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Applications of Queuing Theory in the Tobacco Supply

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Abstract

There are many problems in the supply of goods. In the company, both in the supply of goods in the form of raw materials, as well as in the supply of goods in the form of the final product to the consumer. PT XYZ obtain supplies of dried tobacco (chopped Madura) of the local name tobacco collectors as known as bandol. The queues were quite long and bandol experiencing frequent obscurity of time to be served during the waiting time shortage and obscurity. This has an impact on the cost and time to bandol. Therefore, this research aims are (1) to obtain a supply of tobacco queuing system (2) to obtain a proper queuing system in the supply of tobacco (3) to obtain a minimal cost to the queuing system in the supply of tobacco. Data analysis was performed according to the queuing models in the PT XYZ. The results of the study are (1) queuing systems in the form PT XYZ path queuing system with a multiple channel, the waiting time to be served short enough that 0.003 minutes, the average time of 2.877 minutes in the system, the queue length 0.0006 unit of transportation service is equivalent to one unit of transportation, long queues in the system are 0.605 units of transportation that equal to 21units of transportation (2) the actual occurrence of a long queue outside the queuing system, because the transportation carrying tobacco wants to earn their turn to enter the warehouse and immediately served (3) minimal costs for bandol incurred amounted to Rp 450,000.00 for one unit of transportation (pick up) that it brought 2 workers. Minimal costs incurred amounted to Rp 700,000.00 for other unit of transportation (truck) that it brought two workers to the difference in labour and rental costs.

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1. Introduction

There are many problems in the supply of goods. In the company, both in the supply of goods in the form of raw materials, as well as in the supply of goods in the form of the final product to the consumer. Queue does not need to be eliminated at all, or did not need to develop the facility as possible. The firm should be able to think as a result of the increasingly long queues. The firm should be able to set up to achieve optimal conditions with a row of fairly short queue. That is important for supplier to minimize loss. PT XYZ is a procurement company of Madura tobacco raw materials for other company. PT XYZ obtain supplies of dried tobacco (chopped Madura) of the tobacco collectors known as bandol. Tobacco supply from the bandol is done with sorting systems in order to obtain tobacco in accordance with company standards. Long queue often occurs when tobacco sorting is done. Time obscurity of Bandol experienced to be served and to wait during the sorting. It certainly can make cost and time impact for bandol.

According to Levin (2002) and Bustani (2005), there is a way to eliminate the waiting time. The company can set a server so that there will be no queuing, but it is clearly detrimental to the company by increasing salaries of the employees. Application of queuing theory in various industrial sectors can reduce the cost because time lost to queues and the cost of adding facilities for the queues. A number of issues related to the queue can be solved so will give the lowest total cost because lost time to long waits and to get service and additional costs of service personnel. David (2005) conducted a study with the method of single- channel single phase with an increase in the value of sales at Mc Donald's branch Mall Depok done by increasing the speed of the service so as to reduce the waiting time. The results showed that the optimization of service time can make an efficiency.

Based on the above, the objectives of this study are (1) to obtain a queuing system in the tobacco supply of PT XYZ warehouse (2) to obtain a proper queuing system for the bandol in supplying tobacco (3) to obtain the minimum cost for queuing system in the supply of tobacco.

2. Research Methodology

This research was conducted in the warehouse of PT XYZ at Pamekasan Regency. Arrival time data of bandol before entry into the warehouse were obtained by direct interview. Other data were obtained by documentation from PT. XYZ. Time entry of transportation data into the warehouse for 5 days by the fourth graders and serving time data for 5 days of time served by 4 graders.

