Chapter 5

ANALYSIS OF DATA

Evaluation of Arrival and Departure of International Aircrafts at Bangkok International Airport

According to status of Bangkok International Airport being an air traffic centre for South East Asia , day to day activities here are very busy . Most of flights are commercial flights which mean services for passengers and freight have to be provided here , with enough level of service and shortest working time , for 24-hr. flowing of flights . To study the arrival and departure of such flight will help the planning for service of both passengers and freight which the latter requires more work and more service time for ground handling . For arrival and departure of domestic commercial aircrafts , flights are provided by only single airlines , Thai Airways , with daily scheduled flights that are for this study is 24-hr. flow of aircrafts during 10^{th} - 16^{th} October , 1977 . This data is considered to be adequate for the study since the airlines provided flights here have their circulation of scheduling in a week . Table 5.1 and Table 5.2 are such data recorded at Bangkok International Airport . The tabulations show number of arrival and departure of aircrafts in each hour interval for seven days of recording .

Table 5.1 Arrived number of international aircrafts at Bangkok International Airport , October 1977

Time \ Date	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mean	Total
0600 - 0700	1	1	2	-	1	1	1	1	7
0700 - 0800	-	-	-	-	-	1	-	n.a.	1
0800 - 0900	-	-	-	-	1	3	1	0.71	5
0900 - 1000	4	5	2	3	7	5	4	4.29	30
1000 - 1100	4	5	5	6	2	1	6	4.14	29
1100 - 1200	5	2	4	6	1	1	-	2.71	19
1200 - 1300	4	4	4	3	3	3	2	3.29	23
1300 - 1400	1	1	2	2	1	2	2	1.57	11
1400 - 1500	2	4	1	2	2	1	4	2.29	16
1500 - 1600	3	2	2	2	3	2	4	2.14	18
1600 - 1700	3	2	5	5	2	2	3	3.14	22
1700 - 1800	5	1	4	5	2	4	6	3.86	27
1800 - 1900	2	8	4	4	4	4	4	4.29	30
1900 - 2000	3	3	4	3	6	2	4	3.57	25
2000 - 2100	5	1	1	6	2	7	3	3.57	25
2100 - 2200	2	3	2	2	2	1	1	1.86	13
2200 - 2300	3	2	4	-	3	5	2	2.71	19
2300 - 2400	-	2	1	-	1	2	1	1	7
2400 - 0100	1	2	1	-	1	2	2	1.29	9
0100 - 0200	4	3	4	4	3	5	3	3.71	26
0200 - 0300	1	2	-	1	-	1	3	1.14	8
0300 - 0400	1	-	1	-	-	1	-	0.43	3
0400 - 0500	1	1	1	-	-	-	-	0.43	3
0500 - 0600	-	1	-	1	-	-	1	0.43	3
Mean	2.29	2.29	2.25	2.29	1.96	2.33	2.38		
Total	55	55	54	55	47	57	57		379

Table 5.2 Departed number of international aircrafts at Bangkok International Airport , October 1977

Time \ Date	Mon	Tue	Wed	Thu	Fri	Sat	Sum	Mean	Total
0600 - 0700	-	3	-	-	-	1	-	n.a.	4
0700 - 0800	-	1	1	1	-	-	-	0.43	3
0800 - 0900	5	1	4	-	1	2	2	2.14	15
0900 - 1000	3	3	2	2	3	3	3	2.71	19
1000 - 1100	2	4	3	4	8	6	6	4.71	33
1100 - 1200	6	9	3	2	2	3	3	4.00	28
1200 - 1300	6	2	6	7	1	1	3	3.71	26
1300 - 1400	3	4	3	5	3	3	2	3.29	23
1400 - 1500	1	1	3	1	-	2	1	1.29	9
1500 - 1600	2	4	-	2	3	2	3	2.29	16
1600 - 1700	3	2	3	3	1	2	5	2.71	19
1700 - 1800	2	2	4	4	3	1	3	2.71	19
1800 - 1900	3	1	1	2	1	1	2	1.57	11
1900 - 2000	1	5	4	6	1	4	3	3.43	24
2000 - 2100	1	2	4	1	7	-	2	2.43	17
2100 - 2200	4	1	3	5	2	3	2	2.86	20
2200 - 2300	4	1	1	4	4	5	3	3.14	22
2300 - 2400	3	2	4	1	2	3	1	2.29	16
2400 - 0100	1	1	2	2	2	1	3	1.71	12
0100 - 0200	-	1	-	-	1	-	2	0.57	4
0200 - 0300	4	1	5	3	2	5	1	3.00	21
0300 - 0400	1	3	-	2	1	2	3	1.71	12
0400 - 0500	1	-	-	1	-	1	2	0.71	5
0500 - 0600	1	-	1	-	-	-	2	0.57	4
Mean	2.38	2.25	2.38	2.42	2.00	2.13	2.38		
Total	57	54	57	58	48	51	57		382

From Table 5.1 and Table 5.2 , distribution of arrival and departure of aircrafts at this international airport are classified and displayed as interarrival and interdeparture time and the frequency and probability of both arrival and departure are also shown in Table 5.3 and Table 5.4 . Maximum number of aircrafts in an hour is eight and nine for arrival and departure respectively . From tabulated data , cumulative probability curves of arrival and departure of aircrafts are drawn as shown in Figure 5.1 and Figure 5.2 .

Table 5.3 Probability of interarrival time

No. of aircrafts in 1 hr.	Interarrival time (minutes)	Frequency	Cumulative	
			Frequency	Probability
8	60/8 = 7.5	1	1	0.01
7	60/7 = 8.5	2	3	0.02
6	60/6 = 10.0	6	9	0.06
5	60/5 = 12.0	12	21	0.15
4	60/4 = 15.0	23	44	0.32
3	60/3 = 20.0	20	64	0.46
2	60/2 = 30.0	35	99	0.72
1	60/1 = 60.0	39	138	1.00

Table 5.4 Probability of interdeparture time

No. of aircrafts in 1 hr.	Interdeparture time (minutes)	Frequency	Cumulative	
			Frequency	Probability
9	60/9 = 6.6	1	1	0.00
8	60/8 = 7.5	1	2	0.01
7	60/7 = 8.5	2	4	0.03
6	60/6 = 10.0	6	10	0.07
5	60/5 = 12.0	8	18	0.12
4	60/4 = 15.0	16	34	0.24
3	60/3 = 20.0	34	68	0.48
2	60/2 = 30.0	34	102	0.71
1	60/1 = 60.0	41	143	1.00

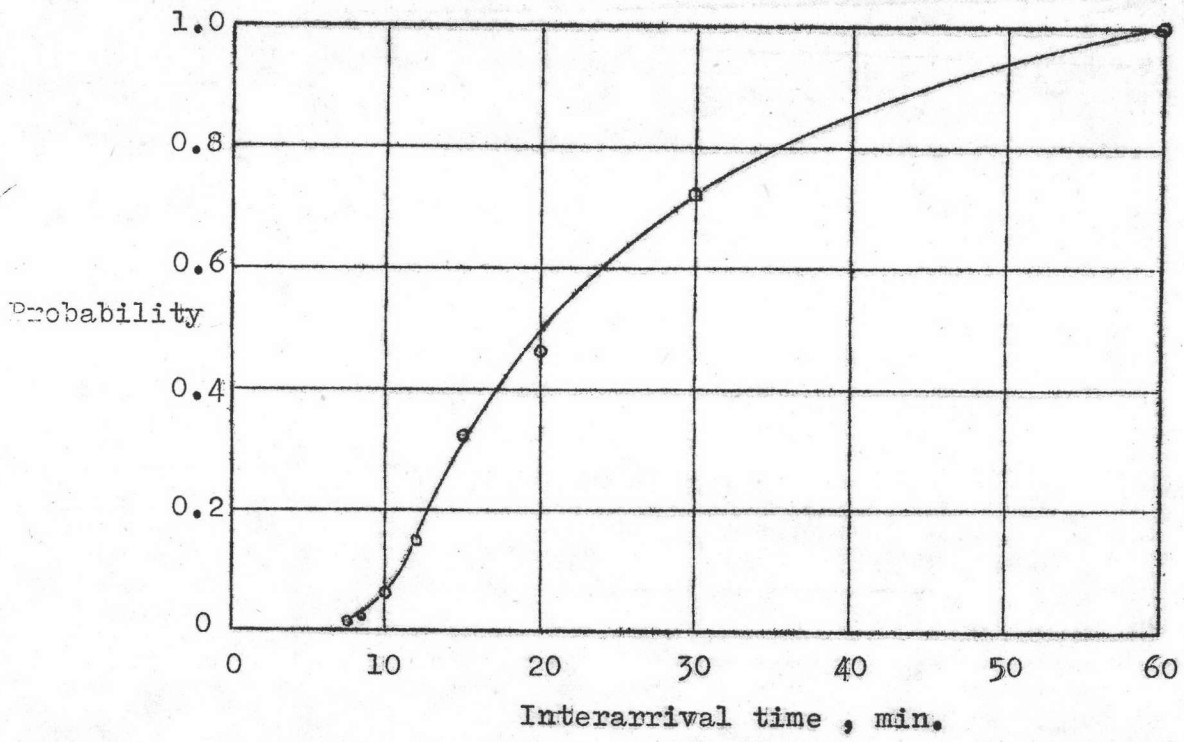


Figure 5.1 Cumulative probability curve of interarrival time

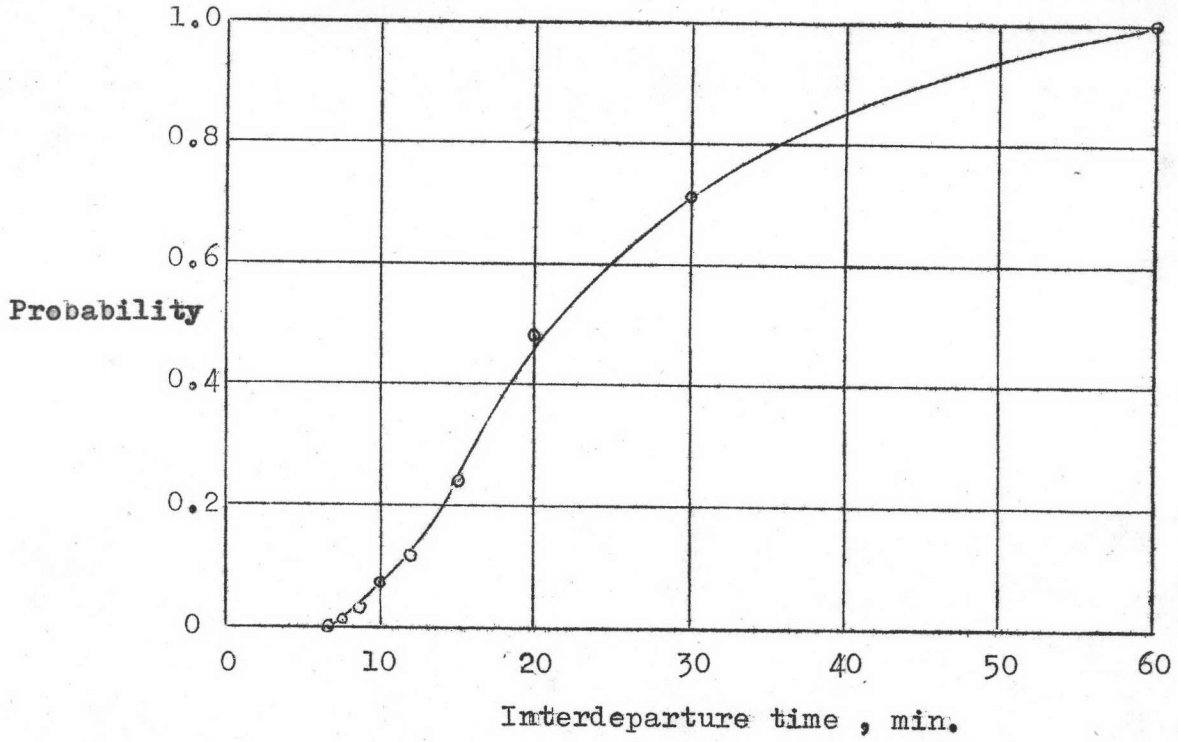


Figure 5.2 Cumulative probability curve of interdeparture time

From cumulative probability curves of both interarrival and interdeparture time , shape seemed to be as Exponential Curve which the equation of this type of curve is written as eq.(1)

$$P_m(t) = 1 - e^{-\lambda t} \quad \ldots\ldots\ldots (1)$$

According to eq.(1) the probability of non-arrival and non-departure aircrafts in any period may be written as

$$\begin{aligned} P_0(t) &= 1 - P_m(t) \\ &= 1 - (1 - e^{-\lambda t}) \\ &= e^{-\lambda t} \quad \ldots\ldots\ldots (2) \end{aligned}$$

Hence , from the theory of Pure Birth Process , probability of n arrived or departed aircrafts may be found by eq.(3)

$$P_n(t) = \frac{(\lambda t)^n e^{-\lambda t}}{n!} \quad \ldots\ldots\ldots (3)$$

which is as Poisson Distribution with λ is equal to rate of arrival or departure aircrafts . From data in Table 5.1 and Table 5.2 number of aircrafts seem to be small during 0300 - 0800 which may be neglected in estimation of aircraft moving . Table 5.5 and Table 5.6 are the illustration of distribution of arrival by comparing between actual and theoritical and also Table 5.7 and Table 5.8 are respectively according to departure . Figure 5.3 and Figure 5.4 are the display of both comparisons which are quite closed between actual and theoritical .

