Preliminary Modelling for Ship Passenger Arrival Distribution Case of Gapura Surya Nusantara Passenger Terminal, Tanjung Perak Port, Surabaya.

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Abstract: Sea Passenger Terminal needs to be designed and operated properly. Its main facilities are parking lot and passenger processing facilities. Their arrangements is of course very much depend on the passenger arrival flow. Three different ship passenger arrival distributions were observed. These three ship departures were chosen in order to get single ship embarking passenger arrival pattern. This research indicate that the passenger arrival distribution pattern follow a certain typical form and can be modeled by the Generalized Poisson function, a slight development of a Poisson probability density function. This model need to be refined.

Keywords: ship passenger, passenger arrival distribution pattern, distribution pattern modelling.

1. INTRODUCTION

Air passenger terminals are generally very well organized and well operated in Indonesia and evenmore in any developed countries. On the other hand, in Indonesia, sea terminal passenger are generally not yet well organized, well designed and well operated. Recently, Indonesia has started to better organize, design and operate the sea passenger terminal. Gapura Surya Nusantara Sea Terminal Passenger at Tanjung Perak Port in Surabaya City has been recently modernized.

Airport passenger terminal has been very well organized, regulated and directed. The International Air Transport Association (IATA) has worked a lot in producing air transport convention, regulation and manual. The IATA Airport Terminal Reference – Manual of course can be refered and surely has been largely refered (IATA,1989). The passenger arrival flow, thus its distribution, is one of important input for the terminal passenger handling process design. Books and research papers on this matter have been written. IATA has produced a an IATA Pattern of Arrival Earliness, classified by 3 different hour periods of the day. The distribution patterns are presented in tabular forms, without mentioning its distribution function. Graphically, the pattern forms are looks like Poisson Distribution, Gamma Distribution or other distributions similar to those two. These three are for domestic flights. Later on, a special Pattern of Arrival Earliness for international flight were also developed. The same as the previous, the distributions are presented in tabular forms (Ahyudanari & Vandebona, 2016; Ashford, 1992; Horonjeff & McKelvey, 1994; IATA, 1989). Walking time variation between the pier and the immigration gate, for Sidney International Airport, have ever been modeled by using logistic, lognormal and gamma functions (Nikoe et al, 2015).

The importance of Arrival Distribution Pattern can also be found in case of Toll Gate Optimization. The optimization can be viewed from the point of view of the design, the traffic intensity, etc. It is about Vehicle Arrival Distribution Pattern and its Composition (Pratelli & Schoen, 2003; Vincent et al, 2014).

For analyzing the performance of a Public Transport Station vis-a-vis the user, Passenger Arrival Rates is also capital. The Passenger Arrival Rates depends on the Passenger Arrival Distribution. An attempt to study a distribution pattern as a combination of a Uniform Distribution and a Shifted Johnson S_B Distribution has ever been made (Luethi, 2006). Non Parametric Regression has ever been used to model Transfer Passenger Flow in subway station in China (Sun et al, 2014).

A small study to reveal the characteristics of Sea Passenger in Gapura Surya Nusantara Sea Passenger Terminal, in Tanjung Perak Port, Surabaya City has ever been done. The study was concentrated on the vehicles used by the passenger to arrive to the terminal : vehicle flow volume, vehicle type, arrival hour distribution pattern, stopping time, passenger drop-off and pick-up demand (Pambudi & Suprayitno, 2016).

As an archipelago country, Indonesian sea passenger play an important part of the inter island passenger transportation. Sea port passenger terminal need to be well designed and operated. Its main facilities, among others are parking area, passenger check-in area, waiting hall, boarding waiting room and others. Their arrangements is very much depend on the passenger arrival flow to the terminal, hence passenger arrival distribution pattern. Therefore, for Indonesia, sea passenger arrival distribution pattern need to be revealed and modeled. This preliminary modelling is designated to design the modelling procedure for Ship Passenger Arrival Distribution Pattern.

2. RESEARCH METHOD

In order to well achieve the objective, the research was executed by following these steps : research objective statement, research case identification, survey design, data collection, analysis, and conclusion.

This modelling is about to develop a mathematical or statistiscal functions which best and well suited to the Passenger Arrival Distribution Pattern. Three functions are tested and the best will be choosen as the model. The Sum of Square Error (SSE) value is used to determine the functions parameter values. The SSE is also used to choose the best function among the three. The best function is a function with the smallest SSE value. Afterward, the Statistical Inference for Goodness of Fit Test equiped with Mean Acceptable Error were used to measure the model appropriateness level. The Mean Absolute Error will be used to measure the Acceptable Error, measured in percentage (Blake 1982; Suprayitno et al, 2016, Suprayitno & Ratnasari 2017).

3. SHIP PASSENGER ARRIVAL DATA

3.1 Problem Statement, Research Case and Survey Design

The research objectives are to reveal the passenger arrival distribution pattern and to develop a mathematical model to represent these passenger distribution pattern. Gapura Surya Nusantara Passengger Terminal at Tanjung Perak Port at Surabaya Indonesia was taken as the

Case Location. Survey must executed for a ship at a time, in order to have undisturbed and unmixed flow. Three ship departures must be taken.

In this sea port passenger terminal, the ship departure is relatively rare, at one to two ships per day. This condition is very ideal to get good samples. However, the modelling must be based on an Unmixed Embarking Passenger Arrival Pattern. It needs a single departure in a day. To find this kind of departure is very rare. Finally, three single departures a day has been gotten and were taken as the research case. Those were KM Kumala, KM Binaiya and KM Tidar, in the period of December 2015, February 2016 and July 2016. Thus, three different Un-mixed Embarking Passenger Arrival Distributions passenger could be gotten.

3.2 Data on Hourly Passenger Arrival Distribution

The observation for those three ships passenger arrival was taken during 11 hour period prior to the departure hour. Those three ships data are presented below.

Table 1 Observed Ship Departure Schedule

No	Ship	Destination	Departure		
1	KM Binaiya	Sampit	Friday	11 Decembre 2015	18:00
2	KM Tidar	Makassar	Thusrday	11 February 2016	17:00
3	KM Kumala	Banjarmasin	Thursday	28 July 2016	14:00

The Passenger Arrival Distribution Pattern for those three observed ship departures are presented below. In order to be clear, a table and a graph of Passenger Arrival Distribution for those three ships are presented one by one, each by a Table and a Graph. Those tables and graphs are presented in Table 2 to Table 4 and in Figure 1 to Figure 3 below.

Table 2 KM Kumala Passenger Arrival Data

No	Hour	n^{th} Hour	Passenger	Precentage
1	03:00 - 04:00	-11	0	0%
2	04:00 - 05:00	-10	15	5.1%
3	05:00 - 06:00	-9	21	7.1%
4	06:00 - 07:00	-8	46	15.5%
5	07:00 - 08:00	-7	33	11.1%
6	08:00 - 09:00	-6	70	23.6%
7	09:00 - 10:00	-5	34	11.4%
8	10:00 - 11:00	-4	28	9.4%
9	11:00 - 12:00	-3	25	8.4%
10	12:00 - 13:00	-2	20	6.7%
11	13:00 - 14:00	-1	5	1.7%
12	Departure	0	0	0.0%
		Total	297	100%

