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Non Poisson Queue Data Analysis at KFC Jimbaran Regular Service

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Abstract

In providing services, it is not uncommon to be faced with a high level of customer arrival so that they have to wait their turn to get service. This waiting line is called a queue, one of which is non- poisson queue. An activity includes a non-poisson queue when the distribution of arrivals or services is non-poisson or exponentially distributed. This research focused on examining the cashier service queue at Kentucky Fried Chicken Fast Food Restaurant in Jimbaran, Bali. Data collection by direct observation was carried out for 4 hours 2 minutes. Service facilities in the system under study are 2 waiters. Researchers made observations of arrival time, queuing time data, service time, the number of queuing customers, and the number of customers served. Next, this data is processed and produces data on the number of Poisson-distributed arrivals, Weibull-distributed inter-arrival times, and General Pareto-distributed service times. Through this, it is concluded that the queuing model at KFC is (M/G/2): (FIFO/∞/∞). After calculating to determine the system performance measure in this model, a utilization factor of 50.75% is obtained. The percentage of the utilization factor indicates that the KFC service facility is not too busy serving customers, so there is no need to add service facilities in the system.

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Keywords: Queuing, Non-Poisson, Arrival, Service

1. Introduction

Queuing or in English is called queueing or waiting line often occurs in everyday life. Generally, everyone has waited in a waiting line at a service facility before getting the service needed. Queuing occurs because the number of customers who come exceeds the number of service facilities provided, so that customers who come cannot be served immediately due to the busyness of the waiter. The queuing process is a process related to the arrival of a customer in a service facility, then waiting in a queue if all the servants are busy, and finally leaving the service after being served. There are 2 types of queues, namely poisson queues and non-poisson queues. Non-poisson queues are queues with an arrival distribution or service distribution that is not poisson or exponentially distributed. In Kendall's notation, the arrival distribution is the distribution of the number of customer arrivals denoted by and the distribution of service times denoted by b. To find out the distribution of an observation, it is necessary to test the distribution with the appropriate method. Next, through this, a poisson or non-poisson queuing model will be obtained. By knowing the queuing model, objects that use the queuing system can be helped to strive for a smooth system so that customers are satisfied, such as minimizing the presence of someone who enters the queue, but has not received service and leaves the queue (reneging) due to a large enough waiting time.

Many queuing cases are found in everyday life, for example in the queue for ordering food at fast food restaurants. In this study we raised the phenomenon of queuing at Kentucky Fried Chicken (KFC) which is one of the fast food restaurants that is in great demand and crowded with buyers in the Jimbaran area. KFC is the most popular fast food restaurant founded in Kentucky, United States in 1952 and present in Indonesia since 1979.

Not infrequently KFC is an alternative for people in various circles ranging from children to the elderly. The service flow is that the customer comes, then there is a choice to enter the queuing system (busy waiter) or immediately get service at the cashier (idle waiter), and then the customer leaves the queuing system. The purpose of this research system is to find out the queuing process in the service facilities provided by the object of research. If a system has more than the optimal number of service facilities, then the expenditure is quite a lot and if the service facility is less than the optimal number, then the service may be delayed. Therefore, researchers are interested in examining whether the service facilities provided by KFC in the Jimbaran area are effective and efficient so that they can satisfy customers. KFC cashier as a waiter, is responsible for providing services in the form of receiving orders to payments made by customers. When the number of customers who come is more than the number of cashiers available, then there is a queue. Service waiting time and queue length can affect customer satisfaction and customer interest in coming back. Through this, determining the nature of the system needs to be done to meet steady state conditions. In addition, determining the queuing model and calculating the performance of the queuing system needs to be done to improve service quality. Through this research, it is hoped that it can provide additional information for the object of research in the sustainability of its business. The data taken in this study are in the form of customer arrival time, queuing time, time to get service, length of service, number of customers who come, number of customers who get service, and time between arrivals.

Research Methodology

1. Data Sources

The type of data used in this study is quantitative data in the form of numbers which can then be calculated with counting units. The data source used is primary data which is data with data collection methods in the form of observation methods, namely direct observation to the location. The research was conducted by taking several samples in a span of 4 hours during one day. This sample is considered to have represented weekdays and weekends.

2. Place and Time of the Research

This research was conducted at Kentucky Fried Chicken Fast Food Restaurant in Jimbaran, South Kuta District, Badung Regency, Bali in November 2022, precisely on Friday, November 23 from 11:54-15:56 WITA. The research was conducted for 4 hours and 2 minutes.