Table 5.5 Estimation of λ-parameter for arrival aircrafts

No. of aircrafts in 1 hr. (t_i)	Frequency (f_i)	Cumulative frequency	$f_i t_i$
0	11	11	0
1	24	35	24
2	34	69	68
3	20	89	60
4	23	112	92
5	12	124	60
6	6	130	36
7	2	132	14
8	1	133	8
Total	133		362

To find estimated value of ;

$$\hat{\lambda} = \frac{\Sigma f_i t_i}{\Sigma f_i}$$

$$= \frac{362}{133}$$

$$= 2.72 \quad \text{aircrafts/hr.}$$

Then , $\hat{\lambda}$ is substituted in eq.(3) as

$$P_n(t) = \frac{e^{-\lambda} \lambda^m}{m!}$$

and the result is as follow ;

$n = 0$, $P_0(t) = e^{-2.72} = 0.0659$

$n = 1$, $P_1(t) = \frac{e^{-2.72} \times (2.72)}{1!} = 0.1792$

$n = 2$, $P_2(t) = \frac{e^{-2.72} \times (2.72)^2}{2!} = 0.2437$

$n = 3$, $P_3(t) = \frac{e^{-2.72} \times (2.72)^3}{3!} = 0.2209$

$n = 4$, $P_4(t) = \frac{e^{-2.72} \times (2.72)^4}{4!} = 0.1502$

$n = 5$, $P_5(t) = \frac{e^{-2.72} \times (2.72)^5}{5!} = 0.0817$

$n = 6$, $P_6(t) = \frac{e^{-2.72} \times (2.72)^6}{6!} = 0.0370$

$n = 7$, $P_7(t) = \frac{e^{-2.72} \times (2.72)^7}{7!} = 0.0144$

$n = 8$, $P_8(t) = \frac{e^{-2.72} \times (2.72)^8}{8!} = 0.0049$

Table 5.6 Comparison of actual and theoritical number of arrival aircrafts

No. of Aircrafts in 1 hr.	Frequency	Probability	Cumulative		$P_n(t)$ by Poisson's (=2.72)	Theoritical Frequency	Cumulative Probability
			Frequency	Probability			
0	11	0.08	11	0.08	0.0659	8.76	0.0659
1	24	0.18	35	0.26	0.1792	23.83	0.2451
2	34	0.26	69	0.52	0.2437	32.41	0.4888
3	20	0.15	89	0.67	0.2209	29.38	0.7097
4	23	0.17	112	0.84	0.1502	19.98	0.8599
5	12	0.09	124	0.93	0.0817	10.87	0.9416
6	6	0.04	130	0.97	0.0370	4.92	0.9786
7	2	0.02	132	0.99	0.0144	1.92	0.9930
8	1	0.01	133	1.00	0.0049	0.65	0.9979

Table 5.7 Estimation of λ-parameter for departure aircrafts

No. of aircrafts in 1 hr. (t_i)	Frequency (f_i)	Cumulative frequency	$f_i t_i$
0	8	8	0
1	30	38	30
2	30	68	60
3	31	99	93
4	16	115	64
5	8	123	40
6	6	129	36
7	2	131	14
8	1	132	8
9	1	133	9
Total	133		354

To find estimated value of λ ;

$$= \frac{\Sigma f_i t_i}{\Sigma f_i}$$

$$= \frac{354}{133}$$

$$= 2.66 \quad \text{aircrafts/hr.}$$

Then , $\hat{\lambda}$ is substituted in

$$P_m(t) = \frac{e^{-\lambda} \lambda^m}{m!}$$

and the result is as follow ;

$m = 0$, $P_0(t) = e^{-2.66} = 0.0699$

$m = 1$, $P_1(t) = \frac{e^{-2.66} \times (2.66)}{1!} = 0.1861$

$m = 2$, $P_2(t) = \frac{e^{-2.66} \times (2.66)^2}{2!} = 0.2475$

$m = 3$, $P_3(t) = \frac{e^{-2.66} \times (2.66)^3}{3!} = 0.2194$

$m = 4$, $P_4(t) = \frac{e^{-2.66} \times (2.66)^4}{4!} = 0.1459$

$m = 5$, $P_5(t) = \frac{e^{-2.66} \times (2.66)^5}{5!} = 0.0776$

$m = 6$, $P_6(t) = \frac{e^{-2.66} \times (2.66)^6}{6!} = 0.0344$

$m = 7$, $P_7(t) = \frac{e^{-2.66} \times (2.66)^7}{7!} = 0.0131$

$m = 8$, $P_8(t) = \frac{e^{-2.66} \times (2.66)^8}{8!} = 0.0043$

$m = 9$, $P_9(t) = \frac{e^{-2.66} \times (2.66)^9}{9!} = 0.0013$

Table 5.8 Comparison of actual and theoritical number of departure aircrafts

No. of Aircrafts in 1 hr.	Frequency	Probability	Cumulative		$P_n(t)$ by Poisson's (=2.66)	Theoritical Frequency	Cumulative Probability
			Frequency	Probability			
0	8	0.06	8	0.06	0.0699	9.30	0.0699
1	30	0.22	38	0.28	0.1861	24.75	0.2560
2	30	0.22	68	0.50	0.2475	32.92	0.5035
3	31	0.23	99	0.73	0.2194	29.18	0.7229
4	16	0.12	115	0.85	0.1459	19.40	0.8688
5	8	0.06	123	0.91	0.0776	10.32	0.9464
6	6	0.05	129	0.96	0.0344	4.58	0.9808
7	2	0.02	131	0.98	0.0131	1.74	0.9939
8	1	0.01	132	0.99	0.0043	0.57	0.9982
9	1	0.01	133	1.00	0.0013	0.17	0.9995

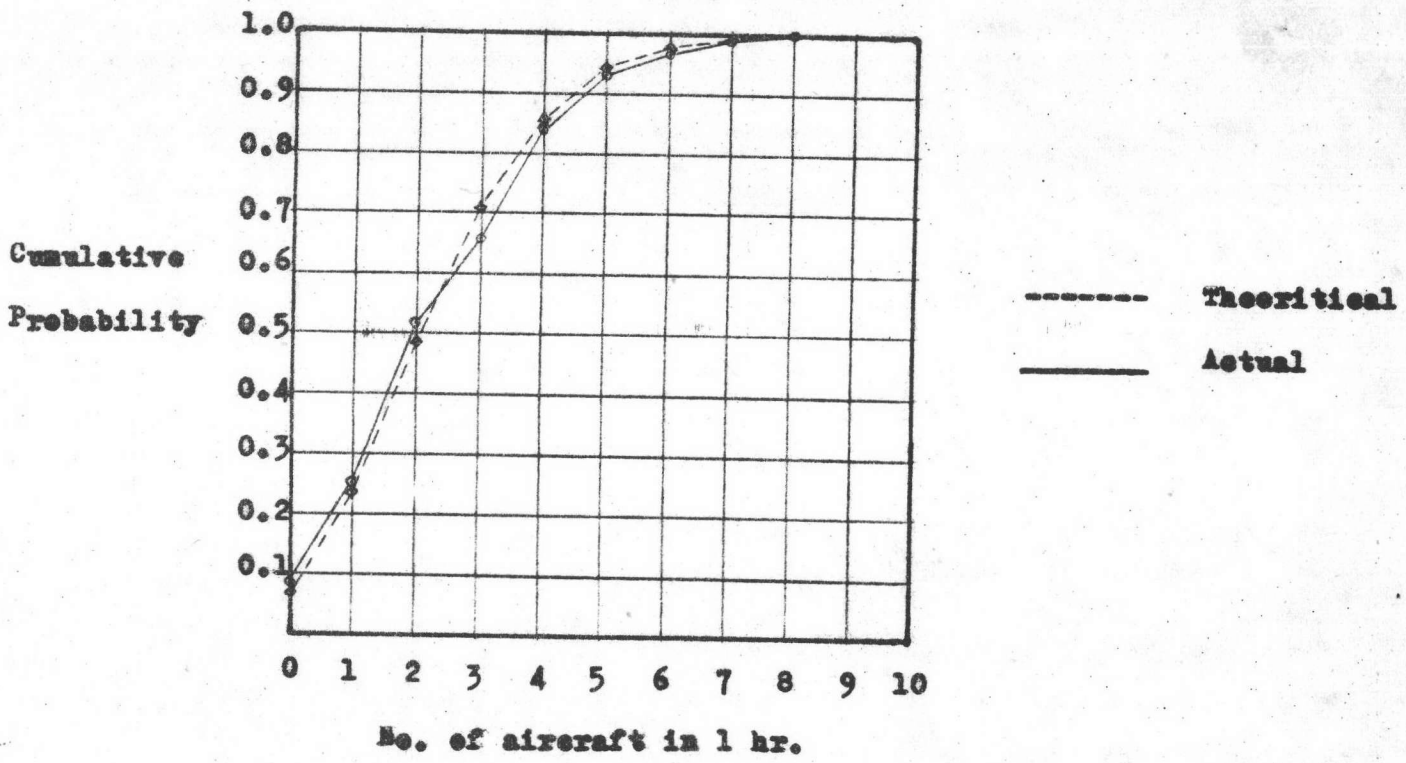


Figure 5.3 Comparison of actual and theoritical number of arrival aircrafts

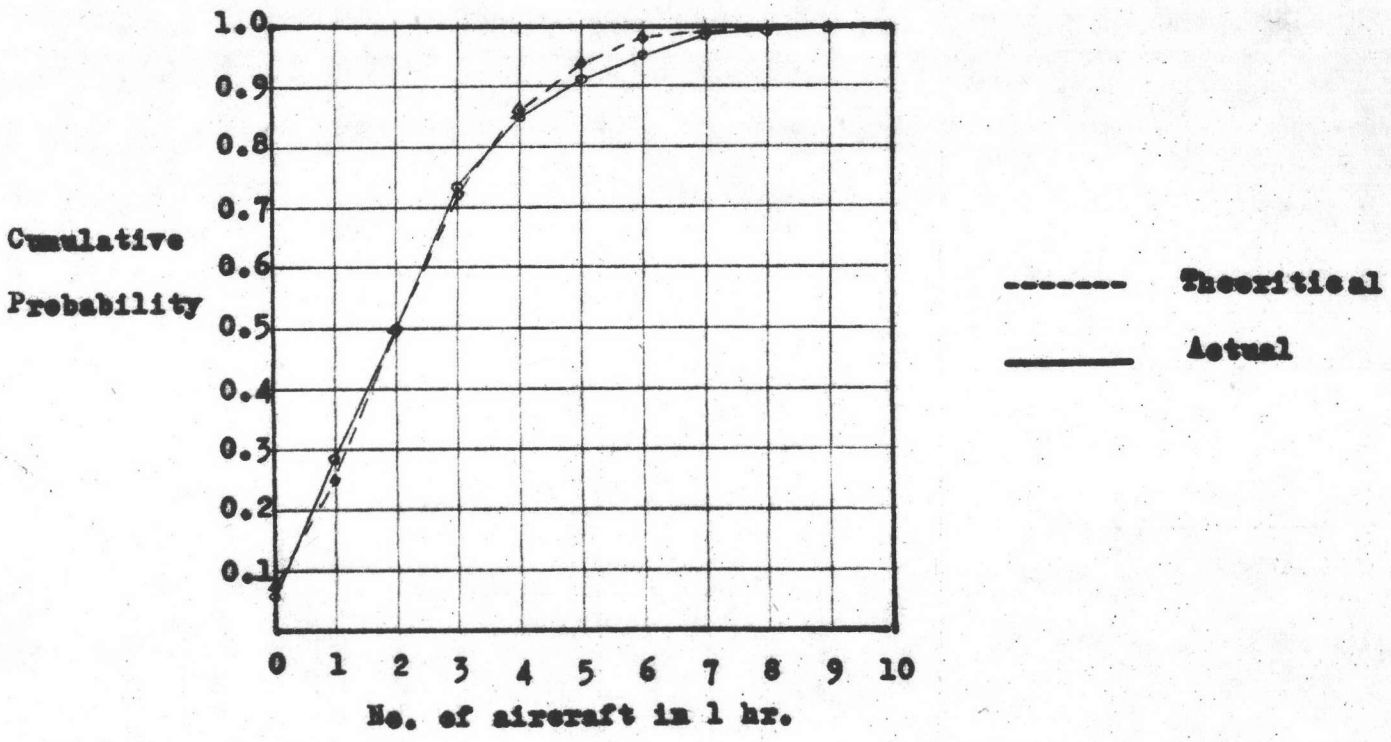


Figure 5.4 Comparison of actual and theoritical number of departure aircrafts

Table 5.9 Evaluation of χ^2-test for arrival

No. of aircrafts in 1 hr.	Theoritical frequency f_t	Actual frequency f_a	$(f_t - f_a)^2$	$\frac{(f_t - f_a)^2}{f_t}$
0	11	8.76	5.02	0.46
1	24	23.83	0.03	0.00
2	34	32.41	2.53	6.40
3	20	29.38	87.98	4.40
4	23	19.98	9.12	0.40
5	12	10.87	1.28	0.11
6	6	4.92	1.17	0.20
7	2	1.92	0.01	0.00
8	1	0.65	0.12	0.12
			Total	12.09

Table 5.10 Evaluation of χ^2-test for departure

No. of aircrafts in 1 hr.	Theoritical frequency f_t	Actual frequency f_a	$(f_t - f_a)^2$	$\frac{(f_t - f_a)^2}{f_t}$
0	8	9.30	1.69	0.21
1	30	24.75	27.56	0.92
2	30	32.92	8.53	0.28
3	31	29.18	3.31	0.11
4	16	19.40	11.56	0.72
5	8	10.32	5.38	0.67
6	6	4.58	2.02	0.34
7	2	1.74	0.07	0.04
8	1	0.57	0.18	0.18
9	1	0.17	0.69	0.69
			Total	4.16

From the assumption that flow of both arrival and departure are according to Poisson Distribution , testing the significance of fitting the model are provided next .

