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Research paper



Monte Carlo Simulation of on-Street Parking Retribution Revenue Potential in Sleman Regency Indonesia

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Abstract

Regional autonomy in Indonesia allows every region in Indonesia to manage its own finances. Each region shall be entitled to regulate their own locally-generated revenue, including taxes and user charges. One source of regional levies is from Public On-street parking. On-Street parking in Sleman Regency Yogyakarta has considerable potential. Sleman is a district with the largest population in DI Yogyakarta province of Indonesia. This is because most of the commercial, educational, health and employment centers are located in Sleman. There are several On-street parking centers in Sleman, and the most are in Depok District. So far, the parking retribution system of On-street parking is one of the sources of locally-generated revenue is to determine the value of certain contracts that must be paid by the parking operator to the government. The value of this contract is fixed monthly for one year and will be reviewed in the following year. The value of this fixed contract indicates the number and types of vehicles coming at that location are fixed every day. For example, if the parking rate of two-wheeled vehicles is IDR 1000 and the monthly contract value is IDR 400,000 then the parking location will only contain a maximum of 13 motorcycles every day. In fact, the frequency of vehicles and vehicle types is a variable that is probabilistic in nature. Therefore, this study will attempt to simulate the potential revenue of parking charges by entering on-street parking probabilistic elements. The result of this research is the combination and number of parking vehicles obtained from simulation result. This simulation model can then be used as a predictor of the potential revenue from on-street parking charge so that it can also be used to determine a more appropriate contract value policy.

Keywords: *Simulation, Monte Carlo, On-street Parking*

1. Introduction

In conducting activities to meet the needs, humans will move from one location to the location with or without using vehicle. When using a vehicle, people need an area to put the vehicle, both from and to the destination location. Activities to stop and put vehicle is called parking. Parking is a state of the vehicle stopping for some time that the rider abandoned. Parking can be done at home (in the garage), in special parking lots, and in public parking lots. Community parking activities is parking done in an area that is intended for parking that does not affect other activities. However, the public road or on-street parking is a type of activity that affects other activities in which on-street parking directly interfere with traffic on the roads so it can lead to traffic jams (1) (2). But for local government, on-street parking also brings advantage as one of originally generated revenue sources, that is included in public service charge class.

Regulations on regional autonomy make regions in Indonesia, including Sleman Regency Yogyakarta, have the right to manage their own sources of income. Sleman is one of the districts in Yogyakarta. Sleman is a district with a fairly solid traffic activity level compared to other districts in Yogyakarta. This is because the number of centers of education, health, commerce and other public activities. Therefore, Sleman became a district with a high income level of parking fees. According to Sleman District Regulation No. 1 of 2012 on Roadside Parking Levy, retribution for public roadside parking services are levies imposed on private persons or entities that use the provision of parking services on public roads. Based on information from the Department of Transportation, Communication and Information of Sleman, almost 50% of parking charge in Sleman is obtained from Depok District, as many as IDR 623.981.600 target with the realization reached IDR 677.605.000.

The on-street parking levy system in Sleman is stipulated in Sleman Regional Regulation No. 1 of 2012 on Parking Service Levies on the Public Road. The regulation stipulates that the object of retribution is the provision of parking services on the public road side determined by the Regional Government in accordance with the provisions of legislation, except for non-motorized vehicles. Principles for determining levy rates are determined by taking into account the costs of providing public roadside parking services, community capacity, fairness, and control effectiveness of public roadside parking services. On street parking charge retrieval system uses a contract system. The government is targeting a certain amount of revenues to be paid by on-street parking operators to local governments. The value of parking charge contracts vary depending on the on street parking density in certain locations. The average contract value for the location in Depok District, Sleman Regency in a year is IDR 400,000, with a maximum contract value of IDR 2,000,000 and minimum of IDR 150,000. The value of this contract is fixed for one year but may change the next year.

The regulation mentions that the level of on-street parking service use is measured based on the frequency of parking use and the

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type of vehicle. It means with monthly contract value of IDR 400,000 for two-wheeled motorcycle (motorcycle) rate of IDR 1000 and four wheel (car) rate of IDR 2000 then the income in a day is only obtained from about 13 motorcycles or 9 motorcycles and 2 cars or a combination of both. In fact, observations in some parking locations in Depok district indicate that the volume of potential vehicles arrival is bigger than that. While with a fixed contract value, the number of parked vehicles is considered to be fixed for one year regardless the actual parking potential.

