Optimization number of car rental to fulfil the demand using simulation technique: A case study of ABC Car Rental Company

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Abstract. This study involves the car rental system of ABC Car Rental Company in Shah Alam. The car rental company faces challenges to meet customer demand. They always face shortage or too many vehicles unused on certain days on weekdays, but they are fully booked on the weekend. So, they need a guideline to manage their car rental to meet their customer demand. This company also faces a problem such as a customer returned the car late as it will affect the next customer. When this problem happens regularly, it affects the company. To find a solution to this problem, simulation model is built using Excel spreadsheet. The simulation model is run for ten 30-day to generate the result. The result of simulation contains customer not served, total sales and average number of the unused car. From this simulation model, 20 alternatives are identified. Then scoring model will be used to find the optimal number of car rental. The findings from this study will serve as a guideline for the car rental company to manage their number of cars for their business. The car rental owner needs to optimize their car rental fleet so that they can increase their business operations performance and managed their inventory of cars prudently.

1. Introduction
In recent years, the transportation sector has been contributed as one of the growing business that gives a high income in the current market. This field also accounted for increasing number of car sales due to the development of Malaysia economy [1]. This shows that the car rental business industry has experienced rapid growth in the current demand. In this study, the car rental phrase refers to the cars that are available to be book or rent in a specific period of time by the people who do not own one or to the people who have a car, but it is temporarily out of service or unreachable. It has become one of the alternatives in the transportation sector that provides a good transport service since other public transports have several weaknesses. For example, it does not allow and provides a door-to-door service even in the cities that have a good public transport network such as some European cities [2]. Because of this limitation and problems, the car rental sector has become one of the good alternatives to people nowadays.

Since 2010, the growth trend of the car rental industry has been maintained and it is expected to continue [3]. Thus, this study is conducted to structure and organize the fleet management of car rental to optimize the number of the car in the company. The most important factor that contributes to the car rental company is the fleet design of the car rental. If the fleet is properly designed, the issues of lack
of booked cars or not able to fulfill the demand from customer can be prevented and a substantial profit can be made [4]. Since this problem has been facing by most of the car rental company where the demand is hard to fulfill and the car fleet management did not meet the expectations of the company, thus provide a useful study to help the car rental business industry to gain more profit and revenue by considering some factors. This issue can be mitigated by optimizing the number of car rental in the company so that there will be no more shortage or surplus problems in the car rental company [4]. This will help the organization to reduce their potential loss in this type of business and help them to manage and control their stocks and inventory in any business area, especially in the car rental sector and industry.

This study uses a method of simulation to find the alternatives to optimize the car rental fleet. It is done by developing a simulation model that uses some of the demand, supply, and several other data to meet the objectives of this study. In order to evaluate and eventually enhance an operating system to maximize its performance, techniques such as simulation need to use to efficiently improve the operating process [5]. This shows that this technique is widely and frequently being used for most of the decision-making process in the car rental industry. The car rental company may control their profit and loss efficiently by using this simulation technique to obtain the number of car rental needed in the company to meet and fulfill the demand of the customers by preventing some problems in the car rental industry such as shortage and surplus of the cars in the organizations. A method of the scoring model also will be used in this study to choose the best alternative to optimize the numbers of car rental in the company. This is to help them to overcome and find the best fleet management of car rental businesses to operate in order to increase their sales by considering some of the factors such as the cost, the number of customers not served, the total profit and the unused car in the company. Therefore, from these four variables, the best alternative will be chosen according to the highest score to determine the optimum number of car rental in the company.

2. Literature review
The optimization of the car rental fleet management can improve the car rental operations [6]. A car rental fleet is referring to the number of cars of different types in the company [3]. It is important to arrange and organize the correct number of car rental in the company to reduce loss and increase the profit of the company. Therefore, the optimization process needs to be performed accurately and efficiently. The profitability of the car rental company is hardly dependent on its fleet and on all its decisions [3]. The increase in revenue in the car rental industry in USA that reached $28.63 billion in the year of 2017 is a result of better operating performance that optimize the car rental fleet management [6]. Thus, it is essential to optimize the number of car rental in the company to increase their profitability and maximizes its utilization. It is stated that, to reduce the shortage of the car rental and the issues of the lack of booked cars, they need to provide an optimized car rental fleet so that high profits can be made [4]. This is to ensure the car rental industry can gain high sales and profit by overcome this common problem experienced by the car rental industry to reduce their loss and shortage of the cars.