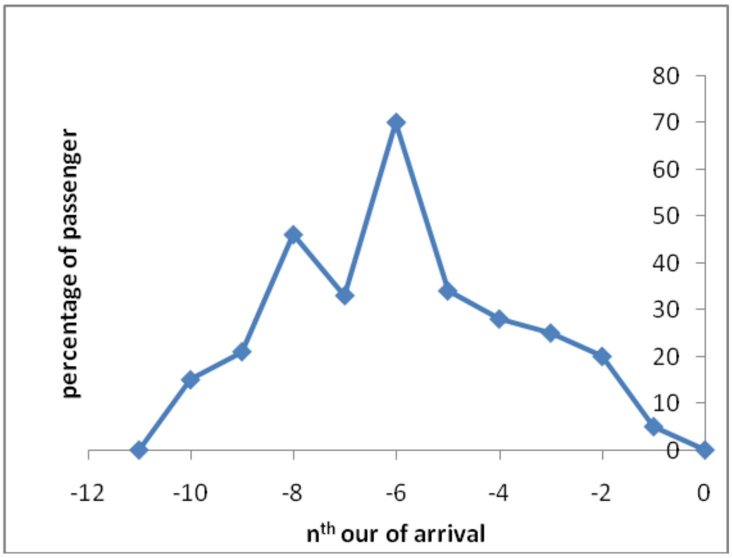

Figure 1 KM Kumala Passenger Arrival Graph

Table 3 KM Binaiya Passenger Arrival Data

No	Hour	n^{th} Hour	Passenger	Precentage
1	07:00 - 08:00	-11	0	0.0%
2	08:00 - 09:00	-10	0	0.0%
3	09:00 - 10:00	-9	11	9.9%
4	10:00 - 11:00	-8	10	9.0%
5	11:00 - 12:00	-7	4	3.6%
6	12:00 - 13:00	-6	6	5.4%
7	13:00 - 14:00	-5	25	22.5%
8	14:00 - 15:00	-4	35	31.5%
9	15:00 - 16:00	-3	20	18.0%
10	16:00 - 17:00	-2	0	0.0%
11	17:00 - 18:00	-1	0	0.0%
12	Departure	0	0	0.0%
		Total	111	100%

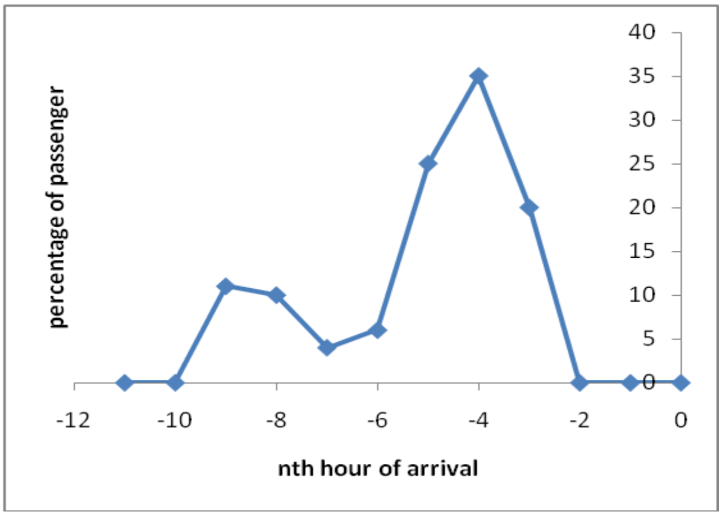

Figure 2 KM Binaiya Passenger Arrival Graph

Table 4 KM Tidar Passenger Arrival Data

No	Hour	n^{th} Hour	Passenger	Precentage
1	07:00 - 08:00	-11	0	0.0%
2	08:00 - 09:00	-10	0	0.0%
3	09:00 - 10:00	-9	0	0.0%
4	10:00 - 11:00	-8	0	0.0%
5	11:00 - 12:00	-7	0	0.0%
6	12:00 - 13:00	-6	47	24.9%
7	13:00 - 14:00	-5	69	36.5%
8	14:00 - 15:00	-4	42	22.2%
9	15:00 - 16:00	-3	20	10.6%
10	16:00 - 17:00	-2	11	5.8%
11	17:00 - 18:00	-1	0	0.0%
12	Departure	0	0	0.0%
		Total	189	100%

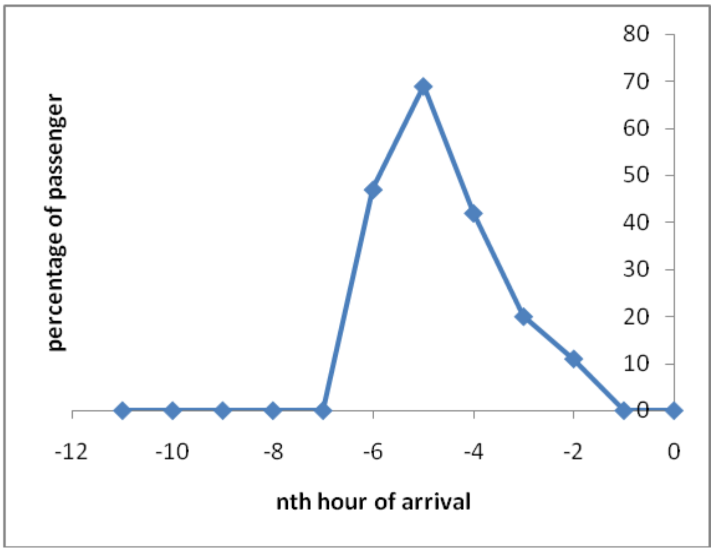

Figure 3 KM Tidar Passenger Arrival Graph

3.3 Resume on Passenger Arrival Distribution Data

It can be noticed that in general the Passengger Arrival Distributions have a typical pattern. The first arrivals start at about -6 to -10 hours prior the departure hour. The number of arrival augment, until it reach the peak volume at about -4 to -6 hours prior the departure. The last arrival happen at about -1 to -3 hours prior the departure. The peak volume is around 30% of the total number of passenger embarking to the ship. The peak hour are in general tend closer to the last arrival hour than to the first arrival hour.

Table 5 Passenger Arrival Distribution General Characteristics

No	Ship	Nbr of Pass.	First Arrival	Last Arrival	Arrival Extent	Peak Hour	Peak Volume
		pax	*hour*	*hour*	*hour*	*hour*	*%*
1	KM Kumala	297	-10	-1	10	-6	23.6
2	KM Bianiya	111	-9	-3	7	-4	31.5
3	KM Tidar	189	-6	-2	5	-5	36.5

4. ANALYSIS AND DISCUSSION

4.1 Analysis Procedure

The research objectives are to reveal sea passenger arrival distribution pattern and to develop a mathematical model of hourly passenger arrival distribution pattern. The analysis was executed by following this procedure : to develop average arrival distribution pattern, to develop several mathematical models to represent the arrival distribution pattern, to choose the most appropriate model.

4.2 Average Distribution Pattern

In order to represent those three different but similar Passenger Arrival Distribution Value, the model must be constructed based on Average Value of Passenger Arrival Distribution. The Average Distribution Calculation is presented in Table 3 below. While, the Average Distribution Graph is presented in Figure 1 below. The Average Distribution has the following characteristics : the First Arrival hour is at hour -10, the Last Arrival hour is at hour -1, the Peak Hour is at hour -5 and the Peak Volume is 23.49% of the total number of passenger.

Tabel 6 Average of Hourly Percentage Passenger Arrival

No	n^{th} Hour	Precentage of Passenger Number			Average
		Ship 1	Ship 2	Ship3	
1	-11	0.00%	0.00%	0.00%	0.00%
2	-10	5.05%	0.00%	0.00%	1.68%
3	-9	7.07%	9.91%	0.00%	5.66%
4	-8	15.49%	9.01%	0.00%	8.17%
5	-7	11.11%	3.60%	0.00%	4.90%
6	-6	23.57%	5.41%	24.87%	17.95%
7	-5	11.45%	22.52%	36.51%	23.49%
8	-4	9.43%	31.53%	22.22%	21.06%
9	-3	8.42%	18.02%	10.58%	12.34%
10	-2	6.73%	0.00%	5.82%	4.18%
11	-1	1.68%	0.00%	0.00%	0.56%
12	0	0.00%	0.00%	0.00%	0.00%
	Total	100.00%	100.00%	100.00%	100.00%