Basically, on-street parking issues can be examined from various viewpoints and disciplines, because the characteristics of the problems that involve many parties. Based on parking system in Sleman regency mentioned above and elaboration on previous research, this research will be conducted with a different viewpoint. This study considers that the amount of parking charge received depends on the frequency of vehicles coming and the type of vehicle. In fact, the number and type of vehicle is a variable that is filled with uncertainty and is always changing every day. In determining the potential and contribution of on-street parking charge to own locally-generated revenue, local governments will never be able to ascertain the exact amount. It requires a method that can accommodate the uncertainty, so that policy of withdrawal and value of counter parking retribution of on-street can be determined based on its potential. One method that can be used to analyze problems with uncertain variables is Monte Carlo simulation. Monte Carlo simulation is a method that involves the use of random numbers to represent uncertain variables so that the behavior of the system simulated will be known. The results of this Monte Carlo simulation can be put into consideration in stipulating policies of parking charges.

2. Literature Review

Research on parking fees has been done before, such as (3) that conducted a quantitative analysis by drawing data in time series and concluded that parking charges have a positive influence on own locally-generated revenue of Surakarta. In contrast, (4) showed that in Kabupaten Pekalongan the contribution of on-street parking fees to own locally-generated revenue still tended to be small. The study was conducted by calculating the potential revenue from on-street parking by using simple and qualitative quantitative methods. Other research is also conducted by (5) in Manado City which aims to analyze and predict the realization of acceptance of parking retribution in 2016-2020. The results of this study indicate that the parking charge revenue continues to increase.

The parking retribution system of on-street parking is an uncertain or probabilistic system. The system is said to be probabilistic if at least an uncertain variable exists. Probabilistic variables that exist in the system include the variable number of vehicles parking every day, the type of vehicle parking and the time between arrivals of the vehicle. One of the methods used to analyze stochastic systems is simulation. Simulation is a powerful quantitative analytical tool used to deal with complexity in the performance measurement issue, which is able to provide solutions to problems in the system quickly through the help of computer programs. Simulation is a process of running a model of a real system in order to study or experiment on real systems in order to 1.) understand system behavior 2.) evaluate system operating strategies and 3.) conduct a series of system scenarios to draw conclusions about real systems (6). Simulation is also defined as a simple imitation of real-world operating systems that aims to evaluate the system (7). There are various simulation methods, one of which is Monte Carlo Simulation.

3. Methodology

Monte Carlo simulation illustrates the possibility of using a known sample data sample. This simulation is run using existing data (historical data). In other words, if you want a simulation model that includes random sampling with probability distributions that can be known and determined, then this simulation can be used (8). Monte Carlo's simulation steps as follows (9):

1. Define probability distribution
2. Convert the probability distribution into a cumulative frequency form.
3. Run the simulation process with random numbers.
4. Use analysis from simulation output as input for alternative problem solving and decision making.

Monte Carlo simulation is an appropriate method used to solve complex and probabilistic problems. Previous studies have given some evidences. (10) used Monte Carlo simulations to control inventory due to uncertain lead time and demand. (11) used Monte Carlo simulation as a tool to estimate the cost to be spent on the project. In a service system, Monte Carlo simulations can also be implemented. Research in the service system conducted by (12) implemented Monte Carlo to overcome the long queue problems in the service system of STNK renewal. In addition, many have also implementated it such as in analyzing parts inventory, bad loans, insurance. Therefore, this study will also use Monte Carlo simulations to illustrate how the probabilistic behavior in on-street parking lot in Sleman Regency. Figure 1 explains Flowchart of Monte Carlo simulation steps.

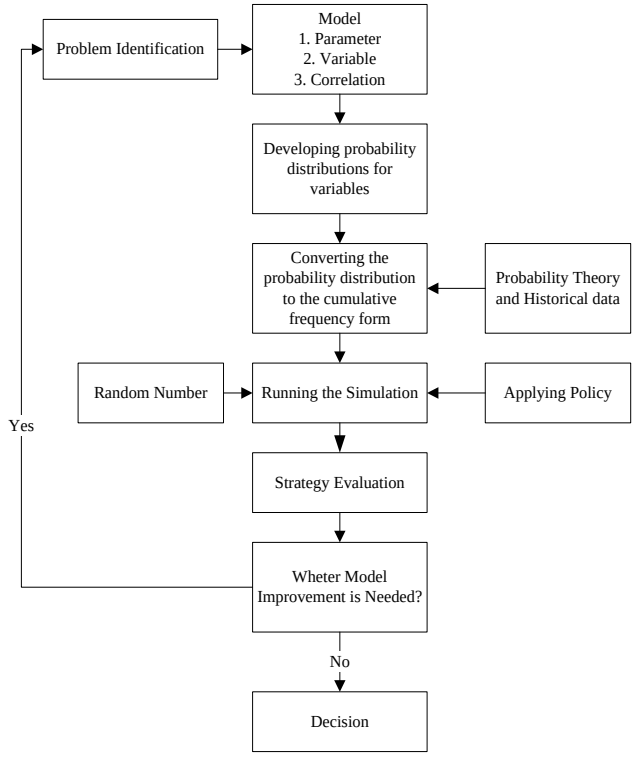


Fig. 1: Flowchart of Monte Carlo simulation (9)