Testing significance of the model

There are many methods of such testing which one is selected here is chi-square . The value of chi-square , χ^2 is as follow ;

$$\chi^2 = \frac{(f_t - f_a)^2}{f_t}$$

where f_t = theoritical value

f_a = actual value

Values of χ^2 for arrival and departure of aircrafts at Bangkok International Airport are evaluated as shown in Table 5.9 and Table 5.10 .

For arrival with degree of freedom = n - 1

= 8

$$\chi^2_{(0.05)} = 15.507 > \chi^2_{test} = 12.09$$

and for departure with degree of freedom = 9

$$\chi^2_{(0.05)} = 16.919 > \chi^2_{test} = 4.16$$

So , from the result of significance test , both arrival and departure of aircrafts at Bangkok International Airport are as Poisson Distribution as that assumed .

Evaluation of Air Freight Quantity to be Handled Per Each Flight

It is known that aircrafts play important role in international flights today are more modern and more capable for loading . Such huge aircrafts as B-747 has the capability of more than thirty tons for lower deck loading . Another types of aircrafts widely used by airlines today are mostly able to fly with loading of more than thirty tons of air freight . But such large quantity of air freight to be handled at this international airport has not much frequency of occurring . Only all-freight flights outward of fresh fruits and vegetables that provided such large quantity of air freight here . For loading and unloading of air freight it seems to be some imbalance betweem both directions of handling . Volume of loading air freight is quite larger than that of unloading and volume per each flight seem to be the same case . From the record in observation period during Monday 10th- Sunday 16th October , 1977 , the result from evaluation of such data do not be held as those of most air freight since the variations of freight quantity occur many times a year . Though , the result from this study may be used as a guidance concerning handling of air freight and the other work in this field . The evaluation includes both international and domestic flights which the distributions of volume of air freight handled per each flight are determined . Collected data of volume of air freight per each flight are as shown in Appendix D-1 , D-2 , D-3 and D-4 .

For international flights , volume of 0-500 kg. per flight are about 30% for loading and 50% for unloading respectively . This size of volume seems to be very little compared with the capability for loading of air freight of commercial aircrafts today . From the result of determination the distribution of volume in Table 5.11 and Table 5.12 , mean volume of loading and unloading are 2,130 and 1,516 kg. respectively . Both volumes are nearly equal to 70^{th} percentile volume of the cumulative weight as indicated in Figure 5.6 and Figure 5.8 . The histograms of volume distribution of both loading and unloading are also shown in Figure 5.5 and Figure 5.7 which such display shown nearly the same figure of distribution . For domestic flights as aircrafts used are only single type with stable loading capability , size of loading and unloading of air freight per flight are not much different . Grouping of volume size are as shown in Table 5.13 and Table 5.14 which they indicate that the imbalance of inward and outward flow of air freight is about 1:4 for inward and outward respectively . From the evaluation , mean value of air freight loaded per flight is 363 kg. and 96 kg. for unloading . Such imbalance seems to be a big disadvantage in economical reason . The returning flights with only passengers and a few volume of air freight or sometime empty space for area of loading are increasing . Therefore , improvements have to be done urgently . Lower rate of transportation or more advertising may make it better than now .

Table 5.11 Grouping of volume of air freight , kg. loaded on each international flight during Monday 10th - Sunday 16th October , 1977

Volume Groups , kg.			Frequency	Cumulative		$f_i X_i$
Lower Limit	Mid Point X_i	Upper Limit	f_i	Frequency	Percent	
1	250	500	97	97	32.1	24,250
501	750	1,000	52	149	49.3	39,000
1,001	1,250	1,500	26	175	57.9	32,500
1,501	1,750	2,000	25	200	66.2	43,750
2,001	2,250	2,500	16	216	71.5	36,000
2,501	2,750	3,000	11	227	75.2	30,250
3,001	3,250	3,500	3	230	76.2	9,750
3,501	3,750	4,000	7	237	78.5	26,250
4,001	4,250	4,500	5	242	80.1	21,250
4,501	4,750	5,000	8	250	82.8	38,000
5,001	5,250	5,500	9	259	85.8	47,250
5,501	5,750	6,000	5	264	87.4	28,750
6,001	6,250	6,500	8	272	90.1	50,000
6,501	6,750	7,000	2	274	90.7	13,500
7,001	7,250	7,500	0	274	90.7	0
7,501	7,750	8,000	4	278	92.0	31,000
8,001	8,250	8,500	1	279	92.4	8,250
8,501	8,750	9,000	4	283	93.7	35,000
9,001	9,250	9,500	0	283	93.7	0
9,501	9,750	10,000	3	286	94.7	29,250
10,001	10,250	10,500	0	286	94.7	0
10,501	10,750	11,000	0	286	94.7	0
11,001	11,250	11,500	1	287	95.0	11,250
11,501	11,750	12,000	0	287	95.0	0
12,001	12,250	12,500	1	288	95.4	12,250
12,501	12,750	13,000	2	290	99.3	25,500
13,001	13,250	13,500	0	290	99.3	0
13,501	13,750	14,000	0	290	99.3	0
14,001	14,250	14,500	1	291	99.7	14,250
14,501	14,750	15,000	1	292	100.0	14,750
		Σ	292			622,000

Mean Volume , $\bar{X} = \frac{\Sigma f_i X_i}{n}$

$= \frac{622,000}{292} = 2,130$ kg.

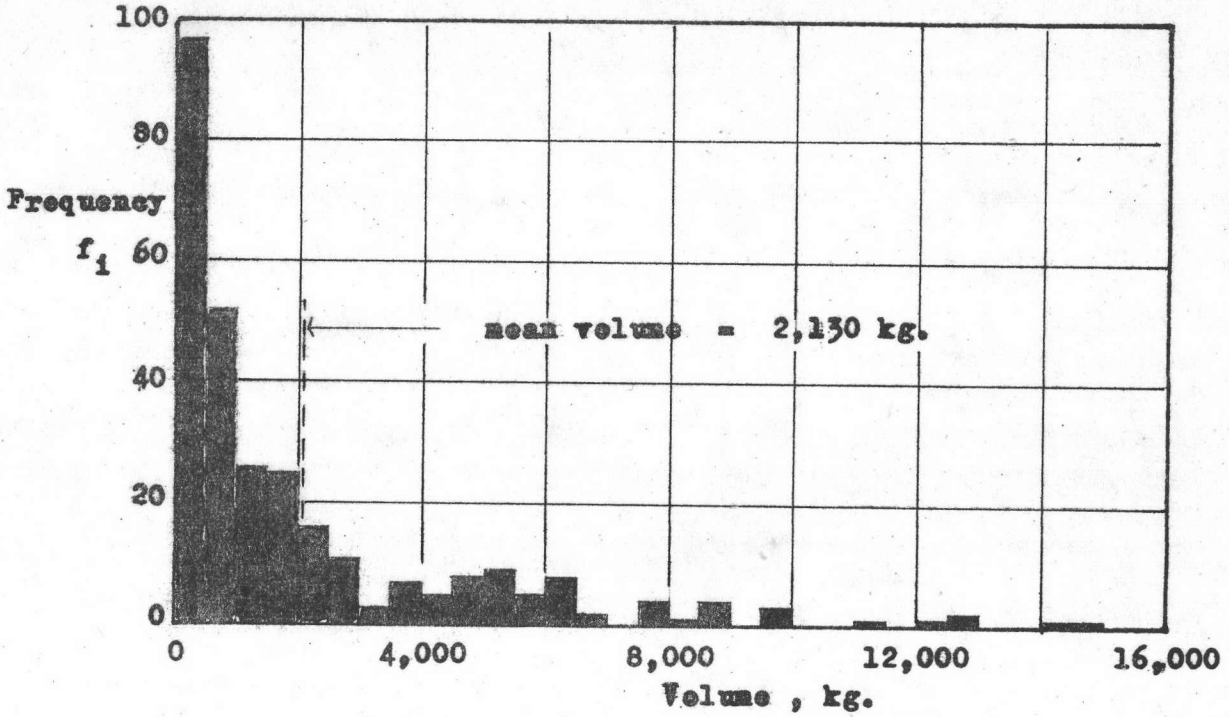


Figure 5.5 Histogram of volume distribution of loaded air freight for each international flight

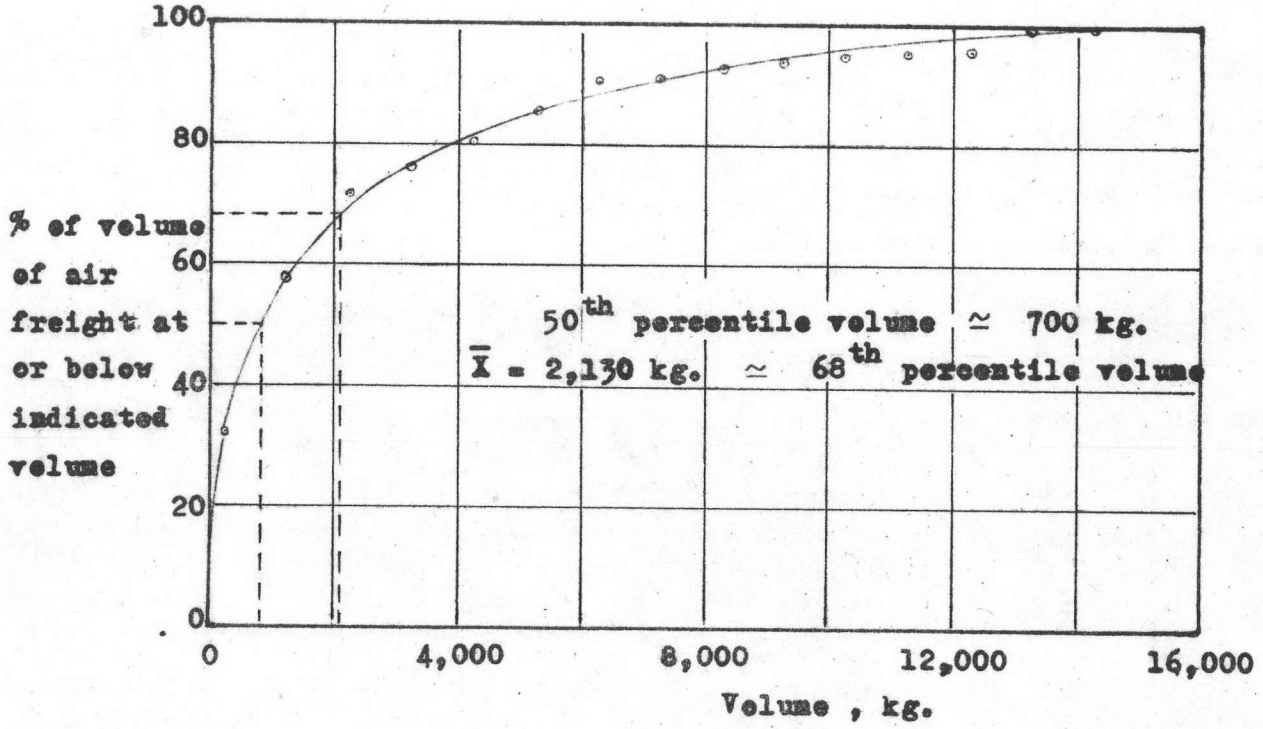


Figure 5.6 Cumulative volume distribution of loaded air freight for each international flight

Table 5.12 Grouping of volume of air freight , kg. unloaded from each international flight during Monday 10th - Sunday 16th October , 1977