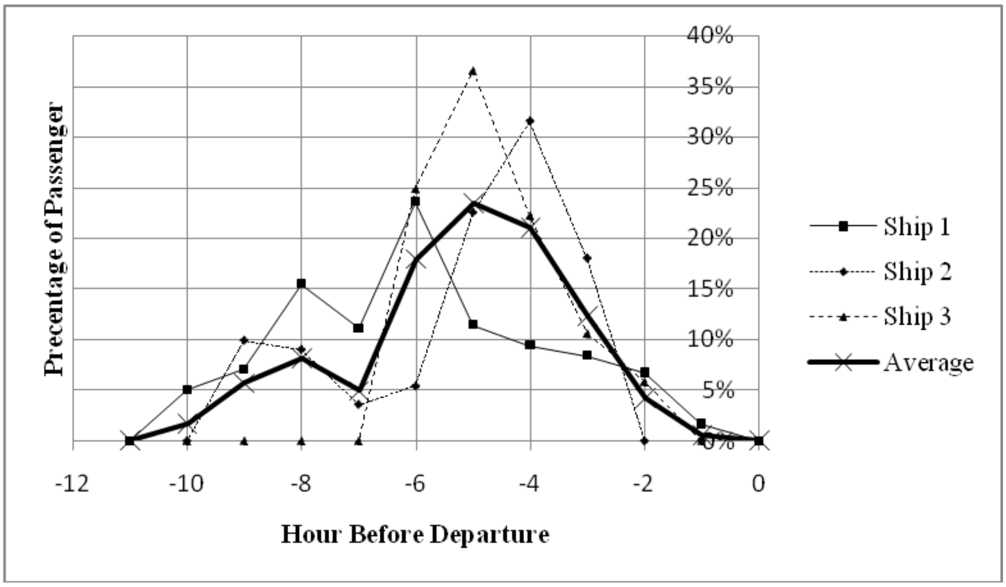

Figure 4 Average Passenger Arrival Distribution Graph

4.3 Model Development

Refering to the Average Distribution Pattern, three mathematical models have been prepared to be tested. The Percentage of Passenger Number (P) is the dependent variable, and the n^{th} Arrival Hour (H) is the independant variable. The model must be able to represent the Distribution Pattern, hence P should be be equal to 0 at Last Arrival Hour and at First Arrival Hour. These lead us to the following two mathematical models and a statistical distribution model, i.e. : Square Polynomial, Power Exponential and Generalized Poisson. The Square Polynomial is an ordinary square polynomial function, with constant value is set equal to zero, in order to have a value of P = 0 at H = 0, as the Average Passenger Arrival Distribution Pattern has such main characteristics. The Power Exponential function is a multiplication of a power function of H multiply by an exponential function of H and by a constant, refered to the Gamma Distribution Function and Tanner Deterrence Function (Blake, 1982; Tamin, 2008; Wack, 2007). While the Generalized Poisson is a slight development of the Poisson probability density function (Poisson pdf), i.e. the Poisson probability density function multiply by a constant. The constant C is for ajusting the original Poisson pdf value to the Distribution Pattern Value. The general formula of those three models are presented below.

Square Polynomial : $P = C_1 H^2 + C_2 H$ (1)

Power Exponential : $P = C \times H^{\alpha} \times e^{\beta H}$ (2)

Generalized Poisson: $P = C \dfrac{e^{-\lambda} \times \lambda^{H}}{H!}$ (3)

where :

P = passenger volume in percentage of the total number of passenger

H = arrival hour prior to the departure hour (expressed in negative value)

α, β, λ, C, C_n = coefficients

The coefficients are those which must be calculated to obtain the models.

Model Development Calculation

As stated in Research Method, the Model Development calculation is based on minimizing SSE. Trial-and-error calculation was made to obtain the minimum SSE value by changing the coefficient values. The SSE is formulated below.

$$SSE = \Sigma (d_i - m_i)^2 \qquad (4)$$

where :

d_i = i^{th} data value

m_i = i^{th} model value

In this research, the Quality Measure for Trip Length Distribution is taken to measure the Distribution Pattern Quality. The quality measure follow the principle of Maximum Acceptable Error at a Certain Confidence Level and of Goodness of Fit. The two measures : Goodness of Fit Acceptance and Maximum Error Acceptance are presented as follows.

Goodness of Fit Acceptance

The Goodness of Test for continous distribution use χ^2 Test. In order that the Distribution Pattern can be accepted, the calculated χ^2 value must be the same or less than the reference χ^2 value. The test formula are presented below.

H_0 : if $\chi^2 \leq \chi_0^2$, the curve is from the reference curve

H_1 : if $\chi^2 > \chi_0^2$, the curve is not from the reference curve.

$$\chi^2 = \Sigma (x_i - x_{0,i})^2 / x_{0i} \qquad (5)$$

$$\upsilon = n - k - 1 \qquad (6)$$

Where :

χ_0^2 : chi square reference value

χ^2 : chi square value

x_i : the model value

$x_{0,i}$: the data value

υ : degree of freedom

n : number of observation

k : number of parameter considered

Based on formula above, the Distribution Pattern Acceptance for this case has to be set. With the degree of freedoom $\upsilon = 10$ and the significance level is taken as $\alpha = 0.005$, the χ_0^2 value is presented below.

$$\chi_0^2 = 25.19$$

Maximum Accepted Error

Maximum Accepted Error is based on Mean Absolute Error. To be accepted, the calculated error must be tha same or less then the Maximum Accepted Error. The error is measure in percentage. The formula are presented below.

$$|e| \leq E \qquad (7)$$

$$|\bar{e}| = (\Sigma |e_i|) / n \qquad (8)$$

$$|e_i| = 100 \text{ x } (d_i - m_i) / d_i \qquad (9)$$

where :

E : accepted error value, measured in percentage

|e| : mean absolute error value, measured in percentage
|ei|: i^{th} absolute error value, measured in percentage
n : number of observation points

Based on formula above, the Maximum Accepted Error has to be set. By considering the accuracy and the acceptability easiness, the E is set as below.

E = 10%.

Example of Model Development - Generalized Poisson

A sample of Model Development Calculation, the Generalized Poisson Model, is presented in Table 4 below.

Table 7 Generalized Poisson Model Development Calculation

		C	109			
		λ	-5.19			
No	**Hour**	**Data**	**Model**	e_i^2	χ_i^2	$\|e_i\|$
1	-11	0.000	1.120	1.254	-	-
2	-10	1.680	2.373	0.481	0.29	41.3
3	-9	5.660	4.573	1.182	0.21	19.2
4	-8	8.170	7.930	0.058	0.01	2.9
5	-7	4.900	12.223	53.627	10.94	149.4
6	-6	17.950	16.486	2.144	0.12	8.2
7	-5	23.490	19.059	19.636	0.84	18.9
8	-4	21.060	18.361	7.285	0.35	12.8
9	-3	12.340	14.151	3.280	0.27	14.7
10	-2	4.180	8.180	15.998	3.83	95.7
11	-1	0.560	3.152	6.719	12.00	462.9
12	0	0.000	0.607	0.369	-	-
Total		99.990	107.095			
		SSE		112.032		
		χ^2			28.84	
		$\|\bar{e}\|$				82.6

Square Polynomial Model Development

After developing the model manually, by using the Trial and Error technics, based on minimizing the SSE, a Square Polynomial model has been gotten. The modelling results : the mathematical model, the SSE value, the χ^2 value, the |ē| value, the acceptability note and the graph are presented below.

$$\text{Model : } P = -1.08H^2 - 10.66H \quad (10)$$

SSE = 964.70
χ^2 = 268.97
|ē| = 274.26

Both the χ^2 and the |ē| are rejected.
This model can not be used.

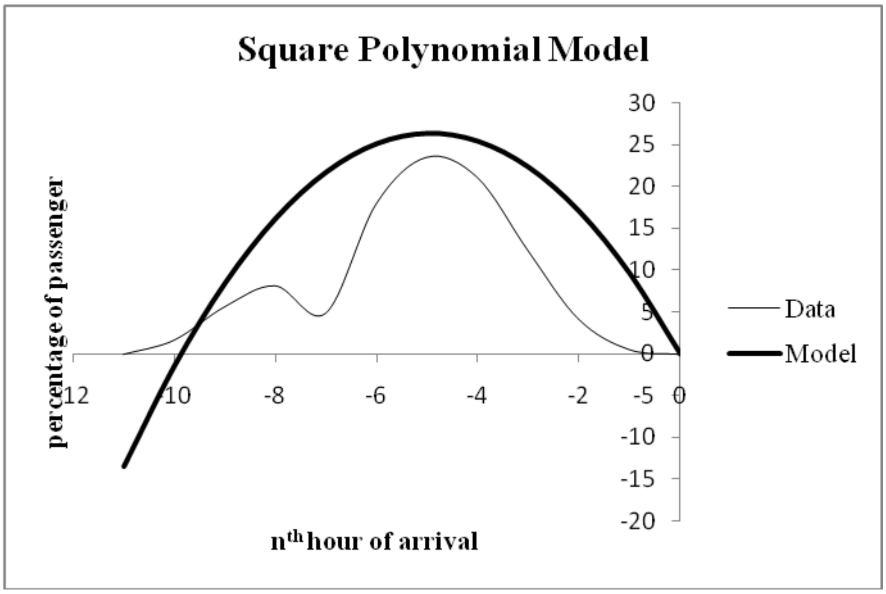

Figure 5 Square Polynomial Model

Power Exponential Model Development

After a sequence of trail-and-error method to minimize the SSE value, a Power Exponential model has been gotten. The modelling results : the mathematical model, the SSE value, the $\chi 2$ value, the error value, the model acceptance and the graph are presented below.