The procedure of this research are according Levin (2002):

1. Obtain the queuing model
   Data analysis was performed adjusted for queuing models in the PT XYZ. Based on preliminary observations of queuing system from PT XYZ that was a Multi-Channel Model with four server (M/M/4).
   The characteristics of a multiple channel queuing system according to Levin (2002) and Bustani (2005), would be useful if the following conditions are met e.g:
   1. The number of arrivals per unit of time is described by the Poisson distribution.
   2. Service time is described by an exponential distribution
   3. Queuing discipline is first come, first served
   4. The population arrival is not limited.
   5. That is multiple channel
   6. The average rate of arrival is smaller than the average level of service.
   7. The available of waiting room for customers in the queue are not limited.
2. calculate the daily arrival level (λ)
3. calculate the daily service level (μ)
4. calculate the probability in the system (P)

$$P = \frac{\lambda}{\mu.s} \quad (1)$$

5. calculate the probability of zero unit in the system (P_0)

$$P_0 = \left[\sum_{n=0}^{s-1} \frac{(\lambda/\mu)^n}{n!} + \frac{(\lambda/\mu)^s}{s!} \frac{1}{(1-(\lambda/s\mu)}\right]^{-1} \quad (2)$$

6. Calculate the unit of transportation in the queuing system with 2 equation e.g.

$$Lq = \frac{P_0(\lambda/\mu)^2 P}{s!(1-p)^2} \quad (3)$$

$$Ls = Lq + \frac{\lambda}{\mu} \quad (4)$$

7. Calculate the average time of the queue in the queuing system with 2 equation e.g.

$$Wq = \frac{Lq}{\lambda} \quad (5)$$

$$Ws = \frac{Lq}{\lambda} \quad (6)$$

8. Analyze of the queuing system

All of calculations were done in manual and also use software Quantitative Methods 2.0 for windows to show the results.

3. Results and Discussion

3.1. Description of Tobacco Supply in the Warehouse of PT XYZ

Procurement activities in the warehouse of PT. XYZ have been arranged by the tobacco companies agreed local government (the price of goods and quotas). Procurement of tobacco in PT. XYZ implemented through partners (bandol) that has working ties. The function and role of bandol is to bridge the PT XYZ with the farmers and the tobacco trade system in implementing the government's economic policies. Therefore, bandol are part of the supply chain from procurement tobacco to the determination of quantity and quality of tobacco that received by PT XYZ. Queuing system in the PT XYZ is a multiple channel queue path model with the poisson distribution of arrival time and the exponential distribution of service time. Before entering the area of tobacco warehouse, transportation from each supplier with an orderly queue outside the barn and will be given the number and letter to entry and then go to destination grader in the warehouse.

3.2. Daily Arrival Level (λ)

Daily arrival level is determined by the arrival number of tobacco's transportation in a queuing system period over a period of arrival time. Assumption for arrival level is poisson distribution. The average number of transportations that come every day in the queuing system, according to data recorded in the warehouse are as many as 202 units. Average arrival time of this transportations for 16 hours, starting from 03:00 pm on the day before until 07.00 a.m will be serviced. Therefore, the arrival level (λ) is equal to 12.625 units/hour.

3.3. Daily Service Level (μ)

Daily service level (μ) is the number of tobacco's transportation that be served in a unit of time. This can be understood as the amount of data that the transportation serviced every day for 5 days divided by the average service time of graders. The daily service time is 7.5 hours distributed from 07.30 am until 12.00 a.m and then 12.00 a.m until 04.00 p.m. The number of transportation serviced on average every day for 5 days is 156.6 equal with 157 units. Therefore, the service level (μ) is as much as 20.88 units/hour. The average service level indicates for 4 graders every day, able to serve the 20.88 units per hour, equivalent with 21 units/ hour.

3.4. Probability in the System (P)

Probability in the system is intensity level of service or utility factor. The calculations show that probability in the system or 0.151. The calculation of probability in the system is done based on the arrival rate, service level and service facility (graders) with the formulation of equation 1. Probability in the system then be used to calculate probability of zero units.