Volume Groups , kg.			Frequency	Cumulative		$f_i X_i$
Lower Limit	Mid Point X_i	Upper Limit	f_i	Frequency	Percent	
1	250	500	129	129	48.7	32,250
501	750	1,000	28	157	59.2	21,000
1,001	1,250	1,500	17	174	65.7	21,250
1,501	1,750	2,000	15	189	71.3	26,250
2,001	2,250	2,500	11	200	75.5	24,750
2,501	2,750	3,000	18	218	82.3	49,500
3,001	3,250	3,500	9	227	85.7	29,250
3,501	3,750	4,000	8	235	88.7	30,000
4,001	4,250	4,500	6	241	90.9	25,500
4,501	4,750	5,000	5	246	92.8	23,750
5,001	5,250	5,500	8	254	95.8	41,600
5,501	5,750	6,000	3	257	97.0	17,250
6,001	6,250	6,500	2	259	97.7	12,500
6,501	6,750	7,000	1	260	98.1	6,750
7,001	7,250	7,500	1	261	98.5	7,250
7,501	7,750	8,000	2	263	99.2	15,500
8,001	8,250	8,500	0	263	99.2	0
8,501	8,750	9,000	2	265	100.0	17,500
		Σ	265			401,850

$$\text{Mean Volume , } \bar{X} = \frac{\Sigma f_i X_i}{n}$$

$$= \frac{401,850}{265} = 1,516 \text{ kg.}$$

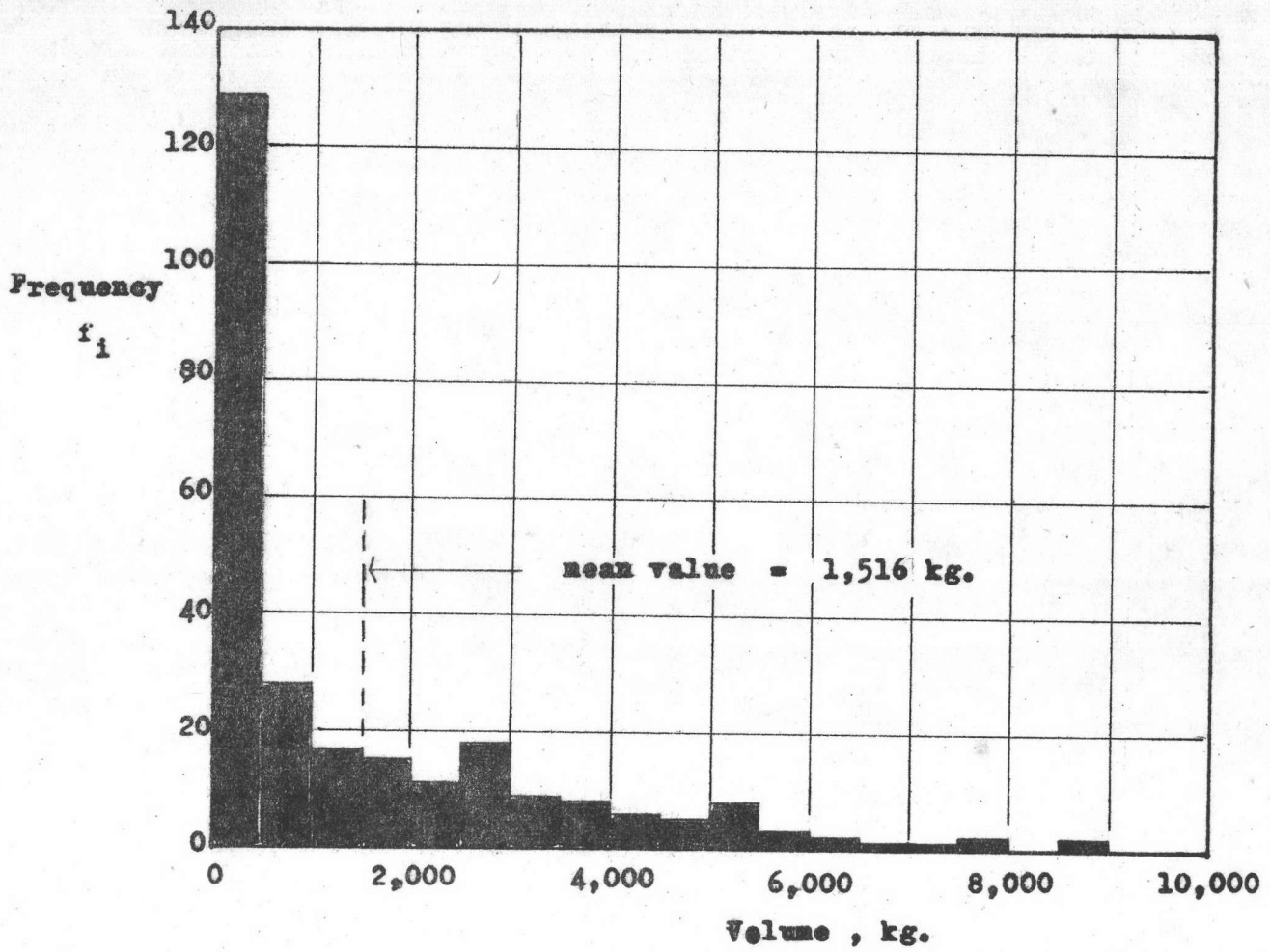


Figure 5.7 Histogram of volume distribution of unloaded air freight for each international flight

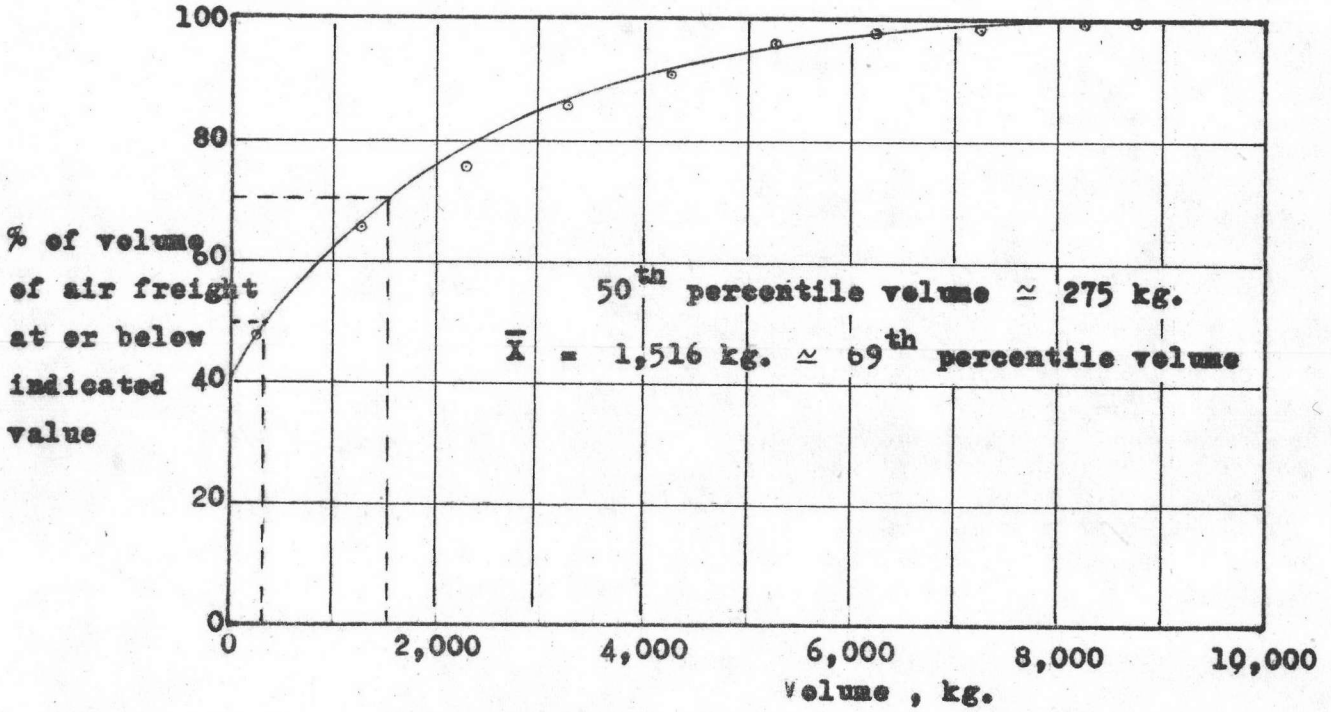


Figure 5.8 Cumulative volume distribution of unloaded air freight for each international flight

Table 5.13 Grouping of volume of air freight loaded on each domestic flight during Monday 10th - Sunday 16th October , 1977

Volume Groups , kg.			Frequency	Cumulative		$f_i X_i$
Lower Limit	Mid Point X_i	Upper Limit	f_i	Frequency	Percent	
1	25	50	6	6	10.9	150
51	75	100	4	10	18.2	300
101	125	150	5	15	27.3	625
151	175	200	2	17	30.9	350
201	225	250	0	17	30.9	0
251	275	300	6	23	41.8	1,650
301	325	350	5	28	50.9	1,625
351	375	400	3	31	56.4	1,125
401	425	450	3	34	61.8	1,275
451	475	500	4	38	69.1	1,900
501	525	550	6	44	80.0	3,150
551	575	600	3	47	85.4	1,725
601	625	650	2	49	89.1	1,250
651	675	700	1	50	90.9	675
701	725	750	1	51	92.7	725
751	775	800	1	52	94.5	775
801	825	850	1	53	96.4	825
851	875	900	1	54	98.2	875
901	925	950	0	54	98.2	0
951	975	1,000	1	55	100.0	975
		Σ	55			19,975

$$\text{Mean Volume , } \bar{X} = \frac{\Sigma f_i X_i}{n}$$

$$= \frac{19,975}{55} = 363 \text{ kg.}$$

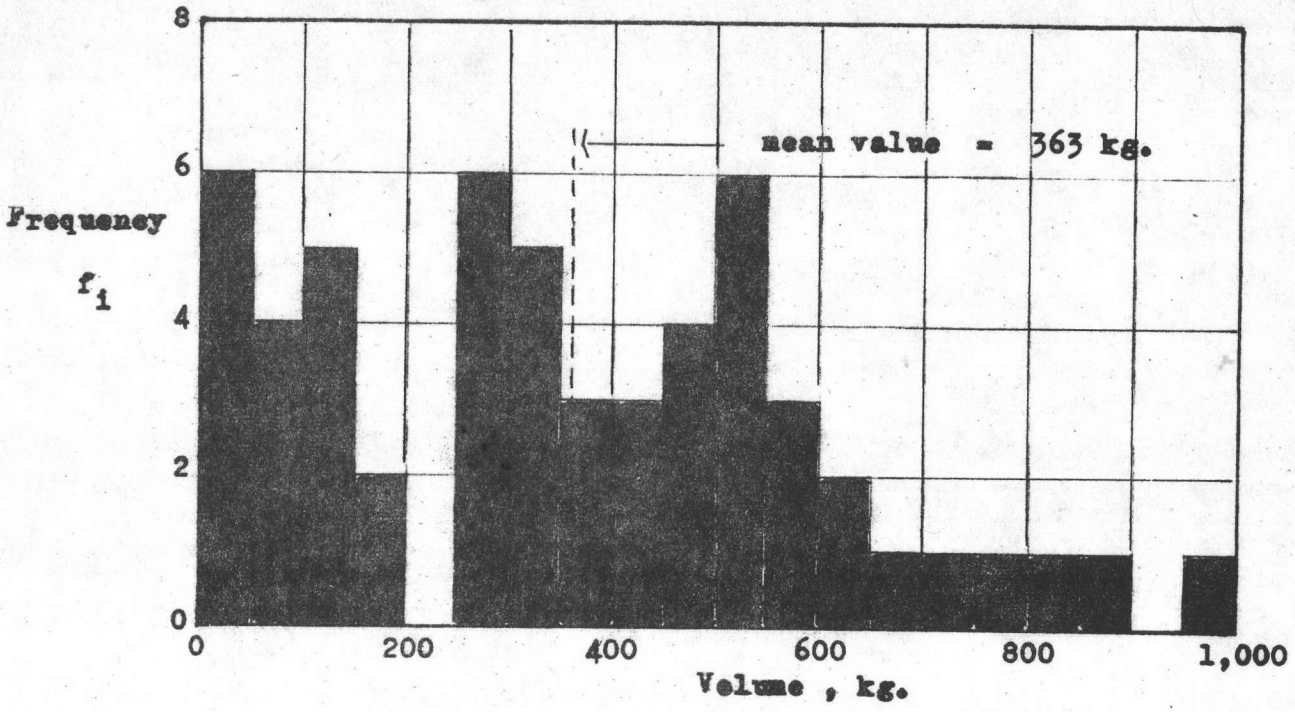


Figure 5.9 Histogram of volume distribution of loaded air freight for each domestic flight

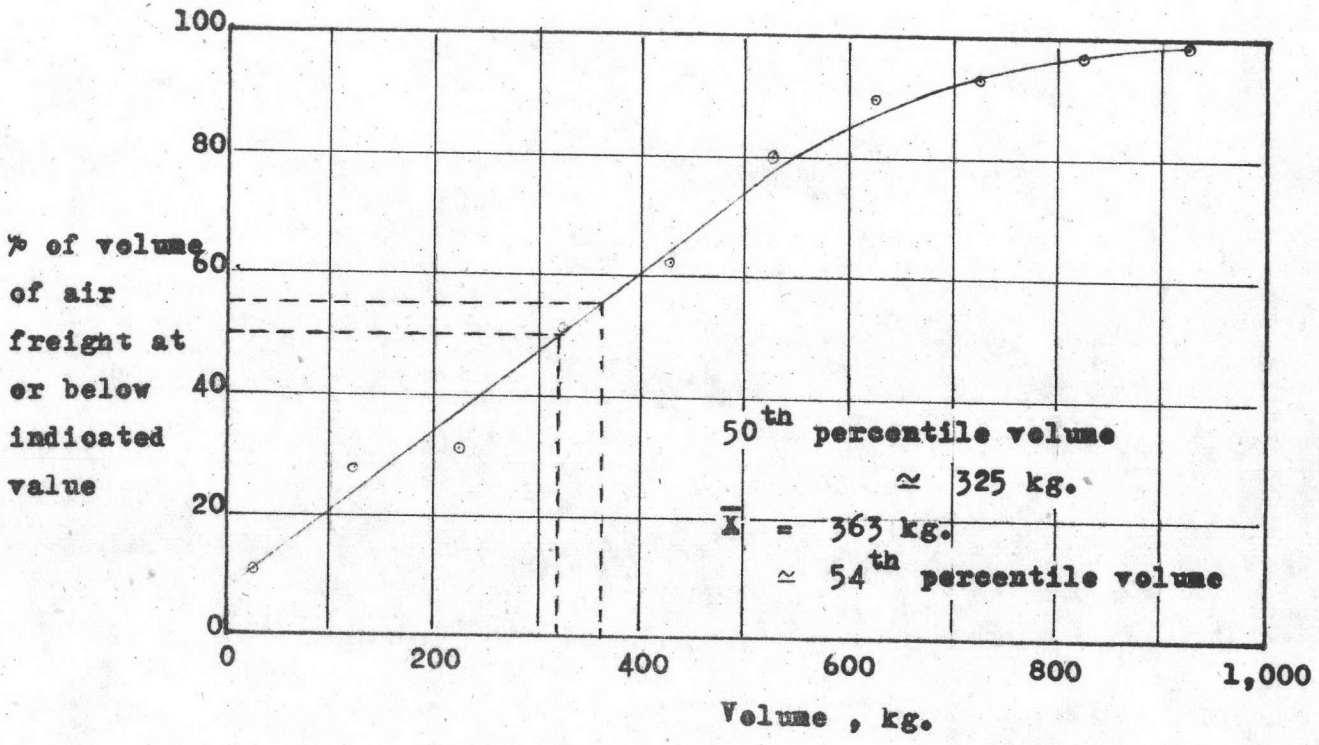


Figure 5.10 Cumulative volume distribution of loaded air freight for each domestic flight