Model : $P = 17 \times -H^{-0.00002} \times e^{0.16H}$ (11)

SSE = 818.99
χ^2 = 391.28
$|\bar{e}|$ = 307.33

Both the χ^2 and the $|\bar{e}|$ are rejected.
This Power Exponential Model can not be used.

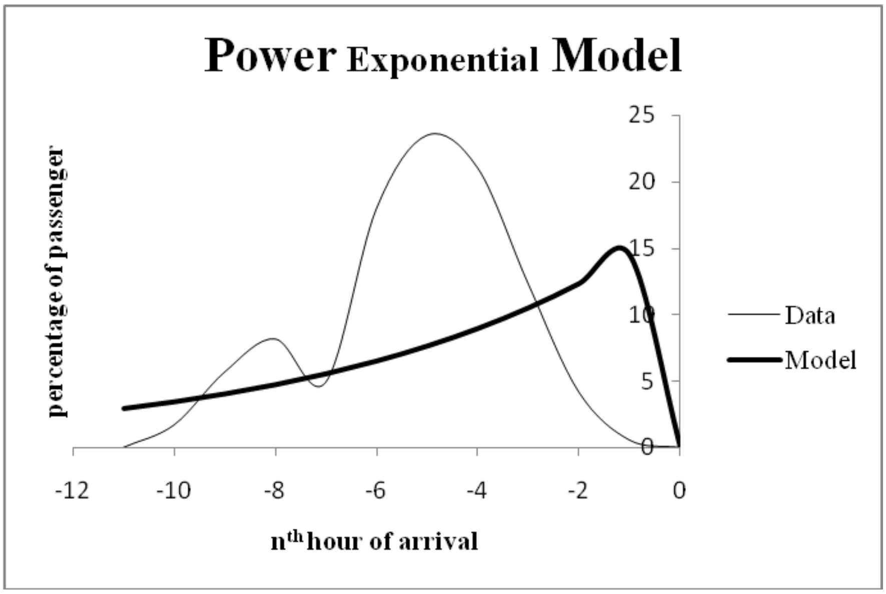

Figure 6 Power Exponential Model

Generalized Poisson Model Development

The Generalized Poisson Model was calculated based on minimizing SSE by using trial-and-error method. The calculation results : the mathematical formulae, the SSE value, the α value and its graph are presented below.

$$\text{Model : } P = 109.1 \frac{e^{-5.18} \times 5.18^{-H}}{(-H)!} \tag{12}$$

SSE = 111.94
χ^2 = 29.09
|ē| = 83.12

The χ^2 is closed to be accepted and the |ē| are rejected.
This Generalized Poisson Model can be used with caution.

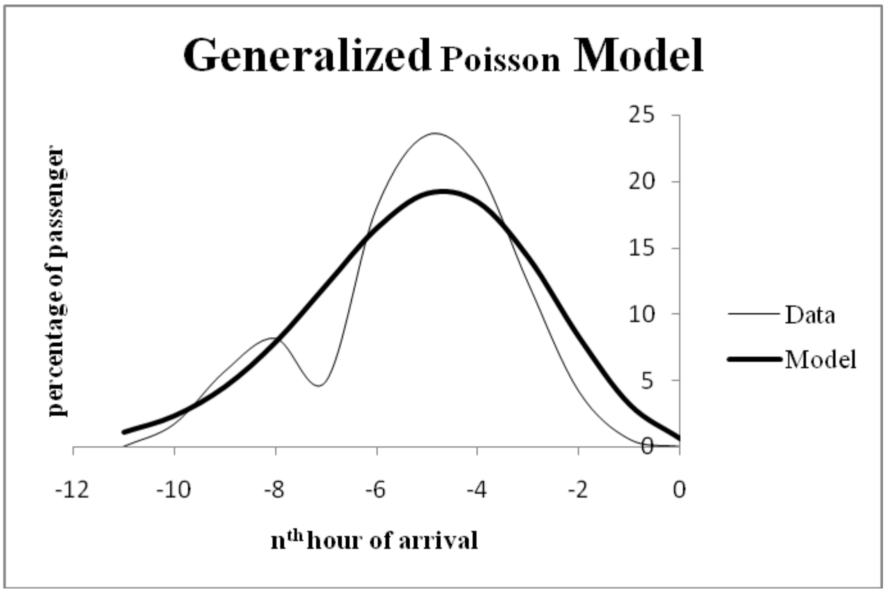

Figure 7 Generalized Poisson Model

4.4 Passenger Arrival Distribution Model

The all three models, as the model development results, are presented in Table 5 below. It can be noted that the Generalized Poisson Model has the least SSE value, χ^2 value and |ē| value. Thus, among those three, the Generalized Poisson Model is the best for representing the Passenger Arrival Distribution Pattern. However, the Curve Pattern Acceptance is slightly not acceptable and the Error Value is not accepted, therefore this General Poisson Model can only be used with caution.

Table 8 Three Passenger Arrival Distribution Pattern Modelling Results

No	Model	Formula	SSE	Goodness of Fit		Error	
				χ^2	Accept.	MAE	Accept.
1	Square Polynomial	$P = -1.08\ H^2 - 10.66\ H$	964.70	268.97	no	274.26	no
2	Power Exponential	$P = 17 \times -H^{-0.00002} \times e^{0.16H}$	818.99	391.28	no	307.33	no
3	Generalized Poisson	$P = 109.1\ (e^{-5.18} \times 5.18^{-H} / (-H)!)$	111.94	29.09	ok	83.12	no

The Generalized Poisson Model as the most suited model is presented in a more clear way below. P is the precentage of passenger number, while H indicates the arrival hour prior to the departure. Even if it is the best model, Goodness of Fit acceptance is only slightly accepted and the error is too high and is not accepted. This Generalized Poisson Model can be used, with caution.

$$P = 109.1 \frac{e^{-5.18} \times 5.18^{-H}}{(-H)!} \qquad (12)$$

5. CONCLUSIONS

The research objectives have been achieved. Three ships passenger arrival distribution has been succesfully collected. Those distribution caharacterictics have been indicated and a mathematical model has been developed. The main conclusions are presented as follows :

- The modelling procedure can be used easily and clearly. The Distribution Pattern Quality Measure is very appropriate.
- In average, the three embarking passenger arrival distribution has a certain typical pattern. Prior to the departure hour, the first arrival hour is at hour -10, the last arrival hour is at hour -2, the peak arrival hour is at hour -5, while the peak volume is at 23,11% of total number of passenger. The peak hour is closer to the latest arrival hour than to the first arrival hour.
- The most appropriate model to represent the embarking passenger arrival distribution pattern is the Generalized Poisson function. The mathematical model is presented below. Of course, it must be noted that the coefficient and the constant value might be different from one terminal to the other.

$$P = 109.1 \frac{e^{-5.18} \times 5.18^{-H}}{(-H)!} \qquad (12)$$

where :
P = precentage of total number of passenger
H = arrival hour prior to the departure hour

The research need to be more developed in three directions. Getting a better representative model by conducting a lot more observations. Getting a better general model, by trying to use other statistical distributions, similar to Poisson Distribution, such as Weibull, Kolmogorov-Smirnov, Gamma, χ^2, F, Betta or others. Investigating the influence of departure hour and the number of passenger to the distribution pattern, by conducting a lot more observations.

Acknowledgement
This pilot study is part of a research program to reveal important characteristics of sea port flow of passengers, goods, vehicles and ships.