3.5. Probability of zero unit in the System (P_0)

Probability of zero units in the system is probability the system is idle or there is not transportation in the service. The calculations show that probability of zero units in the system is 0.546. The probability of zero units' calculation is done with the formulation of equation 2. Probability of zero units in the system then be used to calculate length of the queue (Lq).

3.6. Length or Number of Transportations in the Queuing System

The number of transportations that are in the queuing system, namely the number of transportation that waiting in line to be served (Wq). That are in the queuing system is calculated based on the formulation in Equation 3.The results of calculations with the formulation showed that the number of transportations that are in the queuing system is as much as 0.0006 unit. This is equivalent to 1 unit. The calculations show that the average number of transportations in the queue is as much as 0.0006 unit for 4 graders. This is equivalent to 1 units for each grader.

The number of transportations that are in the queuing system, namely the number of transportation that be served (Ws). Based on the formulation in equation 4. The results of calculations with the formulation showed that the number of transportations that are in the system is as much as 0.048 units. This is equivalent to 1 unit.

3.7. Average Time in Queuing System

The calculation of the average waiting time in the queue (Wq) is done based on length of the queue with the formulation of equation 5. The average time in the queue based on the results of the calculation of the equation shows the average time in the queue until be served is 0.00005 hour or 0.003 minutes or 0.182 second. Calculation of the average time in the system (Ws) is done based on length of the queue with the formulation of equation 6. The average time be served in the queue based on the results shows 0.0479 hour or 2.877 minutes or 172.596 second. Result from formulation and results from running calculation with QM 2.0 shows in figure 1 is not different.

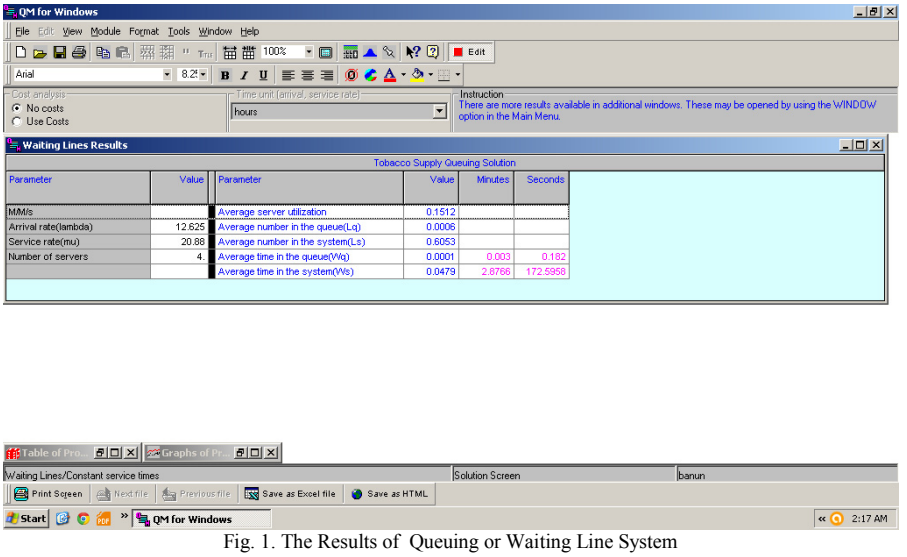

Fig. 1. The Results of Queuing or Waiting Line System

3.8. The Right of Queuing System in PT XYZ Based on Calculation

Queuing system at Warehouse PT XYZ shows that there is quite a long queue. However, this queue be serviced immediately by 4 graders. Queuing system shows that is similar to multiple queues but not a multiple queuing system because a unit of transportation already has a path for each grader. This can be proved by the results of

calculations which show that the number of transportation on average in the queue as much as 1 unit and the number of transportation that are in the queuing system for each graders is as much as 1 units too.