Table 5.14 Grouping of volume of air freight , kg. unloaded from each domestic flight during Monday 10th - Sunday 16th October , 1977

Volume Groups , kg.			Frequency	Cumulative		$f_i X_i$
Lower Limit	Mid Point X_i	Upper Limit	f_i	Frequency	Percent	
1	10	20	4	4	8.9	40
21	30	40	12	16	35.6	360
41	50	60	4	20	44.4	200
61	70	80	2	22	48.9	140
81	90	100	4	26	57.8	360
101	110	120	2	28	62.2	220
121	130	140	4	32	71.1	520
141	150	160	2	34	75.6	300
161	170	180	3	37	82.2	510
181	190	200	6	43	95.6	1,140
201	210	220	0	43	95.6	0
221	230	240	1	44	97.8	230
241	250	260	0	44	97.8	0
261	270	280	0	44	97.8	0
281	290	300	0	44	97.8	0
301	310	320	1	45	100.0	310
		Σ	45			4,330

$$\text{Mean Volume , } \bar{X} = \frac{\Sigma f_i X_i}{n}$$

$$= \frac{4,330}{45} = 96 \text{ kg.}$$

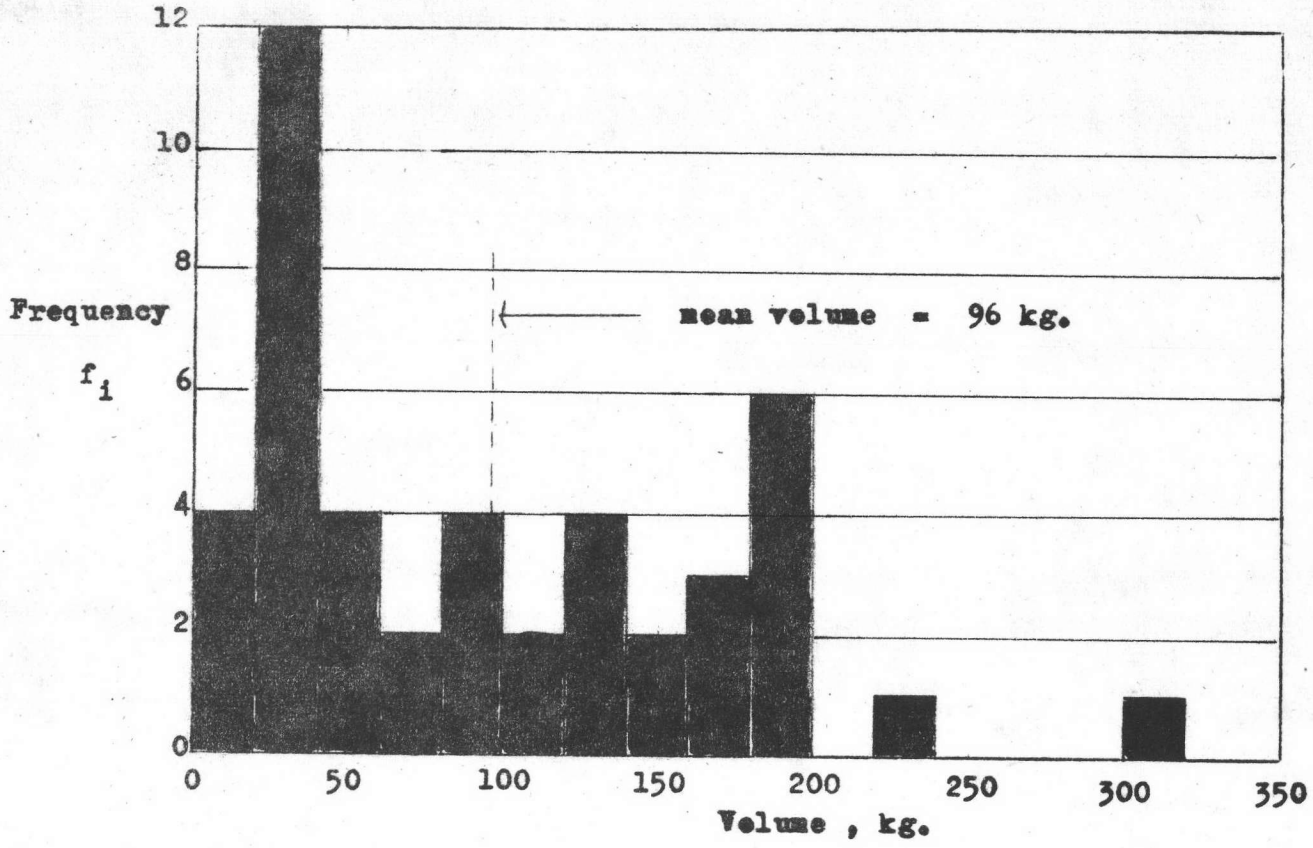


Figure 5.11 Histogram of volume distribution of unloaded air freight for each domestic flight

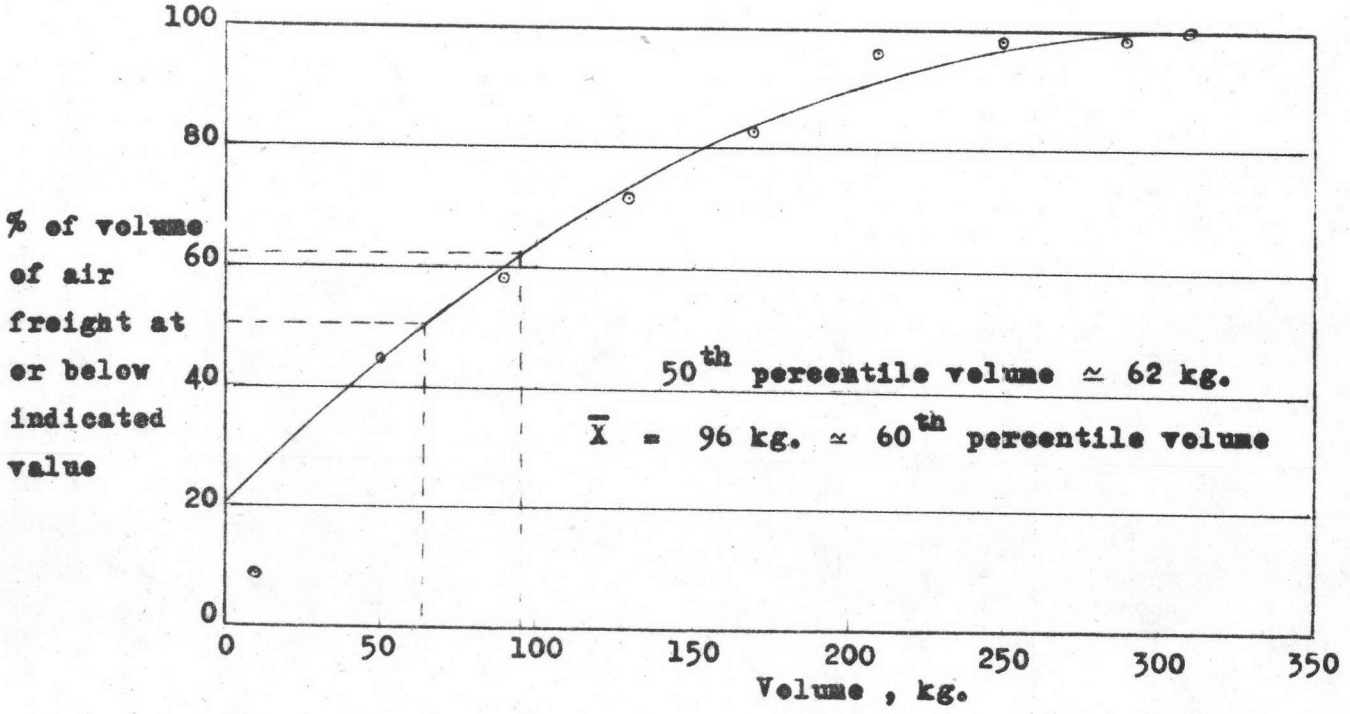


Figure 5.12 Cumulative volume distribution of unloaded air freight for each domestic flight

Fluctuation of Air Freight Flow

For air freight according to international flights , both loaded and unloaded , frequency of flights seem to be very few during the period of 0300-0800 and this means less important volume of air freight during this period . So , recorded data during 0300-0800 is neglected in the determination of hourly flow of air freight for international flights . For domestic flights as only a single airline , Thai Airways Co.Ltd., provides the service , the evaluation of hourly flow is not important since the fluctuation of flow seem to be not much as that of international flight . Table 5.15 and Table 5.16 are recorded data of hourly flow of air freight according to international flights at Bangkok International Airport during Monday 10th- Sunday 16th October , 1977 . Data in both tables are grouped by neglecting the said period and mean values of hourly flow of loading and unloading are about 4,200 and 2,860 kg./hr. as indicated in Table 5.17 and Table 5.18 respectively . Cumulative probability hourly flow of loaded and unloaded air freight from grouping and evaluation in both tables are drawn in Figure 5.13 . From cumulative curves , probability of occuring such mean values of hourly flow are equally about 0.7 .

Fluctuation of hourly flow of air freight to be handled on each day of a week is quite an interesting matter . As it is known that most volume of air freight here depends on scheduled flights , big volume of air freight according to important flights may repeatedly occur at the same time in a week . From a single week observation of such data , the

fluctuation of hourly air freight flow from and to this international airport vary each day . Diagrams showing the fluctuation of hourly flow of air freight during Monday 10th - Sunday 16th October , 1977 are drawn in Figure 5.14 - 5.20 respectively , however , this representative may not be accurate as that of arrival and departure of aircrafts . It is known that density of air freight traffic depend om the seasonal production and need of consumer which are both not vary in a week .

From the diagram we may see that dense loading and unloading often occur at different period . For loading most busy period occur during 0800-1200 and 2000-2400 and for unloading such period occur during 1600-2000 . Table 5.19 is the summary of peak-hour traffic , daily volume and mean-hour traffic of the recording period . From this set of data the average peak-hour may be established by taking the average of seven peak-hour volumes recorded during this period . The average peak-hour for loaded cargo is estimated as 19 tonnes or about 23% of average daily loading , and for unloaded cargo as 14 tonnes or equally about 23% . The combined average peak-hour for loaded and unloaded cargo is about 22% of the average day .

For fluctuation of air freight flow by day of week , the display is as shown in Figure 5.21 . Volume of loaded cargo gradually declines from peak-day on Tuesday untill Sunday which has the lowest volume of loading , for unloading cargo Saturday and Sunday seemed to be the heaviest days . The busiest day for combined loading and unloading was Tuesday .