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Abstract: Sea Passenger Terminal needs to be designed and operated properly. Its main facilities are parking lot and passenger processing facilities. Their arrangements is of course very much depend on the passenger arrival flow. Three different ship passenger arrival distributions were observed. These three ship departures were chosen in order to get single ship embarking passenger arrival pattern. This research indicate that the passenger arrival distribution pattern follow a certain typical form and can be modeled by the Generalized Poisson function, a slight development of a Poisson probability density function. This model need to be refined.

Keywords: ship passenger, passenger arrival distribution pattern, distribution pattern modelling.

1. INTRODUCTION

Air passenger terminals are generally very well organized and well operated in Indonesia and evenmore in any developed countries. On the other hand, in Indonesia, sea terminal passenger are generally not yet well organized, well designed and well operated. Recently, Indonesia has started to better organize, design and operate the sea passenger terminal. Gapura Surya Nusantara Sea Terminal Passenger at Tanjung Perak Port in Surabaya City has been recently modernized.

Airport passenger terminal has been very well organized, regulated and directed. The International Air Transport Association (IATA) has worked a lot in producing air transport convention, regulation and manual. The IATA Airport Terminal Reference – Manual of course can be refered and surely has been largely refered (IATA,1989). The passenger arrival flow, thus its distribution, is one of important input for the terminal passenger handling process design. Books and research papers on this matter have been written. IATA has produced a an IATA Pattern of Arrival Earliness, classified by 3 different hour periods of the day. The distribution patterns are presented in tabular forms, without mentioning its distribution function. Graphically, the pattern forms are looks like Poisson Distribution, Gamma Distribution or other distributions similar to those two. These three are for domestic flights. Later on, a special Pattern of Arrival Earliness for international flight were also developed. The same as the previous, the distributions are presented in tabular forms (Ahyudanari & Vandebona, 2016; Ashford, 1992; Horonjeff & McKelvey, 1994; IATA, 1989). Walking time variation between the pier and the immigration gate, for Sidney International Airport, have ever been modeled by using logistic, lognormal and gamma functions (Nikoe et al, 2015).

The importance of Arrival Distribution Pattern can also be found in case of Toll Gate Optimization. The optimization can be viewed from the point of view of the design, the traffic intensity, etc. It is about Vehicle Arrival Distribution Pattern and its Composition (Pratelli & Schoen, 2003; Vincent et al, 2014).

For analyzing the performance of a Public Transport Station vis-a-vis the user, Passenger Arrival Rates is also capital. The Passenger Arrival Rates depends on the Passenger Arrival Distribution. An attempt to study a distribution pattern as a combination of a Uniform Distribution and a Shifted Johnson S_B Distribution has ever been made (Luethi, 2006). Non Parametric Regression has ever been used to model Transfer Passenger Flow in subway station in China (Sun et al, 2014).

A small study to reveal the characteristics of Sea Passenger in Gapura Surya Nusantara Sea Passenger Terminal, in Tanjung Perak Port, Surabaya City has ever been done. The study was concentrated on the vehicles used by the passenger to arrive to the terminal : vehicle flow volume, vehicle type, arrival hour distribution pattern, stopping time, passenger drop-off and pick-up demand (Pambudi & Suprayitno, 2016).

As an archipelago country, Indonesian sea passenger play an important part of the inter island passenger transportation. Sea port passenger terminal need to be well designed and operated. Its main facilities, among others are parking area, passenger check-in area, waiting hall, boarding waiting room and others. Their arrangements is very much depend on the passenger arrival flow to the terminal, hence passenger arrival distribution pattern. Therefore, for Indonesia, sea passenger arrival distribution pattern need to be revealed and modeled. This preliminary modelling is designated to design the modelling procedure for Ship Passenger Arrival Distribution Pattern.

2. RESEARCH METHOD

In order to well achieve the objective, the research was executed by following these steps : research objective statement, research case identification, survey design, data collection, analysis, and conclusion.

This modelling is about to develop a mathematical or statistiscal functions which best and well suited to the Passenger Arrival Distribution Pattern. Three functions are tested and the best will be choosen as the model. The Sum of Square Error (SSE) value is used to determine the functions parameter values. The SSE is also used to choose the best function among the three. The best function is a function with the smallest SSE value. Afterward, the Statistical Inference for Goodness of Fit Test equiped with Mean Acceptable Error were used to measure the model appropriateness level. The Mean Absolute Error will be used to measure the Acceptable Error, measured in percentage (Blake 1982; Suprayitno et al, 2016, Suprayitno & Ratnasari 2017).

3. SHIP PASSENGER ARRIVAL DATA

3.1 Problem Statement, Research Case and Survey Design

The research objectives are to reveal the passenger arrival distribution pattern and to develop a mathematical model to represent these passenger distribution pattern. Gapura Surya Nusantara Passengger Terminal at Tanjung Perak Port at Surabaya Indonesia was taken as the

Case Location. Survey must executed for a ship at a time, in order to have undisturbed and unmixed flow. Three ship departures must be taken.

In this sea port passenger terminal, the ship departure is relatively rare, at one to two ships per day. This condition is very ideal to get good samples. However, the modelling must be based on an Unmixed Embarking Passenger Arrival Pattern. It needs a single departure in a day. To find this kind of departure is very rare. Finally, three single departures a day has been gotten and were taken as the research case. Those were KM Kumala, KM Binaiya and KM Tidar, in the period of December 2015, February 2016 and July 2016. Thus, three different Un-mixed Embarking Passenger Arrival Distributions passenger could be gotten.

3.2 Data on Hourly Passenger Arrival Distribution

The observation for those three ships passenger arrival was taken during 11 hour period prior to the departure hour. Those three ships data are presented below.

Table 1 Observed Ship Departure Schedule

No	Ship	Destination	Departure		
1	KM Binaiya	Sampit	Friday	11 Decembre 2015	18:00
2	KM Tidar	Makassar	Thusrday	11 February 2016	17:00
3	KM Kumala	Banjarmasin	Thursday	28 July 2016	14:00

The Passenger Arrival Distribution Pattern for those three observed ship departures are presented below. In order to be clear, a table and a graph of Passenger Arrival Distribution for those three ships are presented one by one, each by a Table and a Graph. Those tables and graphs are presented in Table 2 to Table 4 and in Figure 1 to Figure 3 below.

Table 2 KM Kumala Passenger Arrival Data

No	Hour	n^{th} Hour	Passenger	Precentage
1	03:00 - 04:00	-11	0	0%
2	04:00 - 05:00	-10	15	5.1%
3	05:00 - 06:00	-9	21	7.1%
4	06:00 - 07:00	-8	46	15.5%
5	07:00 - 08:00	-7	33	11.1%
6	08:00 - 09:00	-6	70	23.6%
7	09:00 - 10:00	-5	34	11.4%
8	10:00 - 11:00	-4	28	9.4%
9	11:00 - 12:00	-3	25	8.4%
10	12:00 - 13:00	-2	20	6.7%
11	13:00 - 14:00	-1	5	1.7%
12	Departure	0	0	0.0%
		Total	297	100%

