. However, this method is not yet used in vehicle parking analysis, especially in terms of modeling of vehicle parking volume and vehicle parking duration.

Many of vehicle parking studies only come to an end at the calculation of vehicle parking Indicators including accumulation, turnover, dynamic capacity, parking index, volume, and duration [9,11,17]. The other parking study discuss about the relation of parking demand with the public transit accessibility for both shopping centre and supermarket in Beijing, China[18], However, this paper is not only calculating vehicle parking indicators, but also utilize them as the input to create the model for vehicle parking volume as well as parking duration so that they can be used for further function, especially in order to determine the vehicle parking revenue as well as parking tax prediction. This paper is also different from probability of choosing on-street parking facility for motorcycle in Surabaya [19].

The vehicle parking volume model obtained as presented in Table 11 can be used by inputting independent variable of x1, x2, x3, x4 and x5 for accumulation, turnover, dynamic capacity, parking index and average duration, respectively. Meanwhile, the percent duration model of yi as presented in Table 12 and Table 13 can be calculated using the independent variable of x1, x2, x3, x4 and x5 for accumulation, turnover, dynamic capacity, parking index and parking volume, respectively.

However, in its use, the model of percent duration needs to be corrected to the total of 100% since the sum of the percentage of duration (yi) must satisfy this rule, ∑yi=100%. Since, it is highly possible to have the condition that ∑yi obtained from the model is not 100%. Therefore, the result needs to be corrected based on the proportion of yi to ∑yi accordingly so that the ∑yi is equal to 100%. For the illustration, suppose the independent variable values are as follow: accumulation (x1) =42, turnover (x2)=2.42, dynamic capacity (x3)=0.81, parking index (x4)=1.09 and parking volume (x5)=220. Then by using the model for weekday car of percent duration, the y1, y2, y3, y4, y5, y6, y7, y8, y9, y10 will have the result of 6.55%, 28.02%, 32.77%, 8.02%, 7.71%, 3.57%, 3.11%, 2.46%, 3.02%, and 10.93% respectively. The ∑yi in this case is equal to 106,16% (≠100%). Therefore, the value of yi need to be corrected proportionally so that they become 6.17%, 26.40%, 30.87%, 7.56%, 7.26%, 3.36%, 2.93%, 2.32%, 2.84%, 10.29% for y1, y2, y3, y4, y5, y6, y7, y8, y9, y10, respectively. The new corrected ∑yi is then equal to 100%.

paid accordingly. The parking volume model will be useful if the parking charge is only based on a single payment (flat-rate) paid accordingly. The parking volume model will provide Both vehicle parking volume model and vehicle parking duration can help local authorities and investors interested in off-street parking supply to estimate the parking facility's revenue and the parking tax charged be useful paid accordingly. The parking volume model will be useful if the parking charge only based on single payment (flat rate) but when the progressive tariff is applied, both parking volume and parking duration will be very useful. Suppose the vehicle parking tariff scheme for car are as follow; 1. First ten minutes are free, 2. First one hour is Rp. 8000, 3. Additional hourly charge is Rp. 2000 and 4. The maximum charge is 8 hours while the parking tax is 15%. Additionally, the number of car parking in the parking facility is 220 vehicle a day. The illustration of calculating parking revenue is presented in Table 14. The revenue of car parking for weekday within a tear is Rp. 671,871,200, while the parking potential tax is Rp. 100,780,680. Same steps can be applied to other type of the day as well as other type of vehicles.

TABLE XIV
THE ILLUSTRATION OF PARKING REVENUE CALCULATION, YEARLY

Duration (minutes)	**<10**	**10-60**	**60-120**	**120-180**	**180-240**	**240-300**	**300-360**	**360-420**	**420-480**	**>480**
Percentage, a	6.17%	26.40%	30.87%	7.56%	7.26%	3.36%	2.93%	2.32%	2.84%	10.29%
Addition parking charge (Rp), b			2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000
Parking charge (Rp), c	-	8,000	10,000	12,000	14,000	16,000	18,000	20,000	22,000	24,000
Daily car Parking volume (weekday), d	**220**									
Number of vehicles within class interval, e=a×d	13.574	58.08	67.914	16.632	15.972	7.392	6.446	5.104	6.248	22.638
Daily Revenue, Rp. (car, weekday), f=e×c	-	464,640	679,140	199,584	223,608	118,272	116,028	102,080	137,456	543,312
Total daily revenue, Rp. (car, weekday), g=∑f						2,584,120				
Number of weekdays within a year, h						260				
Yearly Revenue, Rp. (car, weekday), i=h×g						671,871,200				
Parking tax should be paid, (15%), Rp., j=0.15×i						100,780,680				

Note: Rp. is Indonesian currency (Rupiah)

IV. Conclusions

Parking volume at the shopping stores can be modeled with the input variable of accumulation, turnover, dynamic capacity, parking index, and average duration. Those variables are commonly used to assess the parking facility performance so that they have a multicollinearity problem. Therefore, the forming of the model use the principal component regression. The example of parking volume model for car during the weekend is y=-62.251594+1.323154x1+3.705282x2+59.809931x3+54.540470x4+0.065764x5. Additionally, the percent duration can also be modeled with the input variable of accumulation, turnover, dynamic capacity, parking index, and parking volume. Like the parking volume model, the independent variables of percent duration, including accumulation, turnover, dynamic capacity, parking index, and parking volume, also have a multicollinearity problem. The model can be developed with principal component regression. The models of vehicle parking for shopping store are available for both vehicle and motorcycle, they are also available for both weekend and weekday to represent the type of the day. The example of percent duration model (duration<10minutes) for car during the weekend is y1=0.032362-0.000458x1+0.005962x2+0.035025x3-0.020813x4+0.000137x5.