The actual occurrence of a long queue outside the queuing system, because the bandol want to be served immediately. Therefore these units of transportation come starting on 03.00 p.m on the previous day, although the load time to put this transportation in the warehouse area to be served by the graders at 06.00 a.m until 07.00 a.m the next day. Service time of the grader has been determined by PT XYZ which is on 07.30 a.m until 12.00 a.m,, and on 12.00 a.m until 01.00 p.m is time of rest and resumed again on 12.00 a.m until 04.00 p.m.

Service time for each transportation from each grader was not too long. The average time in the queue based on the results of the calculation show the average time in the queue until be served is 0.00005 hour or 0.003 minutes or 0.182 second. The service time is greatly influenced by:

1. The type of transportation that be served
   The type of transportation that be served for the queuing system is pick-up and truck. Type of transportation influential because it has a different load capacity. In the calculation of the queuing system does not distinguish the type of transportation. Based on the data type of transportation service to pick up takes between 5-10 minutes and for the type of trucks takes 15-20 minutes.
2. The load of each car
   The load of each transportation is different depending on the type of transportation used. The charge of each different type of conveyance, to kind of pick - up with a load average of 32 bales and for the type of truck as much as 65 bales. The amount of this charge affects the dismantling long time to be served.
3. The number of workers who loading every transportation
   The number of workers is very influential on the speed of service because of the number of workers that more quickly loading. Serving by the graders also become increasingly faster.

There is unnecessary activity like chatted on between graders and bandol services. These things have an impact on the duration of the longer service time. Impact to transportation that has been entered into the warehouse had to stay to be served the next day. Because limited service hours starting at 07.30 a.m until 04.00 p.m every day. Waste of time by graders are as much as 20.4 minutes on average each grader. The mean total service time is much 1719.4 minutes, equivalent to 28.657 hours for 4 graders, so that on average each grader only serve about 7.16 hours. The time available to serve is 7.5 hours every day, so it can be said that waste time is 0.34 hours or 20.4 minutes. Time that is needed to unload of 2 pickup or 1 truck are 20 minutes.

This problem should be followed up by warehouse of PT XYZ by adding existing graders, although this increase will have an impact on the costs. PT XYZ having to pay salaries for graders. Four graders must be added because the average of the 202 cars that come every day only 157 car can be served. The calculation shows that ability of this graders in the queuing system only 77.5 %.

Some alternative problem solving to do is:

1. Limiting the number of bandol arrivals and his load every day
   Restriction of bandol who come every day, each only carry 2 tobacco transportations. If bandol want to deposit it back to the warehouse because a higher price than other warehouse then do the next day. There are 80 bandol are deposited in the PT XYZ warehouse. Each grader is able to serve an average of 40 cars, if there are 4 people, each bandol graders will be served on the same day. This restriction is intended to provide equal opportunities for bandol coming. It also spurred bandol for depositing tobacco every day. These restrictions may affect a bandol if found not to be deposited into the tobacco warehouse, then the bandol can sell opportunity to another bandol.
2. Creating pathways to service different types of tobacco transportation that they used.
3. There are two types of tobacco transportation that they used. There are pick-up and truck. Each type is different payload capacity. Pickup with a payload capacity of 32 bales and trucks with a capacity of 65 bales. Time to unloading the truck and pick up of course is different because of the different amount of charge. There are an average of 8 trucks every day and average of 32 pick-up every day that must be serviced every graders. In fact, from the calculation of average every graders to serve a truck takes an average of 15-20 minutes so one path in the warehouse for trucks and serve by one grader. The results of the calculations of a pick -up takes an average of 5-10 minutes, so it took 3 paths to pick up and served by 3 graders. Therefore, by creating a separate path between pick up and truck are expected to slightly reduce the queues in the system and does not affect the cost of the PT XYZ.
4. Recording and scheduling of service for each bandol

Warehouse of PT XYZ able to collect data on the number of bandol which is fixed and always supply to warehouse. The warehouse give a card system to supply tobacco and how many tobacco can be supplied.