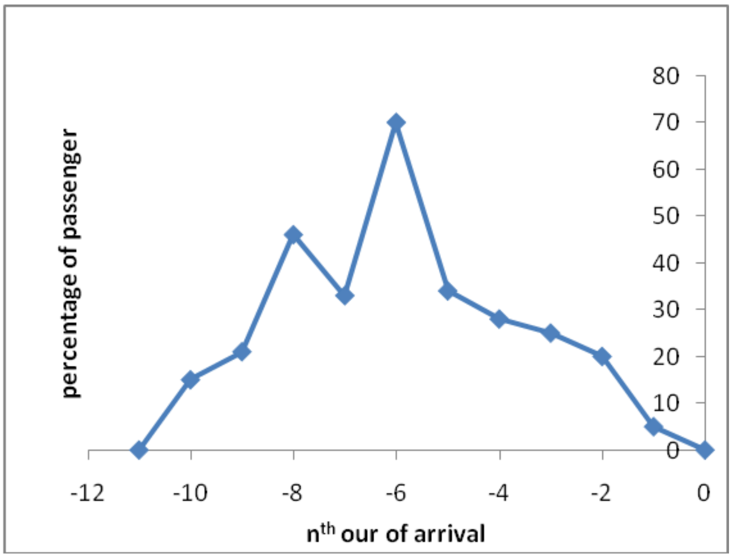

Figure 1 KM Kumala Passenger Arrival Graph

Table 3 KM Binaiya Passenger Arrival Data

No	Hour	n^th Hour	Passenger	Precentage
1	07:00 - 08:00	-11	0	0.0%
2	08:00 - 09:00	-10	0	0.0%
3	09:00 - 10:00	-9	11	9.9%
4	10:00 - 11:00	-8	10	9.0%
5	11:00 - 12:00	-7	4	3.6%
6	12:00 - 13:00	-6	6	5.4%
7	13:00 - 14:00	-5	25	22.5%
8	14:00 - 15:00	-4	35	31.5%
9	15:00 - 16:00	-3	20	18.0%
10	16:00 - 17:00	-2	0	0.0%
11	17:00 - 18:00	-1	0	0.0%
12	Departure	0	0	0.0%
		Total	111	100%

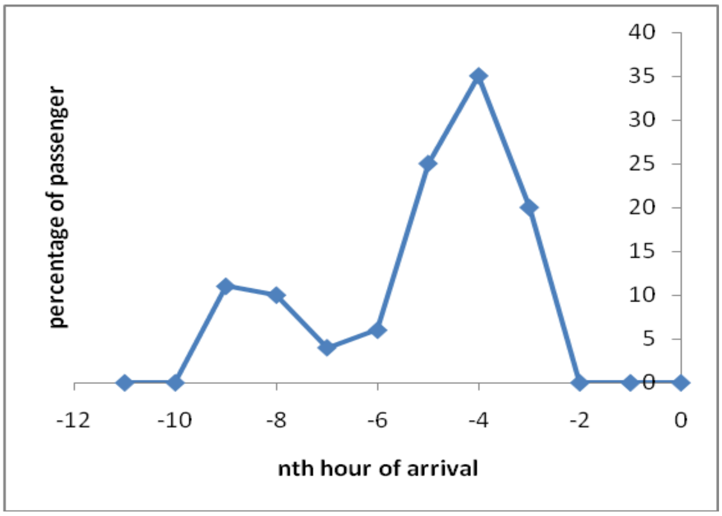

Figure 2 KM Binaiya Passenger Arrival Graph

Table 4 KM Tidar Passenger Arrival Data

No	Hour	n^{th} Hour	Passenger	Precentage
1	07:00 - 08:00	-11	0	0.0%
2	08:00 - 09:00	-10	0	0.0%
3	09:00 - 10:00	-9	0	0.0%
4	10:00 - 11:00	-8	0	0.0%
5	11:00 - 12:00	-7	0	0.0%
6	12:00 - 13:00	-6	47	24.9%
7	13:00 - 14:00	-5	69	36.5%
8	14:00 - 15:00	-4	42	22.2%
9	15:00 - 16:00	-3	20	10.6%
10	16:00 - 17:00	-2	11	5.8%
11	17:00 - 18:00	-1	0	0.0%
12	Departure	0	0	0.0%
		Total	189	100%

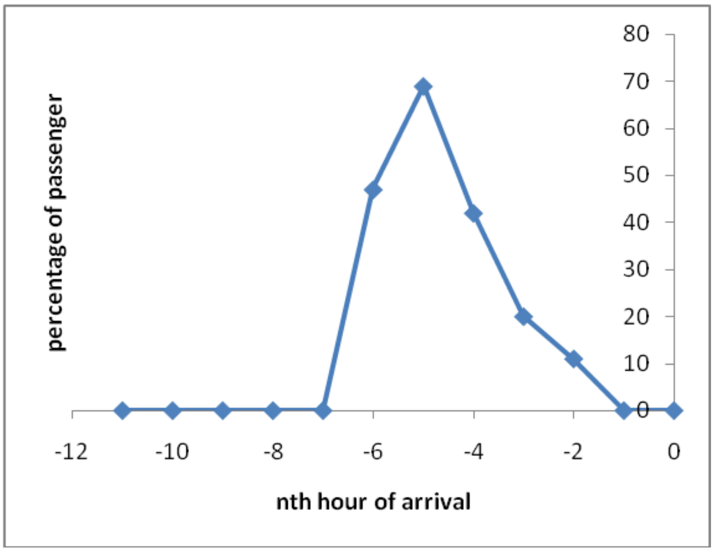

Figure 3 KM Tidar Passenger Arrival Graph

3.3 Resume on Passenger Arrival Distribution Data

It can be noticed that in general the Passengger Arrival Distributions have a typical pattern. The first arrivals start at about -6 to -10 hours prior the departure hour. The number of arrival augment, until it reach the peak volume at about -4 to -6 hours prior the departure. The last arrival happen at about -1 to -3 hours prior the departure. The peak volume is around 30% of the total number of passenger embarking to the ship. The peak hour are in general tend closer to the last arrival hour than to the first arrival hour.

Table 5 Passenger Arrival Distribution General Characteristics

No	Ship	Nbr of Pass.	First Arrival	Last Arrival	Arrival Extent	Peak Hour	Peak Volume
		pax	*hour*	*hour*	*hour*	*hour*	*%*
1	KM Kumala	297	-10	-1	10	-6	23.6
2	KM Bianiya	111	-9	-3	7	-4	31.5
3	KM Tidar	189	-6	-2	5	-5	36.5

4. ANALYSIS AND DISCUSSION

4.1 Analysis Procedure

The research objectives are to reveal sea passenger arrival distribution pattern and to develop a mathematical model of hourly passenger arrival distribution pattern. The analysis was executed by following this procedure : to develop average arrival distribution pattern, to develop several mathematical models to represent the arrival distribution pattern, to choose the most appropriate model.

4.2 Average Distribution Pattern

In order to represent those three different but similar Passenger Arrival Distribution Value, the model must be constructed based on Average Value of Passenger Arrival Distribution. The Average Distribution Calculation is presented in Table 3 below. While, the Average Distribution Graph is presented in Figure 1 below. The Average Distribution has the following characteristics : the First Arrival hour is at hour -10, the Last Arrival hour is at hour -1, the Peak Hour is at hour -5 and the Peak Volume is 23.49% of the total number of passenger.

Tabel 6 Average of Hourly Percentage Passenger Arrival

No	n^{th} Hour	Precentage of Passenger Number			Average
		Ship 1	Ship 2	Ship3	
1	-11	0.00%	0.00%	0.00%	0.00%
2	-10	5.05%	0.00%	0.00%	1.68%
3	-9	7.07%	9.91%	0.00%	5.66%
4	-8	15.49%	9.01%	0.00%	8.17%
5	-7	11.11%	3.60%	0.00%	4.90%
6	-6	23.57%	5.41%	24.87%	17.95%
7	-5	11.45%	22.52%	36.51%	23.49%
8	-4	9.43%	31.53%	22.22%	21.06%
9	-3	8.42%	18.02%	10.58%	12.34%
10	-2	6.73%	0.00%	5.82%	4.18%
11	-1	1.68%	0.00%	0.00%	0.56%
12	0	0.00%	0.00%	0.00%	0.00%
	Total	100.00%	100.00%	100.00%	100.00%