Table 5.15 Loaded volume of international air freight , kg. at Bangkok International Airport , October 1977

Date / Time	Mon 10	Tue 11	Wed 12	Thu 13	Fri 14	Sat 15	Sun 16	Mean	Total
0600-0700	-	1,601	-	-	-	-	-	n.a.	1,601
0700-0800	-	-	-	-	-	-	-	0	0
0800-0900	621	14,695	11,811	-	-	5,460	1,988	4,939	34,575
0900-1000	4,761	6,532	11,362	7,186	7,021	10,559	7,050	7,782	54,471
1000-1100	1,507	15,585	9,043	7,113	16,835	20,755	18,840	12,811	89,678
1100-1200	2,787	9,508	8,980	1,649	1,863	11,937	9,547	6,610	46,271
1200-1300	6,835	4,626	15,511	20,065	6,029	1,709	5,900	8,668	60,675
1300-1400	1,447	3,629	931	1,556	2,330	1,338	-	1,604	11,231
1400-1500	193	538	4,325	-	-	-	-	722	5,056
1500-1600	9	11,611	-	543	1,564	823	900	2,207	15,450
1600-1700	13,227	1,595	4,417	2,450	220	184	8,978	4,439	31,071
1700-1800	1,646	2,226	3,165	4,870	1,162	78	209	1,908	13,356
1800-1900	1,704	841	572	874	692	565	8,405	1,950	13,653
1900-2000	500	13,144	3,711	5,483	40	3,885	1,322	4,012	28,085
2000-2100	-	3,261	1,214	100	10,098	-	-	2,096	14,673
2100-2200	18,637	861	3,562	7,654	4,602	15,207	-	7,218	50,523
2200-2300	26,154	4,273	24	10,059	16,152	3,576	2,783	9,003	63,021
2300-2400	11,352	1,813	13,422	3,799	1,563	2,763	1,293	5,144	36,095
2400-0100	1,768	3,085	951	1,184	7,628	-	356	2,139	14,972
0100-0200	-	1,298	-	-	-	-	58	n.a.	1,356
0200-0300	1,657	16,358	7,269	364	1,125	125	-	3,843	26,898
0300-0400	-	4,704	-	15,437	850	4,497	2,084	3,939	27,572
0400-0500	-	-	-	5,462	-	-	-	n.a.	5,462
0500-0600	70	-	526	-	-	-	2,630	461	3,226
Mean	3,953	5,074	4,200	3,994	3,324	3,478	3,014		
Total	94,875	121,784	100,796	95,848	79,774	83,461	72,343		658,881

Table 5.16 Unloaded volume of international air freight , kg. at Bangkok International Airport , October 1977

Date / Time	Mon 10	Tue 11	Wed 12	Thu 13	Fri 14	Sat 15	Sun 16	Mean	Total
0600-0700	-	11,234	256	-	947	6,904	1,352	2,956	20,693
0700-0800	-	-	-	-	-	5,750	-	n.a.	5,750
0800-0900	-	-	-	-	2,553	3,772	130	922	6,455
0900-1000	3,833	6,024	3,539	2,307	14,070	6,445	922	5,306	37,140
1000-1100	8,846	3,549	1,181	9,559	2,550	-	11,205	5,270	36,890
1100-1200	572	520	4,134	4,363	-	4,756	-	2,049	14,345
1200-1300	234	3,763	5,801	11	9	1,048	6	1,553	10,872
1300-1400	825	395	5,707	2	331	487	1	1,107	7,748
1400-1500	18	3,955	46	600	1,083	564	2,163	1,204	8,429
1500-1600	291	306	518	415	3,802	631	10,824	2,370	16,587
1600-1700	3,548	3,828	6,274	1,116	322	5,388	1,822	3,185	22,298
1700-1800	9,133	2,875	7,384	7,731	2,800	10,511	6,086	6,646	46,520
1800-1900	5,159	13,406	6,719	11,456	5,239	11,149	27,179	11,472	80,307
1900-2000	2,679	1,043	1,115	1,986	4,960	3,703	10,118	3,658	25,604
2000-2100	6,041	-	2,781	2,296	305	53	-	1,639	11,476
2100-2200	2,300	9,209	3,266	8,729	3,455	1,407	1,250	4,231	29,616
2200-2300	563	617	10,293	-	3,115	8,674	327	3,370	23,589
2300-2400	-	-	-	-	247	2,836	1	n.a.	3,084
2400-0100	-	32	1,540	-	31	-	-	229	1,603
0100-0200	3,149	290	941	1,057	-	1,125	3,767	1,476	10,329
0200-0300	-	248	-	1,310	-	-	346	272	1,904
0300-0400	302	-	-	-	-	-	-	n.a.	302
0400-0500	1,348	96	-	-	-	-	-	n.a.	1,444
0500-0600	-	-	-	-	-	-	-	0	0
Mean	2,035	2,558	2,554	2,206	1,909	3,133	3,229		
Total	48,841	61,390	61,295	52,938	45,819	75,203	77,499		422,985

Table 5.17 Grouping of hourly flow of loaded air freight according to international flights

Volume Groups , kg.			Frequency	Cumulative		$f_i X_i$
Lower Limit	Mid Point X_i	Upper Limit	f_i	Frequency	Probability	
	0		19	19	0.15	0
1	500	1,000	27	46	0.35	13,500
1,001	1,500	2,000	23	69	0.53	34,500
2,001	2,500	3,000	6	75	0.58	15,000
3,001	3,500	4,000	9	84	0.65	31,500
4,001	4,500	5,000	7	91	0.70	31,500
5,001	5,500	6,000	3	94	0.72	16,500
6,001	6,500	7,000	3	97	0.75	19,500
7,001	7,500	8,000	7	104	0.80	52,500
8,001	8,500	9,000	3	107	0.82	25,500
9,001	9,500	10,000	3	110	0.85	28,500
10,001	10,500	11,000	3	113	0.87	31,500
11,001	11,500	12,000	5	118	0.91	57,500
12,001	12,500	13,000	0	118	0.91	0
13,001	13,500	14,000	3	121	0.93	40,500
14,001	14,500	15,000	1	122	0.94	14,500
15,001	15,500	16,000	3	125	0.96	46,500
16,001	16,500	17,000	3	128	0.98	49,500
17,001	17,500	18,000	0	128	0.98	0
18,001	18,500	19,000	2	130	1.00	37,000
		Σ	130			545,500

$$\bar{X} = \frac{\Sigma f_i X_i}{\Sigma f_i}$$

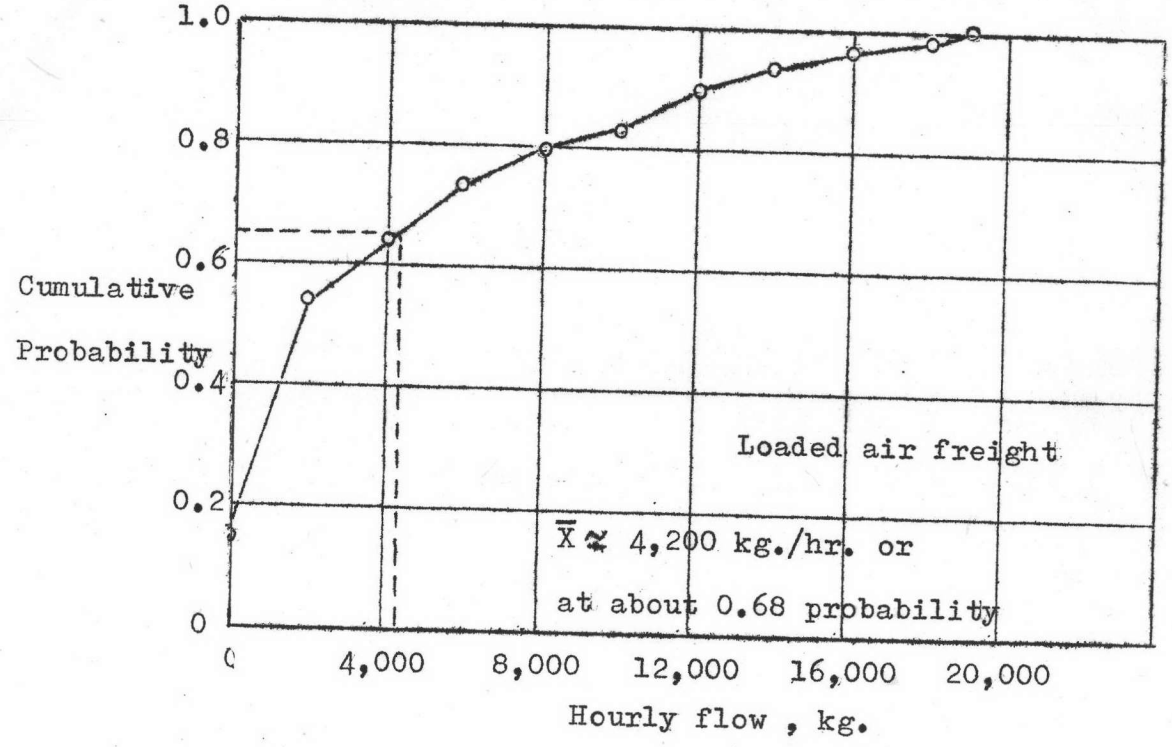
$$= \frac{545,500}{130} = 4,200 \text{ kg./hr.}$$

Table 5.18 Grouping of hourly flow of unloaded air freight according to international flights

Volume Groups , kg.			Frequency	Cumulative		$f_i X_i$
Lower Limit	Mid Point X_i	Upper Limit	f_i	Frequency	Prob. ty	
	0		23	23	0.17	.0
.1	.500	1,000	37	60	0.45	18,500
1,001	1,500	2,000	14	74	0.56	21,000
2,001	2,500	3,000	11	85	0.64	27,500
3,001	3,500	4,000	15	100	0.76	52,500
4,001	4,500	5,000	4	104	0.79	18,000
5,001	5,500	6,000	5	109	0.83	27,500
6,001	6,500	7,000	6	115	0.87	39,000
7,001	7,500	8,000	2	117	0.89	15,000
8,001	8,500	9,000	3	120	0.91	25,500
9,001	9,500	10,000	3	123	0.93	28,500
10,001	10,500	11,000	4	127	0.96	42,000
11,001	11,500	12,000	3	130	0.98	34,500
12,001	12,500	13,000	0	130	0.98	.0
13,001	13,500	14,000	1	131	0.99	13,500
14,001	14,500	15,000	1	132	1.00	14,500
		Σ	132			377,500