Recent research stated that the optimization process in the car rental company can reduce the shortage of car from 55-60 cars in a day to 7-8 cars per day and this will automatically increase the profit by $700,000 in a year [4]. The loss gain in this type of industry can be reduced after the car rental fleet has been optimized efficiently based on several factors. Fleet management is a mechanism that enables businesses to rely on transportation to eliminate or minimize the risks associated with investment in vehicles, improve efficiency, profitability and reduce overall transport costs [7]. The risk of gaining loss can be reduced and prevent by obtaining and maintaining the right number of cars in the company. This is to ensure all the cars are fully utilized to reduce the number of unused cars in the company to prevent the company from experiences loss in their sales. Better utilization of car can reduce the operating cost and implementing the respectable fleet management has demonstrated a decreased in fleet size and operating cost [7]. This is because, the company can increase or decrease their number of car rental to meet the exact demand from their customers so that they will not face any
loss and the cost will be cut. Thus, this shows that the optimization of the car rental is very important to have a better operation in the organization so that it will be organized efficiently and effectively in these sectors.

Simulation technique is one of the most useful methods to analyze and understand the behavior of car rental management system. In the study by [8], their objectives of the study are to simulate system’s operations, to analyze the way the vehicle distribution and service rate evolves with time and to maximize customers’ satisfaction such as minimize unserved demands while offering the most flexible service to the customers. They develop in parallel simulation tools that reproduce the system’s behavior and can implement the newly designed policies.

Next, another study by [9] proposed a simulation optimization strategy to determine the best configuration of an innovative car rental business. Their simulation model is used to analyze and evaluate the dynamic behavior of the process, considering different operative schemes and possible alternatives of investments. In the simulation model, 10 replications for each scenario are ran and their results are compared.

A researcher [10] use discrete event simulation (DES) techniques for their study. Their paper aims to optimize the design and operation of the main packaging line of the company to improve the global efficiency. The proposed simulation model is developed to minimize costs by enhancing resource utilization, reducing time spent and minimizing risk probability. The finding shows that their simulation model is acceptable and can be easily used for the evaluation of alternative scenarios such as the analysis of proposals for possible future changes in the design and operation of the line.

In previous study by [11] also use discrete event simulation model. This study aims to combine the use of Multi Criteria Decision Analysis based on previous researcher’s procedures with discrete simulation to assist Decision Makers in evaluating which Drop and Hook transport system, as specified by its location and set of criteria, will best meet the logistics requirements of supplying sugarcane to the mills. They run 100 replications for their simulation model and having 17 alternatives to choose the best strategy.

Scoring model is a relatively quick and easy to identify the best alternative for a multi-criteria decision problem [12]. In this area of study, there is no researchers that use a scoring model to find the best alternative. Scoring model is one of the methods for multi-criteria decision-making analysis.

In the study by [11], they use multiple criteria approaches to determine the best alternative. The initial interviews with Decision Maker (DM) were conducted to establish and validate the criteria related to their alternatives generated by the simulation model. The criteria weights are based on the DMs’ evaluation. Once the comparison among criteria had been completed, the weights are normalized. The most important criteria, fleet cost, is assigned a weight of 0.5, while the other two criteria are assigned equal weights of 0.25 each. Total weight equals to one. The best alternative is chosen according to the highest scores.

Based on previous studies explain on the car rental market growth in the industry. Therefore, the initiative to study on this matter to optimize number of car rental to fulfill the demand is a must. Simulation technique is one of the most useful methods that widely used to identify alternatives or strategies to improve the car rental management system. Next, scoring model will be used to determine the best alternative or strategy. Then, the best alternative or strategy can be implemented in the actual system.

3. Materials and method

In this study, ABC Car Rental Company in Shah Alam is chosen. This car rental company faces a challenge to meet customer demand especially during peak hours. Uncertainties such as unplanned vehicle maintenance and repairs or late car returns also impact the availability of the fleet [6]. The uncertainty will affect the performance of the company, so they need to find a solution to ensure that they do not lose sales and at the same time can fulfil the demand. The primary research objective of this study is to determine the optimal number of the car rental to fulfil the demand based on certain criteria. The research framework of the study is shown in figure 1.
Phase 1 include collecting data from ABC Car Rental Company. The collection of data involves daily data for one month. The data involves reflect to variables of study that help in determining the optimal number of car rental. Table 1 shows the variables use and their description.