References

[1] Darmaningtyas. Parkir Dan Pembatasan Mobil [Internet]. 2010. Available from: http://instran.org/index.php/in/ruang-berita/depan/25-front-page/349-parkir-dan-pembatasan-mobil-?format=pdf

[2] Auckland Transport. Price Adjustment Policy Parking Buildings Auckland CBD. 2016. Available from: https://at.govt.nz/media/359818/AT-Off-Street-Parking-Price-Policy.pdf

[3] Arditia R. Analisis Kontribusi Dan Efektivitas Pajak Daerah Sebagai Sumber Pendapatan Asli Daerahkota Surabaya. Jurnal Akuntansi AKUNESA. 2013 May 17;1(3).

[4] Suarasurabaya.net. DPRD Surabaya Soroti Kenaikan Tarif Parkir Mal [Internet]. Surabaya; 2015. Available from: https://www.suarasurabaya.net/kelanakota/2015/DPRD-Surabaya-Soroti-Kenaikan-Tarif-Parkir-Mal/

[5] Beritasurabaya.net. Pendapatan Parkir Rendah, Digembol Jukir Nakal [Internet]. Surabaya; 2012 Available from: http://beritasurabaya.net/index_sub.php?category=4&id=5366

[6] Hakim L. Kebocoran Pendapatan Parkir di Surabaya Capai 40% [Internet]. Surabaya; 2014. Available from: https://daerah.sindonews.com/berita/927971/23/kebocoran-pendapatan-parkir-di-surabaya-capai-40

[7] Ferrarese M. A perceptual-behavioural approach with non-parametric experimental coefficient for urban parking business design. Archives of Transport. 2016;37.

[8] Kartika AA, Mochtar IB, Widyastuti H. The Modelling Concept of Volume and Duration of Parking for Various Types of Landuse in Surabaya. IPTEK Journal of Proceedings Series. 2017 Dec 31;3(6).

[9] Putu Preantjaya Winaya. Kajian teoritis karakteristik dan strategi optimasi parkir pada pasar swalayan [Internet]. University of Udayana Bali, Indonesia; 2018. Available from: https://simdos.unud.ac.id/uploads/file_penelitian_1_dir/1d8e90a13cbb1256400dbe997c7eb5ef.pdf

[10] Tamin OZ. Perencanaan dan pemodelan transportasi. Penerbit ITB; 2000.

[11] Evriyani D, Soehodho S. Kajian Analisis Karakteristik Parkir Off-Street Kendaraan Angkutan Barang Dan Pengantaran Barang Di Pusat Perbelanjaan Pasar Jatinegara. InThe 17th FSTPT of International Symposium 2014. Prosiding Forum Studi Transportasi Antar Perguruan Tinggi.

[12] Prasetyo HB, Handayani D, Rahayu W. Analisis Regresi Komponen Utama Untuk Mengatasi Masalah Multikolinieritas Dalam Analisis Regresi Linier Berganda [Internet]. 2008. Available from: https://adia08.files.wordpress.com/2008/07/jurnal_haris.pdf

[13] Dyah NR. Feature reduction using the minimum noise fraction and principal component analysis transforms for improving the classification of hyperspectral images. Asia-Pacific Journal of Science and Technology. 2017 Apr 26;22(1).

[14] Wattanakul N, Morakul S, Lorjaroenphon Y, Jom KN. Metabolic profiles analysis and DPPH radical-scavenging assay of 'Nam Dok Mai'mango wine during fermentation. Asia-Pacific Journal of Science and Technology. 2019 Dec 26;24(04):1-7.

[15] Johnson RA, Wichern DW. Applied multivariate statistical analysis. Statistics. 2015;6215(10):10.

[16] Siburian JN, Rahmawati R, Hoyyi A. Regresi Komponen Utama Robust S-Estimator Untuk Analisis Pengaruh Jumlah Pengangguran Di Jawa Tengah. Jurnal Gaussian. 2020 Feb 27;8(4):439-50.

[17] Lajqi N, Sh L, Doçi I. The Methodology For Vehicles Parking Analysis: Case Study–City of Prishtina. Machines. Technologies. Materials.. 2017;11(10):499-503.

[18] Qin H, Xiao Q, Guan H, Pan X. Analysis on the parking demand of the commercial buildings considering the public transport accessibility. Nature and Science. 2010;8(3):63-8.

[19] Mudjanarko SW, Sulistio H, Djakfar L, Wicaksono A. Behaviour Model of Motor Cycle User in Selecting Parking Location (Case study in Surabaya City of Indonesia). Journal of Basic and Applied Scientific Research (JBASR). 2013;3:842-6.