$$\bar{X} = \frac{\Sigma f_i X_i}{\Sigma f_i}$$

$$= \frac{377,500}{132} = 2,860 \text{ kg./hr.}$$



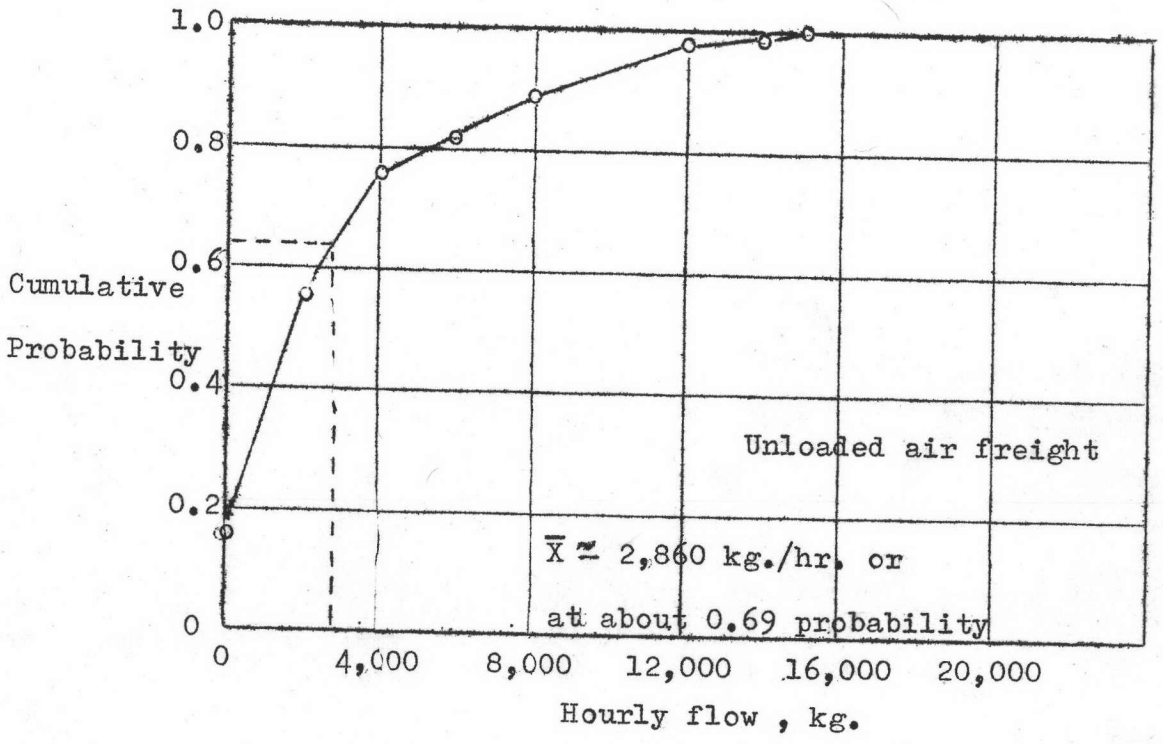


Figure 5.13 Cumulative probability of hourly flow of international air freight

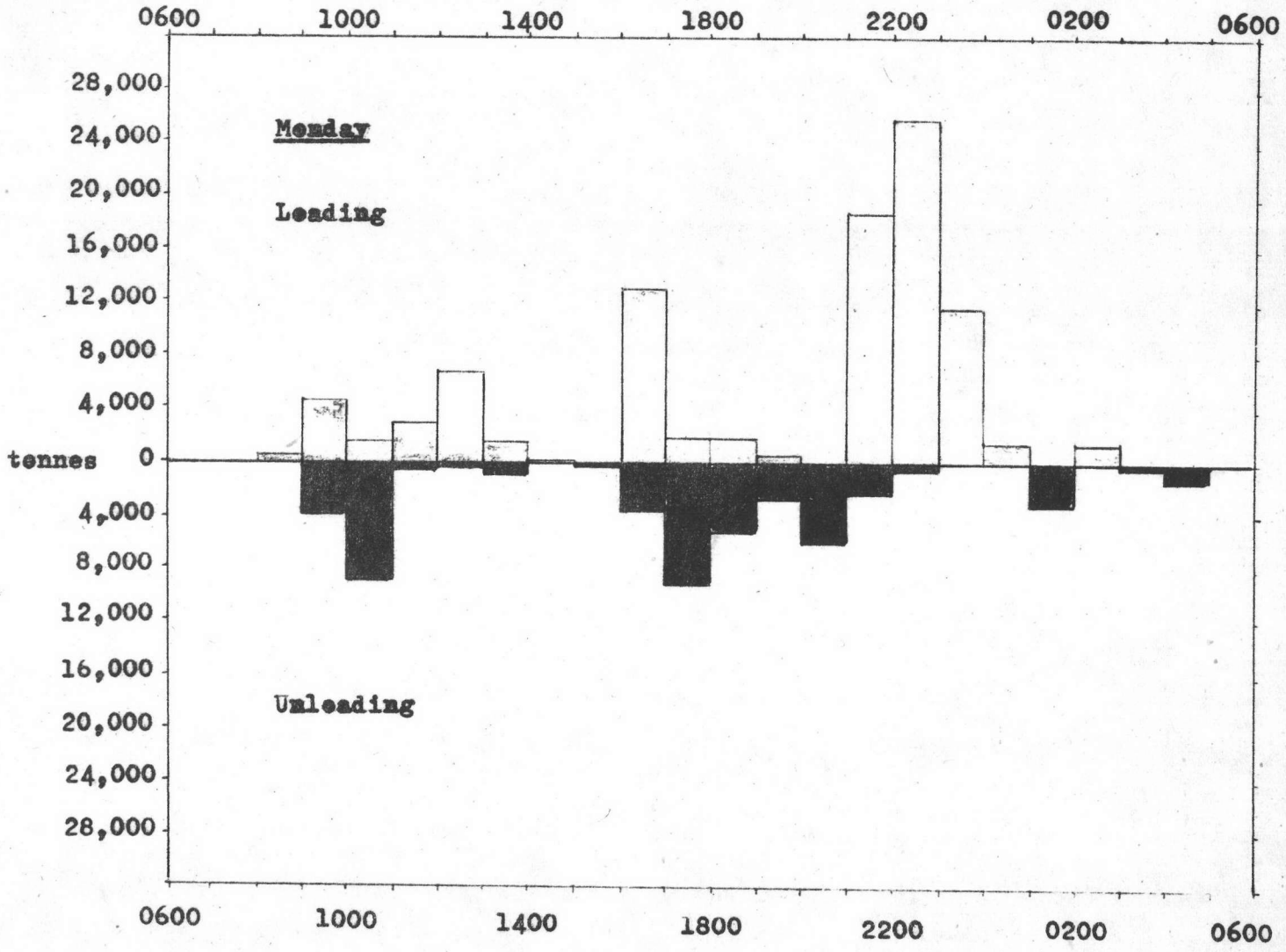


Figure 5.14 Hourly flow of loading and unloading of air freight on October 10th, 1977

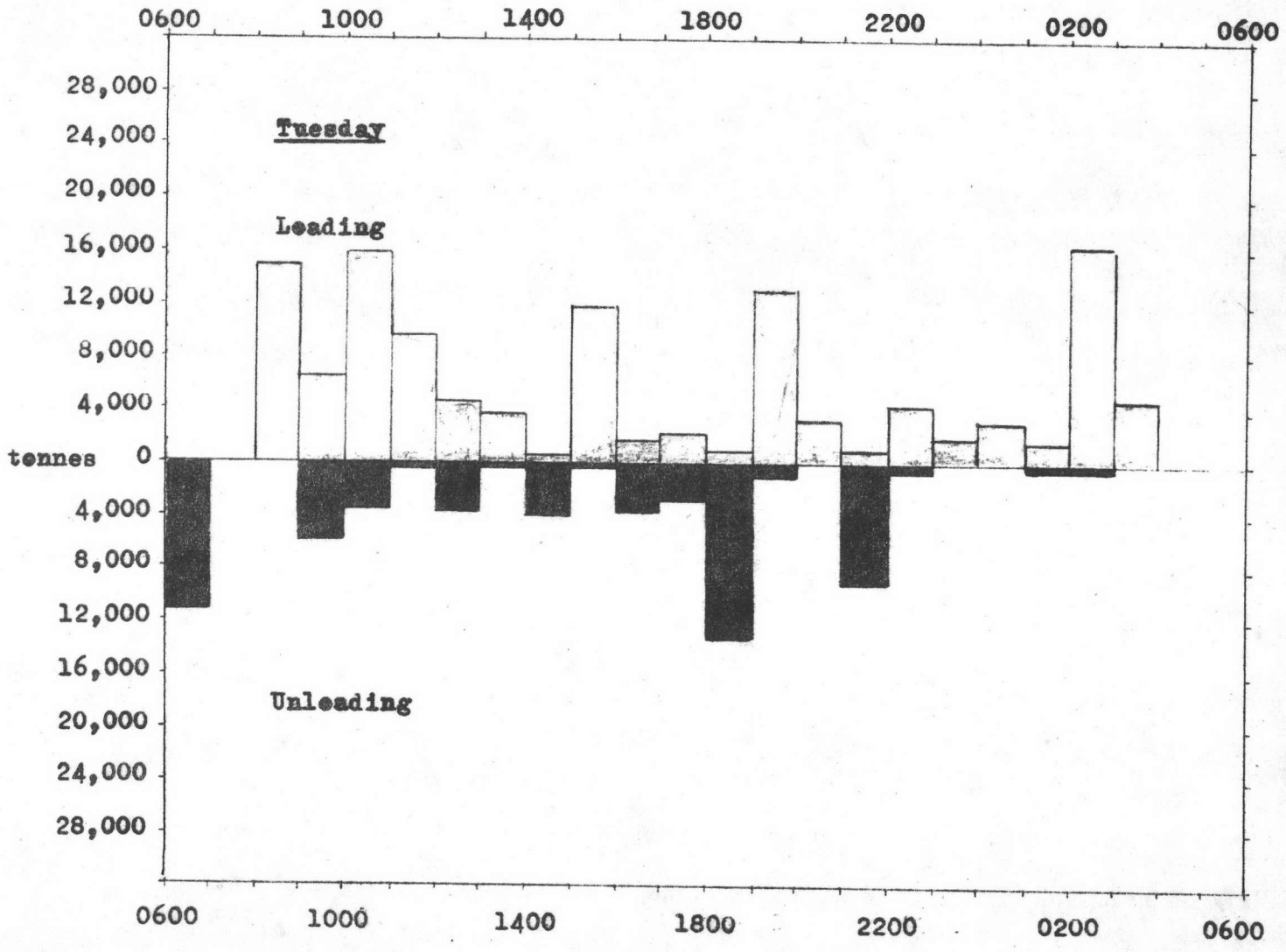


Figure 5.15 Hourly flow of loading and unloading of air freight on October 11th, 1977

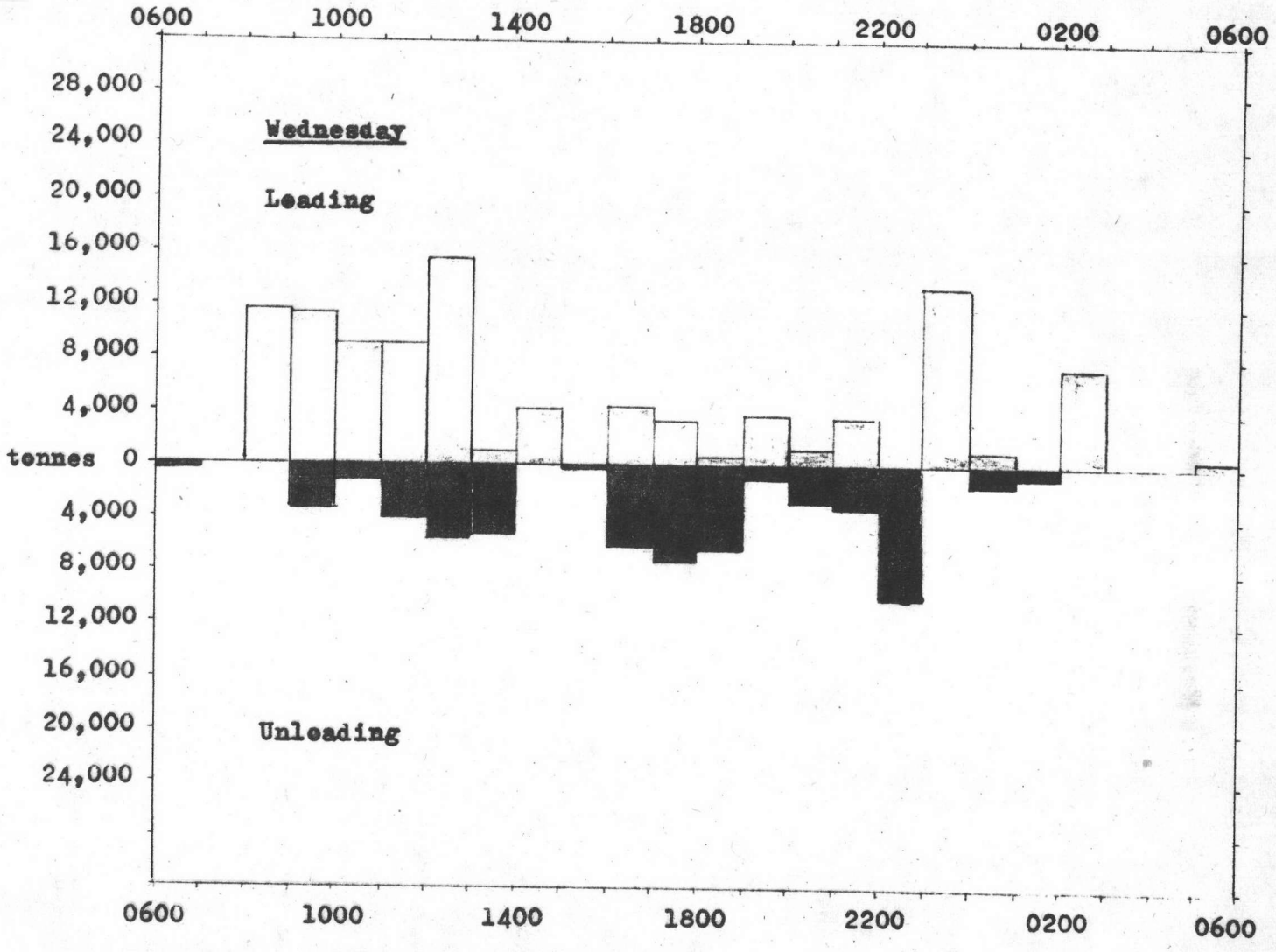


Figure 5.16 Hourly flow of loading and unloading of air freight on October 12th, 1977

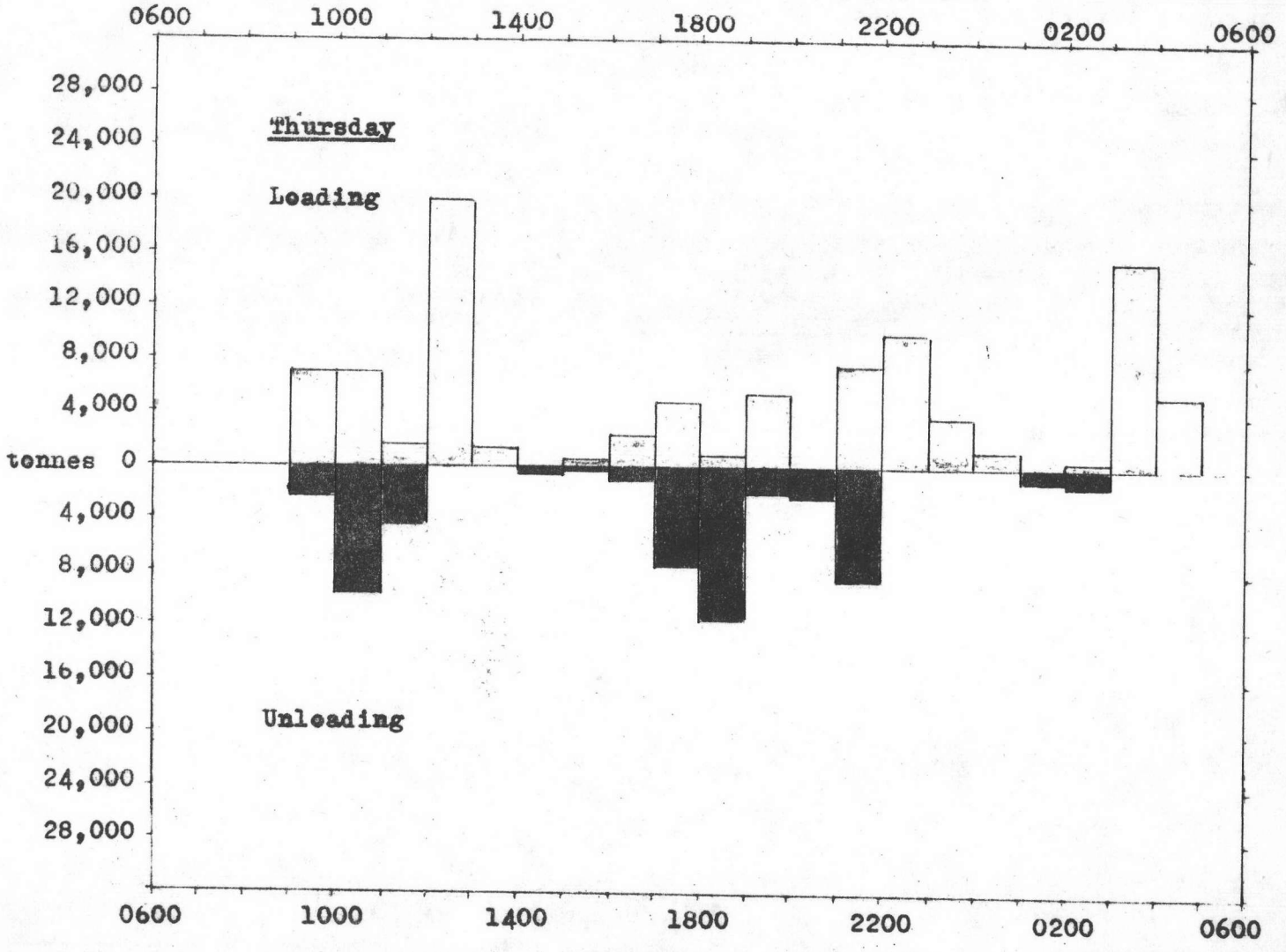


Figure 5.17 Hourly flow of loading and unloading of air freight on October 13th, 1977