3. Research Variable

The variables used in this study are

- Data on the number of arrivals and the number of customers served at Kentucky Fried Chicken Fast Food Restaurant in Jimbaran, Bali.
- Data on time between arrivals and service time at Kentucky Fried Chicken Fast Food Restaurant in Jimbaran, Bali.

4. Analysis tools

The analytical tool used is a stopwatch to record arrival time and length of service. In data processing, statistical software is used, namely Minitab, SPSS, Easy Fit, and Microsoft Excel.

5. Research Steps

The analysis steps taken in this study are as follows (Sugito *et al*., 2017) [6]:

- Determine the place of research and research methods to be used
- Compile the data obtained, namely through observing arrival time, queuing time data, service time, the number of queuing customers, and the number of customers served.

- **Determine Steady State**

Steady-state is a condition when the nature of the system is constant or does not change over time. This condition is expected when the average customer arriving is comparable to the average customer who has been served (the average customer arriving does not exceed the average customer who has been served) ($\lambda < c\mu$), so that $\rho < 1$ is constant. Obtained:

$$\rho = \frac{\lambda}{c\mu} < 1$$

1. Test the suitability of the number of arrivals distribution using the Chi-square test, service time distribution, and arrival time distribution using the Kolmogorov-Smirnov test. The hypotheses about the arrival distribution are:
2. $\boldsymbol{H_0}$**:** The number of arrivals of Kentucky Fried Chicken Fast Food Restaurant customers in Jimbaran is Poisson distributed
3. $\boldsymbol{H_1}$**:** The number of arrivals of Kentucky Fried Chicken Fast Food Restaurant customers in Jimbaran is not Poisson distributed.

The hypothesis about the distribution of time between arrivals is

- $\mathbf{H_0}$**:** The time between arrivals of Kentucky Fried Chicken Fast Food Restaurant customers in Jimbaran is Exponentially distributed
- $\mathbf{H_1}$**:** The time between arrivals of Kentucky Fried Chicken fast food restaurant customers in Jimbaran is not exponentially distributed.

The hypothesis about the distribution of service time is

- $\boldsymbol{H_0}$**:** The customer service time of Kentucky Fried Chicken Fast Food Restaurant in Jimbaran is Exponentially distributed
- $\boldsymbol{H_1}$**:** Kentucky Fried Chicken Fast Food Restaurant customer service time in Jimbaran is not exponentially distributed
- Find the distribution that fits the observed data

Poisson distribution

The Poisson distribution is a discrete probability distribution that expresses the probability of the number of customer arrivals that occur in a certain period of time, if the average arrival is known and in a time that is randomized with the previous arrival time. The probability of arrival in Poisson distribution can be done by:

$$P(x) = \frac{\lambda^x e^{-\lambda}}{x!}$$

Description

$P(x)$ = probability of arrival

λ = average arrival per unit time
x = number of arrivals per unit time
e = natural number ($e \approx 2.71828$)

- **General Pareto Distribution**

The Pareto distribution has a shape parameter denoted by ξ and a scale parameter denoted by σ. The probability density function of the General Pareto distribution is:

$$f(x|\xi,\sigma) = \begin{cases} \frac{1}{\sigma}\left(1+\frac{\xi x}{\sigma}\right)^{-\frac{1}{\xi}-1}, \xi \neq 0 \\ \frac{1}{\sigma} exp\left(-\frac{x}{\sigma}\right), \xi = 0 \end{cases}$$

With $0 \leq x < \infty$ if $\xi \geq 0$ and $0 \leq x < -\frac{\sigma}{\xi}$ if $\xi < 0$

- Weibull Distribution

The Weibull distribution has a shape parameter and a scale parameter denoted by α and β. The probability function of the Weibull distribution is:

$$f(x;\alpha,\beta) = \begin{cases} \frac{\alpha}{\beta^{\alpha}} x^{\alpha-1} \, exp\left(-\frac{x}{\beta}\right)^{\alpha}, x,\alpha,\beta > 0 \\ 0, others \end{cases}$$

- **Determine the non-poison queuing model**
- **Kendall notation**

The standard notation of queues is called Kendall-Lee notation as an efficient tool for identifying queuing models (Ayuningtyas, *et al.*, 2021) [2].