4. Result and Finding

Most of vehicles parking in on-street parking are cars or motorcycles. Therefore, the object of the study will only be limited to the two types of vehicles. In the study of on-street parking fees, probabilistic variable used is the type of vehicle (motorcycle or car), the time between arrivals of the vehicle and the number of vehicles parking every day. On-street parking location selected is Babarsari street, Depok district, Sleman regency. Babarsari is known as a fairly densely populated area. In the area there are many edu-

cational centers, offices and commerce. Among them are UPN Yogyakarta campus, Atma Jaya Campus, Proklamasi 45 University, Jwalk Mall, shopping area, board building, STTN Batan, Transportation Department, Post Office and some other service centers. The data collected includes two types of data, namely primary and secondary. Primary data obtained by doing direct observation at the on-streep parking location. Secondary data is the contract value data obtained from the Department of Transportation of Sleman Regency. The location data along with the contract value of each location are described in Table 1. The agreed parking rate for is IDR 1000 for the motorcycle, and IDR 2000 for cars.

Table 1: Parking location and contract value of retribution

No	Location Name	Contract Value
1	Satria Net	IDR 300.000
2	Yamie Panda Shop	IDR 300.000
3	Skyblue Store	IDR 300.000
4	Petraco Store	IDR 300.000

Primary data was taken by observing for 10 days at 4 (four) on-street parking area at Babarsari street of Sleman Regency. The data includes the number and type of vehicles and time between arrivals of vehicles for each location. The number and types of vehicles for each location are taken in accordance with Table 2 (MC : Motor Cycle, C : Car).

Table 2: Data on the number and types of vehicles

Day	Satria NET		Yamie Panda		Skyblue Store		Petraco Store	
	MC	C	MC	C	MC	C	MC	C
1	123	8	110	8	130	18	88	11
2	135	10	120	11	109	10	77	6
3	105	9	108	8	93	10	88	11
4	116	6	99	5	82	14	52	12
5	125	6	101	10	94	9	44	12
6	115	9	101	6	73	8	64	12
7	122	8	122	10	95	13	62	9
8	134	6	118	6	96	7	73	8
9	135	9	133	12	105	11	34	6
10	124	5	124	10	139	15	50	11

The first step in data processing is to determine the probability distribution of the frequency of the event and the random number representing it. The data between arrival time and the data of the number of vehicles have a large number of variations so that it will be grouped in intervals and class length according to statistical rules. Tables 3, 4 and 5 respectively describe examples of probability distributions for the assigned location of Satria Net. Similar calculations are also made for 3 (three) other locations. (TBA: Time Between Arrival, RN: Random Number).

Table 3: Distribution of time probability between vehicle arrivals at Satria Net location

No	TBA		Rel. Freq.	Cum. Freq.	Prob.	Cum. Prob.	RN	
1	0	5	49	49	0,583	0,583	1	583
2	6	11	17	66	0,202	0,786	584	786
3	12	17	11	77	0,131	0,917	787	917
4	18	23	3	80	0,036	0,952	918	952
5	24	29	1	81	0,012	0,964	953	964
6	30	35	2	83	0,024	0,988	965	988
7	36	41	1	84	0,012	1,000	989	1000
Total			84		1			

Table 4: Distribution of probability of vehicle number at Satria Net location

No	Number of Vehicle		Rel Freq.	Cum. Freq.	Prob.	Cum. Freq.	Random Number	
1	114	122	2	2	0,2	0,2	1	200
2	123	131	5	7	0,5	0,7	201	700
3	132	140	1	8	0,1	0,8	701	800
4	141	149	2	10	0,2	1	801	1000
Total			10		1			

Table 5: Distribution of vehicle type probability

No	Vehicle Type	Rel. Freq.	Cum. Freq	Prob.	Cum. Freq.	Random Number	
1	MC	1234	1234	0,942	0,942	1	942
2	Car	76	1310	0,058	1,000	943	1000
Total		1310		1			

The simulation process is done by generating random numbers to represent the three probabilistic variables in the on-street parking system. In one day, the number of vehicles for the four locations is not up to 200 units of vehicles. Therefore, the simulation time between arrivals and the type of vehicle will be done as much as 200 times the arrival of the vehicle. Using software help of MS Excel, this research developed a random spreadsheet for each arrival. Table 6 describes the simulation process performed.