Table 1. Variable of study.

| No | Variables                  | Description                                                                 |
|----|----------------------------|-----------------------------------------------------------------------------|
| 1  | Day                        | Count of day of car rental service operates                                 |
| 2  | Number of Car              | Total number of cars owned by a company                                       |
| 3  | Random number              | Random number assigned that occur in sequence such that two conditions are met. |
| 4  | Number of rentals          | The number of cars that has been rent in a day.                              |
| 5  | Duration of rental (day)   | The number of days the car has been booked by the customer.                  |
| 6  | Car day available/return   | The day when the car rental has been returned to the owner.                  |
| 7  | Available Car              | The number of cars that available to rent by the customer.                   |
| 8  | Customer Not Serve         | The number of customers that could not get the car rental in a month.        |
| 9  | Total Profit               | The amount of revenue obtains in a month.                                    |
| 10 | Total Cost                 | The maintenance cost for car rental in a month.                              |
| 11 | Unused Car                 | The number of cars that not been rent                                        |

In Phase 2, simulation model is developed. Before developing the simulation model, there are several assumptions consider in this study. The assumptions are: 1) Demand is uncertain, 2) The type of car (Car A and Car B) involves in the analysis have the same rate of rental price which is RM90 per day, 3) the model develops using the data within a month where there are no festivals or any other occasion involve, 4) The cost consider in this model is only maintenance cost which is RM500 per car and, 5) Whenever the car is insufficient to meet customer demand, the shortage is considered a loss.

Phase 2 is to develop the simulation model of the actual system. This step begins with defining the problem and determining the important input variables. It is important to understand the behavior of the actual system because the development of simulation model using Excel spreadsheet includes the formation of the formulas and equations based on the flow of the actual system. In this study, there are
two random input variables, number of car rental per day and rental duration in days. Therefore, both are analyzed to determine the appropriate probability distribution. Based on analysis, both variables follow discrete probability distribution. Once the simulation model has been built and ran for ten 30-day, the next step is to verify the formulas and equations that has been used in the model is free from logical error. Verification is the process of evaluating the operation of the model. Then, next step is to validate the simulation model. Validation is the process of determining how the model captures and corresponds accurately to the actual system [13]. In this study, the differences in values between the simulation output and actual data must be around ±10% or less, to satisfy the validity level of the built model to the actual system [12]. The validity level can be calculated using equation (1).

\[ \text{Difference (\%)} = \left( \frac{|\text{simulation output} - \text{actual data}|}{\text{actual data}} \right) \times 100 \]  

The model is functioning as projected on the computer and no logical error occur along the simulation model is running. Thus, the model is verified. Table 2 shows the differences in percentage between the simulation output and actual data using equation (1). Since all values are not more than 10%, it shows that the model is valid. Partial of simulation model using Excel spreadsheet is shown in figure 2.

**Table 2.** The differences between simulation output and actual data on the variables.

| Variables                     | Simulation Output | Actual data | Difference (%) |
|-------------------------------|-------------------|-------------|----------------|
| Number of car rental per day (units) | 2.45              | 2.43        | 0.82           |
| Rental duration (days)        | 2.48              | 2.69        | 8.47           |

![Figure 2. Partial of simulation model using excel spreadsheet.](image-url)
best alternative are total number of customers not served in a month, total profit in a month, total cost in a month and average number of unused cars.

After obtaining the simulation output for 20 alternatives, next in Phase 3 scoring model will be used to determine the best alternative. Thus, these are the steps required in this study for scoring model: 1) Develop a list of the criteria to be considered, 2) Assign weight to the list of criteria 3) Find the value for each alternative, 4) Compute the score and, 5) Choose the best alternative. Equation (2) refer to scoring model [12].

$$S_j = \sum_i w_ir_{ij}$$  \hspace{1cm} (2)

Where, $S_j$ is score for decision alternative $j$, $w_i$ is the weight for criterion $i$ and $r_{ij}$ is the value for criterion $i$ and alternative $j$. The criteria chosen and weight obtained is from interview session and discussion with the management of the company. Table 3 shows the list of criteria and its weight.

| Criteria                  | Weight, $w_i$ |
|---------------------------|---------------|
| Customer Not Served       | 0.20          |
| Total Profit              | 0.35          |
| Total Cost                | 0.25          |
| Unused Car                | 0.20          |
| Total                     | 1.00          |

The alternative with the highest score is determined as the best alternative based on four criteria which can optimize the number of car rental.

4. Results and discussion

The simulation model is built using Excel spreadsheet. The simulation outputs of 20 alternatives are generated using simulation model. The simulation outputs refer to four criteria values. These four criteria are considered to determine the best alternative of how many numbers of car rental that the company should own. Table 4 shows the result of the simulation model for 20 alternatives along with their value of customer not served, total profit, total cost, and average number of unused cars. The result in table 4 will be used in the next section where the best alternative will be determined by using scoring model.