5. Service System Must be Changed
   Service system can be changed to unload all of carrier and graders went there. This is like that done by the competitors' warehouse. This method also has a drawback if the tobacco is not immediately addressed and put into storage would reduce the quality of tobacco. According Makfoeld (2005), the things that can reduce the quality factor of tobacco include air, dust factor, thus reducing the smelt and color quality of tobacco.
6. Adding facility for receiving and unloading tobacco.
   Addition facility can be placed in between two the warehouse that has not been used for queuing area.

3.9 Minimizing Costs in the Supply of Tobacco

The effects of the queuing system is done from this bandol can be increasing cost to be incurred by the bandol if they must stay in the warehouse location. The costs include transportation costs such as the cost of eating, drinking and smoking as well as labour costs and the cost of the rental a truck or a pick up that used to transport tobacco. This can be exemplified if one pick up stays with 2 labour so the costs required are:

a. The cost of eating, drinking and smoking for workers: Rp 50,000.00/workers, so for 2 workers need Rp 100,000.00.
b. The cost of workers' wages and rental a pick up : Rp 350,000.00/day and Rp 100,000.00/day for 1 day to pick up if must stays so the cost will need Rp 450,000.00.

Therefore, the cost above conditions will be need as much as Rp 550,000.00 per day with two workers for pick-up. It can also be exemplified if one truck stays with 2 labor so the costs required are:

a. The cost of eating, drinking and smoking for workers: Rp 50,000.00/workers, so for 2 workers need Rp 100,000.00.
b. The cost of workers' wages and rental a truck: Rp 600,000.00/day and Rp 200,000.00/day for 1 day to truck if must stays so the cost will need Rp 800,000.00.

Therefore, the cost above conditions will be need as much as Rp 900,000.00 per day with two workers for truck.

This will not happen if bandol not stay at locations around the PT XYZ warehouse. Bandol can save costs with details of expenses incurred:

1. When using a pick-up with 2 workers:

a. The cost of eating, drinking and smoking workers: Rp 50,000.00/worker, so for 2 workers need Rp 100,000.00.
b. The cost of workers and rental a pick up: Rp 350,000.00/day.

Therefore, if the above conditions then it will be removed cost as much as Rp 450,000.00 per day with two workers for a pick-up.

2. When using a truck:

a. The cost of eating, drinking and smoking worker is Rp 50.000,00 / worker, so for 2 workers need Rp 100,000.00.
b. The cost of worker or labour and rental one truck is Rp 600,000.00/day.

Therefore if the above conditions then it will be removed cost as much as Rp 700,000.00/day. The cost difference is only at the cost of workers' wages and the cost of the rental a tobacco transportation. Minimal cost that must be paid by bandol Rp 450,000,00 for 1 pickup that carried 2 workers. Minimal cost that must be paid by bandol Rp 700,000.00 for 1 truck that carried 2 workers.

4. Conclusions

Based on the results and discussions, the conclusions of this study as follows:

1. Preview queuing system in PT XYZ is a queuing system with a multiple channels queue. The waiting time average is very long before bandols being served, having to wait start from 03.00 p.m. the previous day. The waiting time in the queue is 0.003 minutes, service time within a fairly short queue that is of 2.877 minutes in the system, the length of queue is 0.0006 unit in service equivalent of 1 unit, long queues in the system is 0.6059 units equivalent of 1 units.
2. The actual long queues occur outside the queuing system, because the pick up or truck that carrying tobacco

wants to earn their turn to enter the warehouse and immediately served. Alternatives that can be done by the warehouse that does not impact the cost of: (1). Creating pathways to service different types of transportation vehicles used . (2). Logging and service scheduling for each bandol.

3 . Minimal costs of Bandol that must be paid Rp 450,000.00 for one pick -up with 2 workers. Minimal costs of Bandol that must be paid Rp 700,000.00 for one truck with 2 workers. Differences in cost is only at the cost of workers' wages and the cost of a pick up or a truck rental.

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