$$(a/b/c):(d/e/f)$$

With to f denotes

a = Arrival distribution
b = Service time distribution
c = Number of service facilities in the system ($s = 1,2,3,4,\ldots,\infty$)
d = Service discipline
e = Maximum number of consumers allowed in the system (in service plus waiting line)
f = Calling source

- Common queuing models that are often known are M/M/1/∞, M/M/1/N, M/M/c/∞, M/M/c/c, M/M/∞/∞, M/M/1/K/K, M/M/c/K/K, dan M/M/c/c/c. The model is an example of a non-poisson queue model. According to the terms of the so-called non-poisson queue, the examples that include the non-poisson queue model are as follows.
- Queuing model (M/G/c): (GD/∞/∞)

The arrival pattern of this model is Poisson distributed with a general distribution service pattern with a number of service facilities as many as c. In addition, the maximum capacity allowed in the system and the size of the call source are unlimited (Gross and Harris, 1998). The following is the formulation used.

- **Arrival rates (λ)**

$$\lambda = \frac{n}{I} \quad (1)$$

- Service level (μ)

$$Average\ service\ time = \frac{total\ length\ of\ service\ time\ data}{length\ of\ service\ time\ data} \quad (2)$$

$$\mu = \frac{1}{average\ service\ time} \quad (3)$$

- Busy waiter opportunities

$$\rho = \frac{\lambda}{c\mu} \quad (4)$$

- Off-busy waiter opportunities

$$P_0 = 1 - \frac{\lambda}{c\mu} \quad (5)$$

- Average customer waiting time in queue

$$W_q = \frac{\lambda^c E[t^2](\lambda E[t])^{c-1}}{2(c-1)!(c-\lambda E[t])^2\left[\sum_{n=0}^{c-1}\frac{(\lambda E[t])^n}{n!}+\frac{(\lambda E[t])^c}{(c-1)!(c-\lambda E[t])}\right]} \quad (6)$$

- Average number of customers in queue

$$L_q = \lambda(W_q) \quad (7)$$

- Average number of customers in the system

$$L_s = \lambda W_s \quad (8)$$
$$L_s = L_q + \lambda E[t] \quad (9)$$

- Average customer waiting time in the system

$$W_s = \frac{L_s}{\lambda} \quad (10)$$

This model can change according to the non-poisson queuing conditions encountered.
Obtain performance measures of the model system

Research Results

Researchers observed a queuing system at KFC where there were 3 regular cashiers (one cashier was not used) and 1 ojol cashier. This research is only focused on serving 2 cashiers only and observing queue performance starting from queuing, placing orders, to paying for orders and leaving the queue. In this fast food restaurant, service is not carried out in stages. Data collection was carried out on Wednesday, November 23 from 11:54-15:56 WITA by taking data as many as 78 samples. The conditions observed to be used as observation data are arrival time, queuing time, time to get service, time to leave, the number of customers who come, and the number of customers served. Obtained data summary as follows.

Table 1: Data summary

Data amount	Number of customers arrival	Number of customers served	Service time (minutes)	Inter-arrival time (minutes)
78	158	158	243,5833	239,6667

- **Determination of steady state**

In KFC services, researchers only observe the services of 2 cashiers so that c = 2 is used. In determining the steady state, the following calculation table is obtained.

Table 2: Calculation result

n	C	λ	μ
78	2	0,3250	0,3202

λ = average customer arrivals per minute
μ = average number of customers served per minute

Therefore, steady state conditions are met for all data, because $\rho = \lambda/c\mu = 0.3250/(2 \times 0.3202) = 0.5075 < 1$. This utilization factor value is obtained as 0.5075. This means that in one working day, the respective percentage of busy waiters is 50.75% of the working hours.

- **Distribution fit test**

Chi-square Test

In this study, researchers conducted a hypothesis test using the *Chi- square* test to prove the alleged distribution of the number of arrivals. This is because the *Chi- square* test is considered closer to the reality of the Poisson distribution test. Through this test, it can be determined whether the sample is randomly distributed *Poisson*.

- **Determining the Hypothesis**

The hypothesis about the arrival distribution is

- ***H_0*:** The number of customer arrivals at *Kentucky Fried Chicken* Fast Food Restaurant in Jimbaran is Poisson distributed
- ***H_1*:** The number of customer arrivals at *Kentucky Fried Chicken* Fast Food Restaurant in Jimbaran is not Poisson distributed.