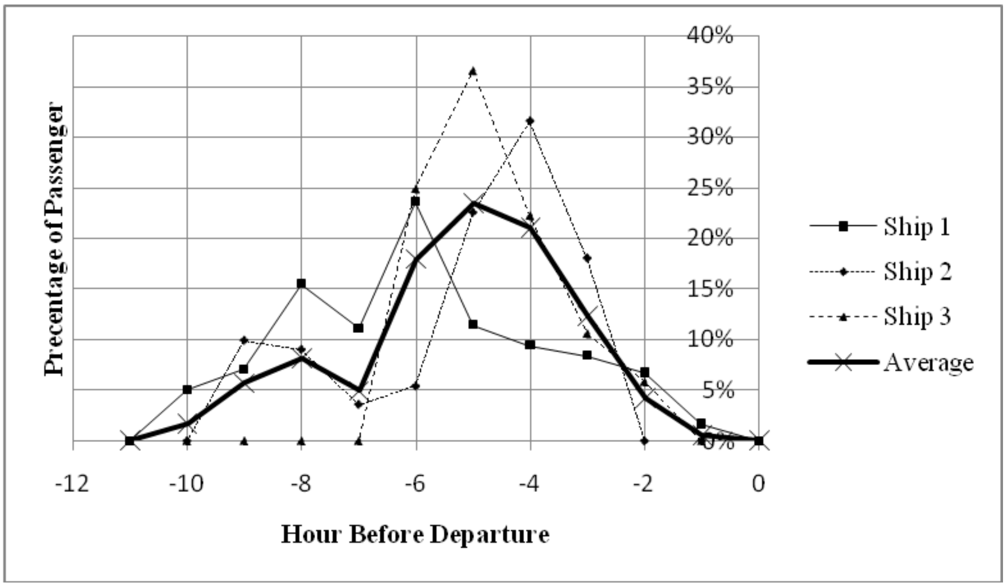

Figure 4 Average Passenger Arrival Distribution Graph

4.3 Model Development

Refering to the Average Distribution Pattern, three mathematical models have been prepared to be tested. The Percentage of Passenger Number (P) is the dependent variable, and the n^{th} Arrival Hour (H) is the independant variable. The model must be able to represent the Distribution Pattern, hence P should be be equal to 0 at Last Arrival Hour and at First Arrival Hour. These lead us to the following two mathematical models and a statistical distribution model, i.e. : Square Polynomial, Power Exponential and Generalized Poisson. The Square Polynomial is an ordinary square polynomial function, with constant value is set equal to zero, in order to have a value of P = 0 at H = 0, as the Average Passenger Arrival Distribution Pattern has such main characteristics. The Power Exponential function is a multiplication of a power function of H multiply by an exponential function of H and by a constant, refered to the Gamma Distribution Function and Tanner Deterrence Function (Blake, 1982; Tamin, 2008; Wack, 2007). While the Generalized Poisson is a slight development of the Poisson probability density function (Poisson pdf), i.e. the Poisson probability density function multiply by a constant. The constant C is for ajusting the original Poisson pdf value to the Distribution Pattern Value. The general formula of those three models are presented below.

Square Polynomial : $$P = C_1 H^2 + C_2 H \quad (1)$$

Power Exponential : $$P = C \times H^{\alpha} \times e^{\beta H} \quad (2)$$

Generalized Poisson: $$P = C \frac{e^{-\lambda} \times \lambda^H}{H!} \quad (3)$$

where :

P = passenger volume in percentage of the total number of passenger

H = arrival hour prior to the departure hour (expressed in negative value)

α, β, λ, C, C_n = coefficients

The coefficients are those which must be calculated to obtain the models.

Model Development Calculation

As stated in Research Method, the Model Development calculation is based on minimizing SSE. Trial-and-error calculation was made to obtain the minimum SSE value by changing the coefficient values. The SSE is formulated below.

$$SSE = \Sigma (d_i - m_i)^2 \quad (4)$$

where :

d_i = i^{th} data value

m_i = i^{th} model value

In this research, the Quality Measure for Trip Length Distribution is taken to measure the Distribution Pattern Quality. The quality measure follow the principle of Maximum Acceptable Error at a Certain Confidence Level and of Goodness of Fit. The two measures : Goodness of Fit Acceptance and Maximum Error Acceptance are presented as follows.

Goodness of Fit Acceptance

The Goodness of Test for continous distribution use χ^2 Test. In order that the Distribution Pattern can be accepted, the calculated χ^2 value must be the same or less than the reference χ^2 value. The test formula are presented below.

H_0 : if $\chi^2 \leq \chi_0^2$, the curve is from the reference curve

H_1 : if $\chi^2 > \chi_0^2$, the curve is not from the reference curve.

$$\chi^2 = \Sigma (x_i - x_{0,i})^2 / x_{0i} \quad (5)$$

$$\upsilon = n - k - 1 \quad (6)$$

Where :

χ_0^2 : chi square reference value

χ^2 : chi square value

x_i : the model value

$x_{0,i}$: the data value

υ : degree of freedom

n : number of observation

k : number of parameter considered

Based on formula above, the Distribution Pattern Acceptance for this case has to be set. With the degree of freedoom $\upsilon = 10$ and the significance level is taken as $\alpha = 0.005$, the χ_0^2 value is presented below.

$$\chi_0^2 = 25.19$$

Maximum Accepted Error

Maximum Accepted Error is based on Mean Absolute Error. To be accepted, the calculated error must be tha same or less then the Maximum Accepted Error. The error is measure in percentage. The formula are presented below.

$$|e| \leq E \quad (7)$$

$$|\bar{e}| = (\Sigma |e_i|) / n \quad (8)$$

$$|e_i| = 100 \times (d_i - m_i) / d_i \quad (9)$$

where :

E : accepted error value, measured in percentage

|e| : mean absolute error value, measured in percentage
|ei|: i^th absolute error value, measured in percentage
n : number of observation points

Based on formula above, the Maximum Accepted Error has to be set. By considering the accuracy and the acceptability easiness, the E is set as below.

E = 10%.

Example of Model Development - Generalized Poisson

A sample of Model Development Calculation, the Generalized Poisson Model, is presented in Table 4 below.

Table 7 Generalized Poisson Model Development Calculation

		C	109			
		λ	-5.19			
No	**Hour**	**Data**	**Model**	$\mathbf{e_i^2}$	χ_i^2	$\lvert e_i \rvert$
1	-11	0.000	1.120	1.254	-	-
2	-10	1.680	2.373	0.481	0.29	41.3
3	-9	5.660	4.573	1.182	0.21	19.2
4	-8	8.170	7.930	0.058	0.01	2.9
5	-7	4.900	12.223	53.627	10.94	149.4
6	-6	17.950	16.486	2.144	0.12	8.2
7	-5	23.490	19.059	19.636	0.84	18.9
8	-4	21.060	18.361	7.285	0.35	12.8
9	-3	12.340	14.151	3.280	0.27	14.7
10	-2	4.180	8.180	15.998	3.83	95.7
11	-1	0.560	3.152	6.719	12.00	462.9
12	0	0.000	0.607	0.369	-	-
Total		99.990	107.095			
		SSE		112.032		
		χ^2			28.84	
		$\lvert\bar{e}\rvert$				82.6

Square Polynomial Model Development

After developing the model manually, by using the Trial and Error technics, based on minimizing the SSE, a Square Polynomial model has been gotten. The modelling results : the mathematical model, the SSE value, the χ^2 value, the $|\bar{e}|$ value, the acceptability note and the graph are presented below.

Model : $P = -1.08H^2 - 10.66H$ (10)

SSE = 964.70
χ^2 = 268.97
$|\bar{e}|$ = 274.26

Both the χ^2 and the $|\bar{e}|$ are rejected.
This model can not be used.

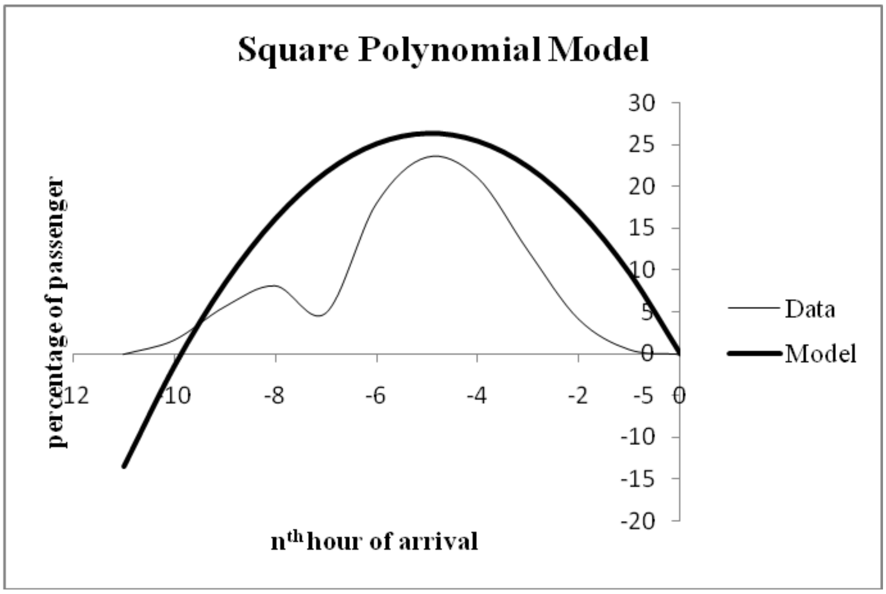

Figure 5 Square Polynomial Model

<u>Power Exponential Model Development</u>

After a sequence of trail-and-error method to minimize the SSE value, a Power Exponential model has been gotten. The modelling results : the mathematical model, the SSE value, the $\chi 2$ value, the error value, the model acceptance and the graph are presented below.