Tabel 6: Simulation of time between arrivals and type of vehicle

No	RN	TBA	RN	Vehicle Type	Parking Fee	Revenue
1	25	3	194	MC	1000	1000
2	610	11	499	MC	1000	2000
3	573	0	836	MC	1000	3000
4	369	2	638	MC	1000	4000
5	127	0	748	MC	1000	5000
6	734	6	954	Car	1000	6000
7	454	1	940	MC	1000	7000
8	353	3	401	MC	1000	8000
9	777	9	675	MC	1000	9000
10	284	0	991	Car	2000	11000
.....	.....		.....	.....	.....	.....
199	348	1	284	MC	1000	214000
200	588	10	867	MC	1000	215000

Simulation in Table 6 shows the probability or possibility of vehicle arrival based on the historical data that has been collected. For example, random number 25 in Satria Net represents the time between arrivals is 0 (zero) up to 5 (five), according to Table 3. Possible vehicle coming is motorcycles according to the random number representing it. Generating a certain number of random numbers shows how much revenue earned from each arrival as shown in the "Revenue" column. The next step simulates the number of vehicles each day according to Table 7.

Table 7: Simulation of the number of vehicles and income each day for one month

No	Random Number	Number of Vehicle per Day	Revenue per Day
1	438	129	Rp 138.000
2	528	131	Rp 141.000
3	485	128	Rp 137.000
4	372	127	Rp 136.000
5	114	118	Rp 125.000
6	892	143	Rp 153.000
7	194	119	Rp 126.000
8	550	129	Rp 138.000
9	89	120	Rp 127.000
10	343	130	Rp 140.000
.....	.....	.....	.....
29	846	147	Rp 157.000
30	79	120	Rp 127.000
Revenue per month			Rp 4.108.000
Number of Vehicle per month			3850

Table 7 shows how many possible vehicles come at the Satria Net location. The possibility of vehicle is arrival is based on the probability distribution data in Table 4 where its emergence is repre-

sented by random numbers. The number of vehicles consists of motorcycle and car types, in which the composition of motorcycle and automobile is also probabilistic and its appearance is based on calculations in Table 6. Prior to use, the simulation results must be validated to ascertain whether the simulation model is in accordance with the real system or not. The validation was done by using chi square test with MS Excel. Validation was performed on all simulation results from all four locations. Validated variables are the average number of vehicles for a month of real systems and simulated outputs. Validation results can be seen in Table 8. Number of vehicles in Satria Net location in Table 7 and Table 8 differs caused by different random number during simulation.

Table 8: Validation of simulation results

Location	**Revenue per month**	
	Actual	**Simulation**
Satria Net	3.930	3.848
Yamie Panda Shop	3.666	3.693
Sky Blue Store	3.393	3.279
Petraco Store	2.190	2.218
Chi-Square Probability		0,1069
Counted Chi Square		6,0980
Tabel's Chi-Square		7,8147
Result Analysis :		
H_0 : Simulation Result Fits to Actual Data		
H_1 : Simulation Result Fitless to Actual Data		
If X^2 counted > X^2 Tables, H0 would be refused		
If X^2 counted < X^2 Tables, H0 would be accepted		
Result : Simulation Result :	***FIT***	**with Actual Data**

5. Conclusion

In this study, variables that are considered probabilistic and their emergence are represented by random numbers include vehicle type, inter arrival time and number of vehicles. These three variables are variables in the on-street parking system in which its value cannot be determined by anyone. The simulation process shows that Monte Carlo simulation can be used as an estimation tool to represent the uncertainty in the on-street parking system. The simulation results show that the potential revenue of parking fees is far lower the government's revenue target. Satria Net Location, for example, generates monthly income of about 4 (four) millions rupiah, with the number of vehicles about 3850. This is certainly very much lower compared to the contract value of only 300 thousand rupiah per month. The results show that on-street parking is a potential source of income for the government when managed better. The results of this study can be used as one of the policy inputs in determining the target and the value of government revenue contracts from on-street parking fees. This simulation is done using spreadsheet help from Ms. Excel, in which it is easy to reuse with different data.

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