- Significance level

Using 5% alpha

- One-Sample Test Statistics

$$\chi^2 = \sum \frac{(O_i - E_i)^2}{E_i} \qquad (10)$$

With

χ^2: Chi-square distributon
O_i: Sample observation frequency in the i-th cell
E_i: Expected frequency of sample in i-th cell

- **Test criteria**

If the calculated *Chi-square* value $\chi 2 \geq$ *Chi-square* table, it is significant (reject H_0). If the *p-value* < the significance level (0.05), then make a decision (reject H_0).

- **Distribution fit test result**

With the help of *Minitab software*, the following *output* was obtained.

Chi-Square Test

N	DF	Chi-Sq	P-Value
158	77	62.1772	0.890

Fig 1: Chi-Square Test with Minitab

The output above illustrates that testing the distribution of the number of customer arrivals gives a p-value of 0.890. According to the test criteria, the p-value of 0.890 > 0.05 so, there is not enough evidence to reject H_0. Therefore, the number of customer arrivals is Poisson distributed.

Kolmogorov-Smirnov Test

In this study, researchers conducted a hypothesis test using the Kolmogorov- Smirnov test to prove the alleged distribution of inter-arrival time and service time distribution. The Kolmogorov-Smirnov test itself is one of the Goodness of Fit Tests that is suitable because the sample used is more than 50 samples. Through this test it can be determined whether the sample is random exponential distribution.

- **Determining the Hypothesis**

The hypothesis about the distribution of time between arrivals is:

H_0 : The inter-arrival time of Kentucky Fried Chicken Fast Food Restaurant customers in Jimbaran is exponentially distributed.

H_1 : The time between arrivals of Kentucky Fried Chicken Fast Food Restaurant customers in Jimbaran is not exponentially distributed.

The hypothesis about the distribution of service time is :

H_0 : The customer service time of Kentucky Fried Chicken Fast Food Restaurant in Jimbaran is Exponentially Distributed.

H_1 : The customer service time of Kentucky Fried Chicken Fast Food Restaurant in Jimbaran is not exponentially distributed

- **Significance Level**

Using the significance level is 5%

- **Test statistics**

$$D = \sup|S(x) - F_0(x)| \qquad (12)$$

With

D: Difference Absolut
S(x): Cumulative distribution of sample data (arrival count data andservice time data).
$F_0(x)$: Cumulative distribution of the hypothesized distribution (for customer arrival using Poisson distribution, while for customer service time using distribution Exponential).

- **Test criteria**

Reject H_0 if D value > D ∗ (a) or sig value < value sig a. Value D ∗ (a) is the critical value obtained from the Kolmogorov-Smirnov table

- **Distribution Fit Test**

With the help of SPSS software, the following data was obtained.

- **Inter-arrival time Distribution Fit Test**

The p-value is 0.001 <0.05 so reject H_0 which means that the time between arrivals is not exponentially distributed (assumed to be general distribution).

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
antarkedatangan3	.141	77	.001	.881	77	.000

a. Lilliefors Significance Correction

Fig 2: Kolmogorov-smirnov Test of Interarrival Time Distribution

- **Service time distribution fit test**

The p-value is $0.000 < 0.05$ so reject H_0 which means that the service time is not exponentially distributed (assumed to be general distribution).

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
pelayanan3	.155	78	.000	.870	78	.000

a. Lilliefors Significance Correction

Fig 3: Kolmogorov-smirnov Test of Service Time Distribution

- **Distribution Grouping**

Because the Kolmogorov-Smirnov test found observations with a general distribution, researchers wanted to find out more about the specific distribution of the observations. So, the next step is to conduct a Goodness of Fit Test (distribution fit test) in finding a suitable distribution for observations using the help of Easy Fit software (Rosnani Ginting and Wulan Pratiwi, 2019) [5]. It is obtained that the number of arrivals is Poisson distributed, the time between arrivals is General Pareto distributed, and the service time is Weibull distributed.

- **Queue Design and Discipline**

The queue for payment services at the cashier at Kentucky Fried Chicken Fast Food Restaurant in Jimbaran uses multichannel single phase. The queuing discipline applied is First Come First Served (FCFS) or First In First Out (FIFO) which means that customers who arrive first, will be served first.

- **Determination of Queuing Model**

The KFC queuing system at the regular cashier section, has a system with a Poisson-distributed number of arrivals, a general Pareto-distributed inter-arrival time, and a weibull-distributed service time. Through this, a queue model is obtained that matches Kendall's notation, namely $(M/G/2):(FIFO/\infty/\infty)$.