Model : $P = 17 \text{ x } -H^{-0.00002} \text{ x } e^{0.16H}$ (11)

SSE = 818.99
χ^2 = 391.28
$|\bar{e}|$ = 307.33

Both the χ^2 and the $|\bar{e}|$ are rejected.
This Power Exponential Model can not be used.

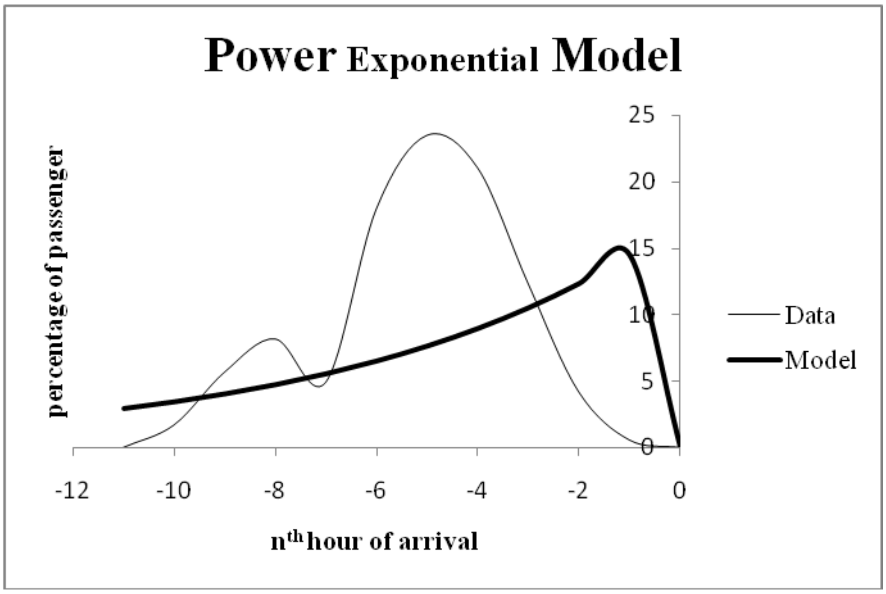

Figure 6 Power Exponential Model

Generalized Poisson Model Development

The Generalized Poisson Model was calculated based on minimizing SSE by using trial-and-error method. The calculation results : the mathematical formulae, the SSE value, the α value and its graph are presented below.

$$\text{Model : } P = 109.1 \frac{e^{-5.18} \times 5.18^{-H}}{(-H)!} \quad (12)$$

SSE = 111.94
χ^2 = 29.09
|ē| = 83.12

The χ^2 is closed to be accepted and the |ē| are rejected.
This Generalized Poisson Model can be used with caution.

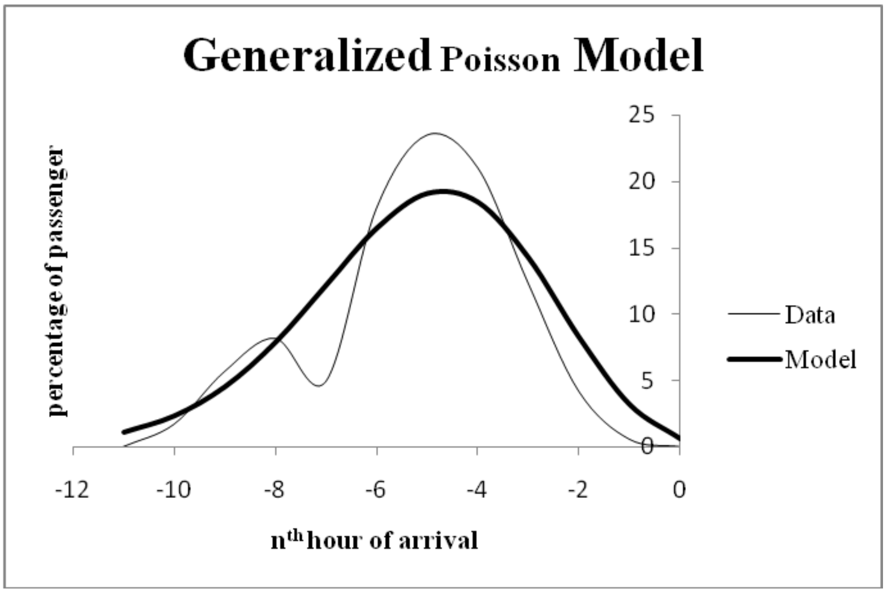

Figure 7 Generalized Poisson Model

4.4 Passenger Arrival Distribution Model

The all three models, as the model development results, are presented in Table 5 below. It can be noted that the Generalized Poisson Model has the least SSE value, χ^2 value and |ē| value. Thus, among those three, the Generalized Poisson Model is the best for representing the Passenger Arrival Distribution Pattern. However, the Curve Pattern Acceptance is slightly not acceptable and the Error Value is not accepted, therefore this General Poisson Model can only be used with caution.

Table 8 Three Passenger Arrival Distribution Pattern Modelling Results

No	Model	Formula	SSE	Goodness of Fit		Error	
				χ^2	Accept.	MAE	Accept.
1	Square Polynomial	$P = -1.08\ H^2 - 10.66\ H$	964.70	268.97	no	274.26	no
2	Power Exponential	$P = 17 \times -H^{-0.00002} \times e^{0.16H}$	818.99	391.28	no	307.33	no
3	Generalized Poisson	$P = 109.1\ (e^{-5.18} \times 5.18^{-H} / (-H)!)$	111.94	29.09	ok	83.12	no

The Generalized Poisson Model as the most suited model is presented in a more clear way below. P is the precentage of passenger number, while H indicates the arrival hour prior to the departure. Even if it is the best model, Goodness of Fit acceptance is only slightly accepted and the error is too high and is not accepted. This Generalized Poisson Model can be used, with caution.

$$P = 109.1 \frac{e^{-5.18} \times 5.18^{-H}}{(-H)!} \tag{12}$$

5. CONCLUSIONS

The research objectives have been achieved. Three ships passenger arrival distribution has been succesfully collected. Those distribution caharacterictics have been indicated and a mathematical model has been developed. The main conclusions are presented as follows :

- The modelling procedure can be used easily and clearly. The Distribution Pattern Quality Measure is very appropriate.
- In average, the three embarking passenger arrival distribution has a certain typical pattern. Prior to the departure hour, the first arrival hour is at hour -10, the last arrival hour is at hour -2, the peak arrival hour is at hour -5, while the peak volume is at 23,11% of total number of passenger. The peak hour is closer to the latest arrival hour than to the first arrival hour.
- The most appropriate model to represent the embarking passenger arrival distribution pattern is the Generalized Poisson function. The mathematical model is presented below. Of course, it must be noted that the coefficient and the constant value might be different from one terminal to the other.

$$P = 109.1 \frac{e^{-5.18} \times 5.18^{-H}}{(-H)!} \tag{12}$$

where :
P = precentage of total number of passenger
H = arrival hour prior to the departure hour

The research need to be more developed in three directions. Getting a better representative model by conducting a lot more observations. Getting a better general model, by trying to use other statistical distributions, similar to Poisson Distribution, such as Weibull, Kolmogorov-Smirnov, Gamma, χ^2, F, Betta or others. Investigating the influence of departure hour and the number of passenger to the distribution pattern, by conducting a lot more observations.

Acknowledgement

This pilot study is part of a research program to reveal important characteristics of sea port flow of passengers, goods, vehicles and ships.

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