| Alternative | Number of Car Rental (unit) | Customer Not Served/month (unit) | Total Profit/month (RM) | Total Cost/month (RM) | Unused Car/day (unit) |
|-------------|-----------------------------|----------------------------------|-------------------------|-----------------------|-----------------------|
| Actual system | 10                          | 5.5                              | 10318                   | 5000                  | 5.66                  |
| 1            | 11                          | 3.8                              | 9026                    | 5500                  | 6.28                  |
| 2            | 12                          | 3.2                              | 10353                   | 6000                  | 6.74                  |
| 3            | 13                          | 0.7                              | 7252                    | 6500                  | 8.54                  |
| 4            | 14                          | 1.5                              | 8903                    | 7000                  | 8.68                  |
| 5            | 15                          | 1.5                              | 8583                    | 7500                  | 9.75                  |
| 6            | 16                          | 0.4                              | 6661                    | 8000                  | 10.95                 |
| 7            | 17                          | 0.1                              | 7934                    | 8500                  | 11.34                 |
| 8            | 18                          | 0.2                              | 6147                    | 9000                  | 12.82                 |
| 9            | 19                          | 0.2                              | 5143                    | 9500                  | 13.93                 |
After obtaining the value of each alternative from the simulation model, the scoring model is computed using equation (2) to obtain the best alternative of this study.

Table 5. Total scores for 20 alternatives using scoring model.

| Alternative | Number of Car Rental (unit) | Customer Not Served/month (unit) | Total Profit/ month (RM) | Total Cost/ month (RM) | Unused Car/day (unit) | Total score |
|-------------|----------------------------|-------------------------------|-------------------------|----------------------|---------------------|-------------|
| 10          | 20                         | 0                             | 5102                    | 10000                | 14.70               |             |
| 11          | 21                         | 0                             | 6258                    | 10500                | 15.05               |             |
| 12          | 22                         | 0                             | 4372                    | 11000                | 16.69               |             |
| 13          | 23                         | 0                             | 2999                    | 11500                | 17.87               |             |
| 14          | 24                         | 0                             | 2283                    | 12000                | 19.02               |             |
| 15          | 25                         | 0                             | 2710                    | 12500                | 19.65               |             |
| 16          | 26                         | 0                             | 1391                    | 13000                | 20.99               |             |
| 17          | 27                         | 0                             | 2025                    | 13500                | 21.63               |             |
| 18          | 28                         | 0                             | 2029                    | 14000                | 22.43               |             |
| 19          | 29                         | 0                             | 2519                    | 14500                | 23.19               |             |
| 20          | 30                         | 0                             | 156                     | 15000                | 24.68               |             |

Table 5 shows the scoring model for this study. The highest score for the scoring model is chosen as the best alternative among 20 alternatives. Based on Table 5, Alternative 2 with 12 number of car rental is the best alternative as the value of the scoring model is the highest and consider as the optimum number of car rental. Thus, the company should consider this optimum number of car rental that they should have.
In order to make a good decision, the number of car rental that company currently own and the best alternative gained is compared. The company own 10 cars to run their car rental business and based on the best alternative obtained from the methodology the company is suggested to have 12 cars to run their business smoothly. Table 6 represent the comparison between the actual system and Alternative 2.

|                         | Actual system | Alternative 2 |
|-------------------------|---------------|---------------|
| Number of Car (unit)    | Available car = 10 | Available car = 12 |
| Customer Not Served (unit) | 5.5         | 3.2           |
| Total Profit (RM)       | RM10,318      | RM10,353      |
| Total Cost (RM)         | RM 5,000      | RM6,000       |
| Unused Car (unit)       | 5.66          | 6.74          |

Based on the actual system, it shows that this company unable to serve many customers since they have 5.5 – 6 customers are not served compared to Alternative 2 there have only 3.2 – 3 customers are not served. Even though the company gained profit and less unused cars, it will give an impact to the company in the future. The customer will have less satisfaction and choose another car rental company to rent a car. To solve this problem, Alternative 2 suggests this company to add more cars to fulfill customer demand. The company is suggested to add 2 more cars to cater the shortage of cars that they always face. The total profit will increase if they have 12 cars from RM10,318 to RM10,353. The company can gain more profit in the festive season or any other occasion since their company can fulfill customer demand. It will get a good impression and gain trust from the customer to use the car rental company services. By that, it can maximize the company’s sales.

5. Conclusions
This study is conducted with the goal of developing the simulation model of car rental system to obtain the optimization number of car rental. This is accomplished by using simulation technique and scoring model based on four criteria which are customer not served, total profit, total cost and unused car are carried out to determine which number of car rental is the most suitable for the company. In order to find the best alternative, the highest score of the scoring model is obtained. The company can consider the number of car rental suggested to fulfill customer demand. As in the result, with 12 cars, the customer not served are reduced and the total profit is increased. Successful obtaining optimize number of car rental is important for the car rental company. This will help the company to meet the demand of the customer.

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