M: Poisson-distributed number of arrivals
G: Weibull-distributed service level
2: The number of servers (c) is 2
FIFO: First In First Out or the same as First Come First Served (FCFS) which means customers who come first, will be served first.
∞: Maximum infinite queue limit
∞: Infinite population size

- **System Performance Measures**

By using the queue model $(M/G/2):(FIFO/\infty/\infty)$, the system performance measures can be found as follows.

- **Arrival rate (λ)**

Through research, data on the number of arrival rates was obtained, namely 78 people with a daily time interval of 48 observation time intervals (5 minutes interval in 4 hours and 2 minutes).

Referring to formula (1) is obtained

$$\lambda = \frac{n}{I} = \frac{78}{48} = 1{,}625 \text{ per 5 minutes}$$

$\approx 0{,}3250$ per minute
≈ 1 person per minute

- **Service level**

Average service time $= \frac{243{,}5833}{78} = 3{,}1229$

Through formula (3) obtained:

$$\mu = \frac{1}{3{,}1229}$$

$$= \frac{1}{3{,}1229} = 0{,}320 \approx 1 \text{ person per minute}$$

- **The probability of a busy waiter**

Through formula (4) obtained

$$\rho = \frac{0{,}3250}{2(0{,}3202)} = \frac{0{,}3250}{0{,}6404} = 0{,}5075$$

$$\%\rho = \rho \times 100\% = 0{,}5075 \times 100\% = 50{,}75\%$$

- **The probability of off-busy waiter**

$$P_0 = 1 - 0{,}5075 = 0{,}4925$$

$$\%P_0 = P_0 \times 100\% = 0{,}4925 \times 100\% = 49{,}25\%$$

- **Average customer waiting time in queue**

$$W_q = \frac{\lambda^2\left(\frac{2}{\mu^2}\right)\left(\frac{1}{\mu}\right)}{2\left(2-\frac{\lambda}{\mu}\right)^2\left[1+\frac{\left(\frac{\lambda}{\mu}\right)^2}{\left(2-\frac{\lambda}{\mu}\right)}+\left(\frac{\lambda}{\mu}\right)+\frac{\left(\frac{\lambda}{\mu}\right)^2}{\left(2-\frac{\lambda}{\mu}\right)}\right]}$$

$$= \frac{0{,}3250^2\left(\frac{2}{0{,}3202^2}\right)\left(\frac{1}{0{,}3202}\right)}{2\left(2-\frac{0{,}3250}{0{,}3202}\right)^2\left[1+\frac{\left(\frac{0{,}3250}{0{,}3202}\right)^2}{\left(2-\frac{0{,}3250}{0{,}3202}\right)}+\left(\frac{0{,}3250}{0{,}3202}\right)+\frac{\left(\frac{0{,}3250}{0{,}3202}\right)^2}{\left(2-\frac{0{,}3250}{0{,}3202}\right)}\right]}$$

$$= \frac{6{,}43477}{7{,}96911} = 0{,}8078\ menit$$

- **Average number of customers in queue**

$$L_q = 0{,}3250(0{,}8078) = 0{,}2625 \text{ person} \approx 1 \text{ person}$$

- **Average number of customers in system**

Using formula (9) is obtained

$$L_s = 0{,}2625 + \left(\frac{0{,}3250}{0{,}3202}\right) = 1{,}2775 \text{ people } \approx 2 \text{ people}$$

- **Average customers waiting time in the system**

$$W_s = \frac{1{,}2775}{0{,}3250} = 3{,}9308 \text{ minutes}$$

Through the results of this study, it is obtained that the customer arrival rate (λ) is 1 person per minute, the service level (μ) is 1 person per minute. The level of server busyness or utility is 50.75%. Average customer waiting time in queue which is 0.8078 minutes, the average number of customers in the queue is 1 person, the average number of customers in the system is 2 people, and the average waiting time for customers in the system is 3.9308 minutes.

Conclusion

Based on the discussion that has been carried out, it is obtained that the queuing system at *Kentucky Fried Chicken* Fast Food Restaurant in Jimbaran, Bali is running quite well because the average customer arrival (λ) does not exceed the average level of customer arrival service (μ). In addition, it is seen from the percentage level of busy waiters of 50.75%, which means that with 2 cashiers, the waiter has a fairly moderate level of busyness, so 2 cashiers is enough

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