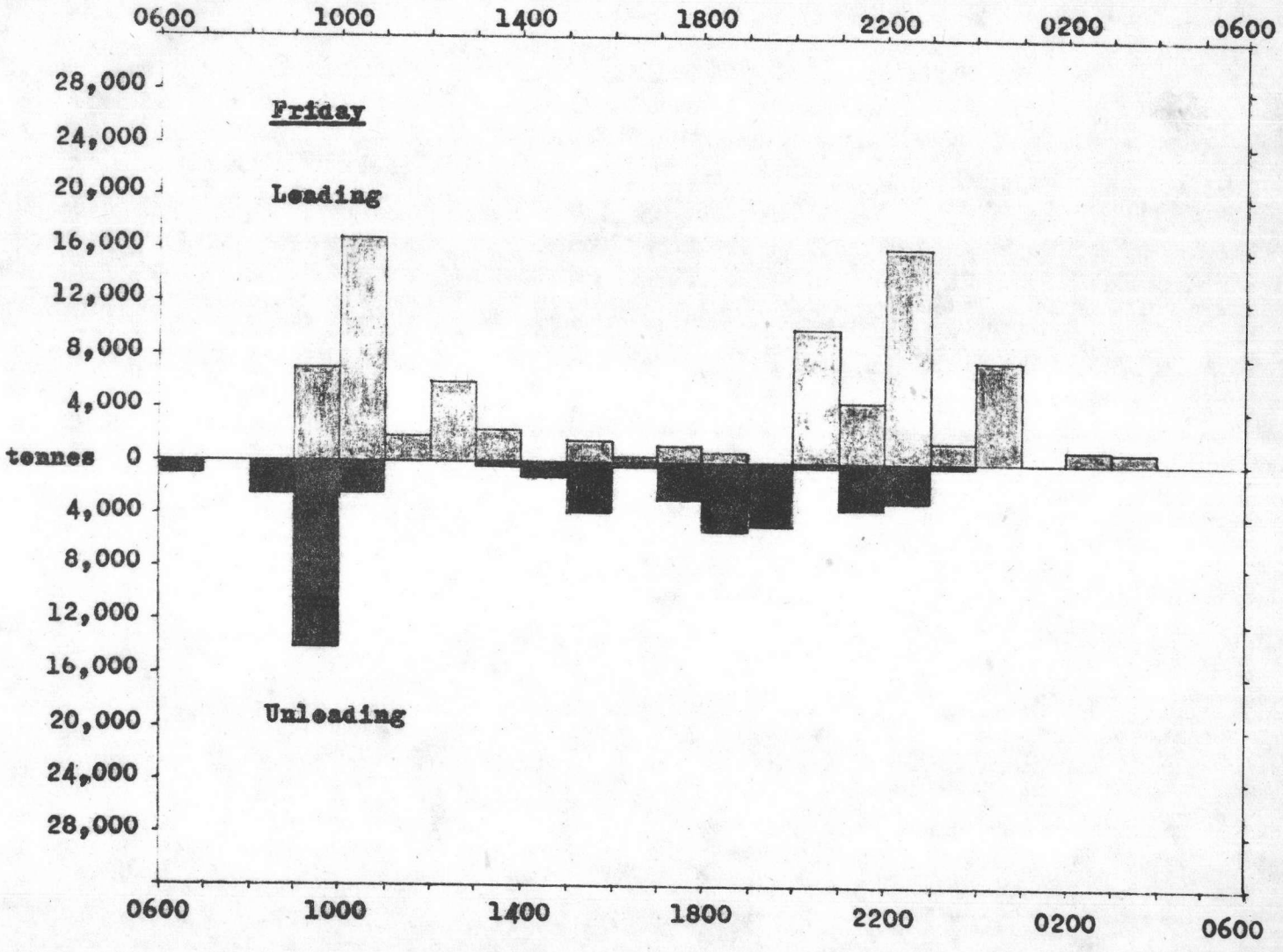


Figure 5.18 Hourly flow of loading and unloading of air freight on October 14th, 1977

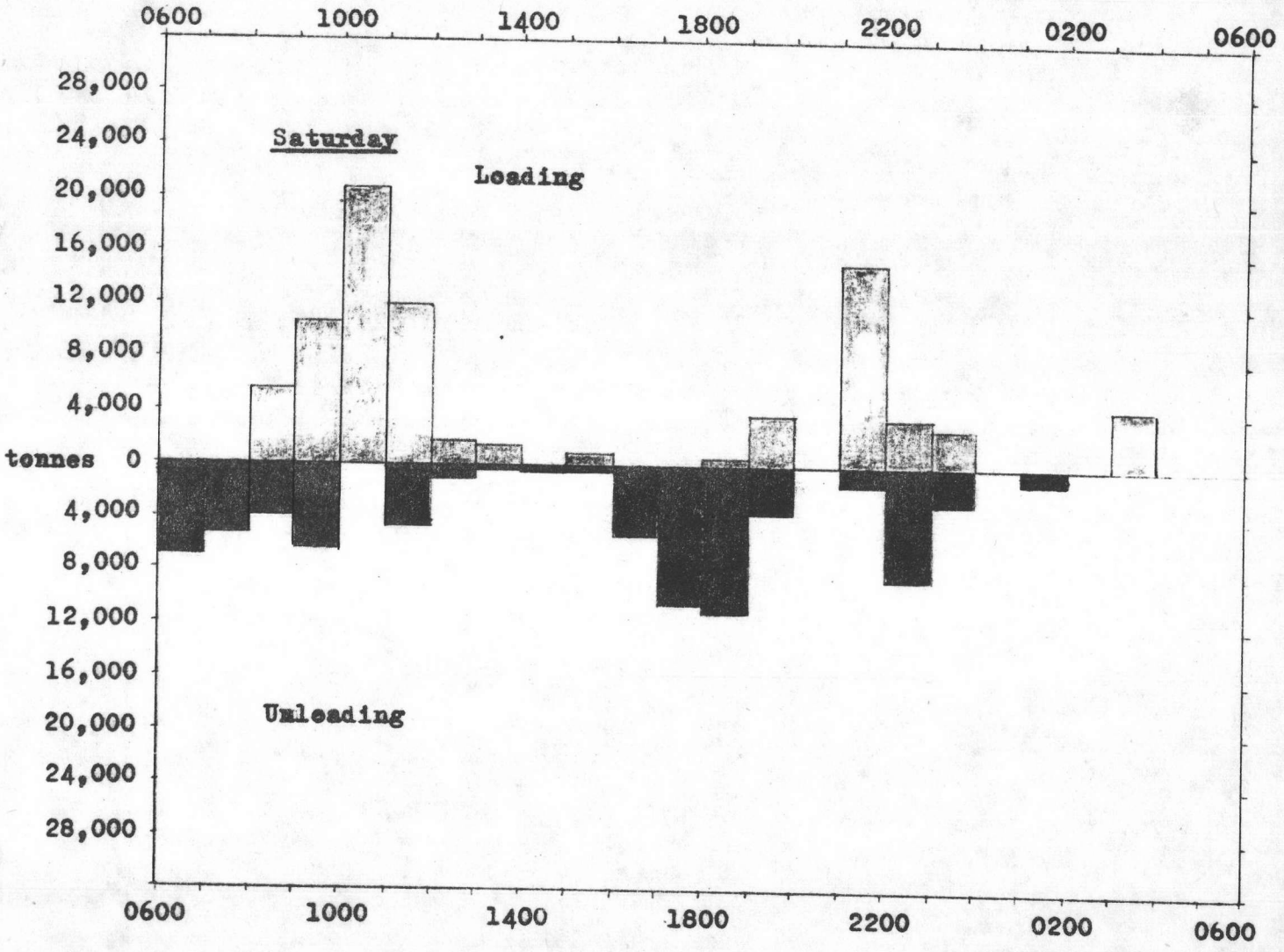


Figure 5.19 Hourly flow of loading and unloading of air freight on October 15th, 1977

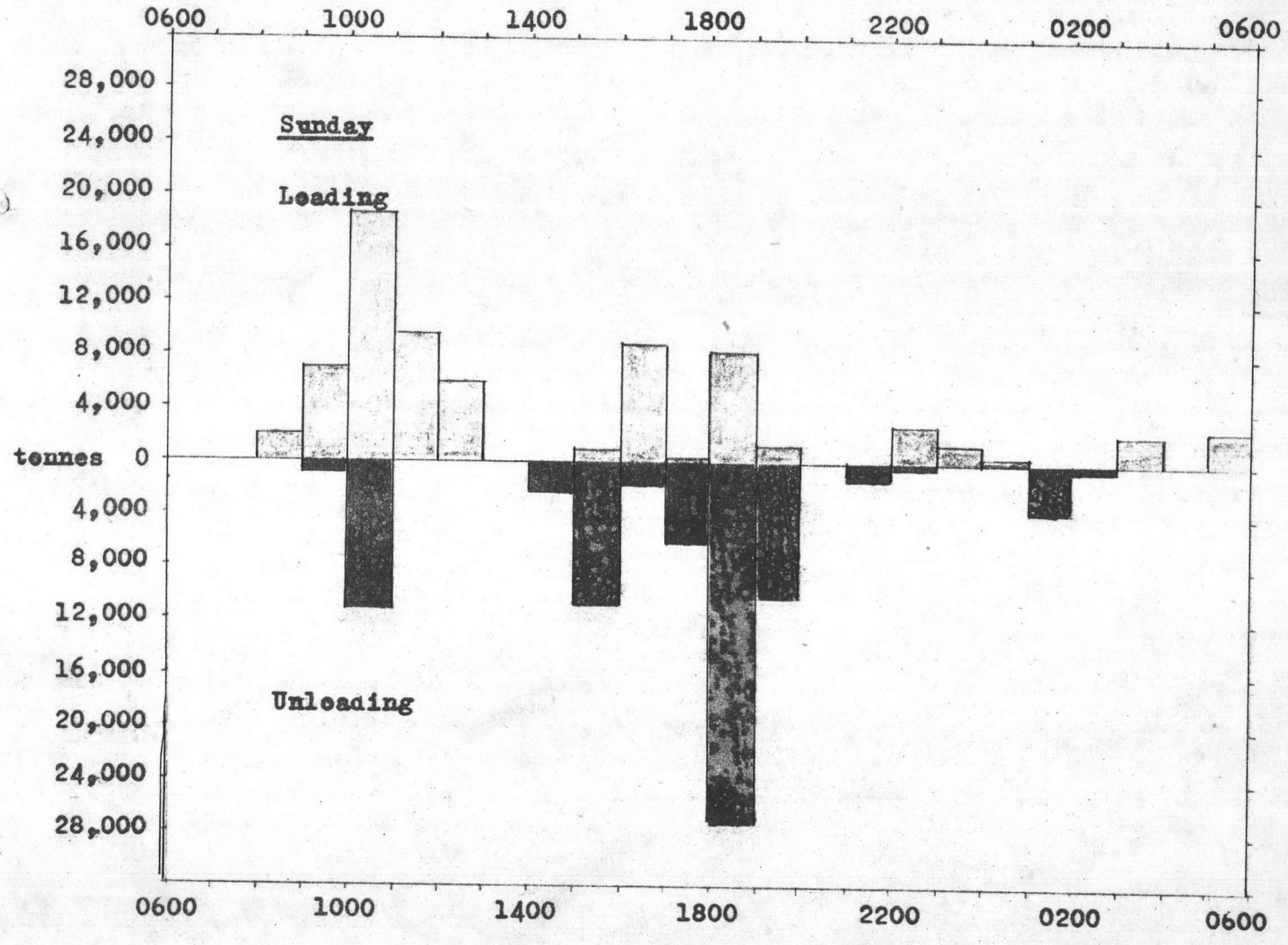


Figure 5.20 Hourly flow of loading and unloading of air freight on October 16th, 1977

Table 5.19 Summary of hourly and daily flow of air freight

Date	Direction	Peak Hourly Flow		Total Volume kg.	Mean Hourly Flow kg.
		Period	Volume, kg.		
Monday 10th	Loading	2200-2300	26,154	94,875	3,953
	Unloading	1700-1800	9,133	48,841	2,035
Tuesday 11th	Loading	0200-0300	16,358	121,784	5,074
	Unloading	1800-1900	13,406	61,390	2,558
Wednesday 12th	Loading	1200-1300	15,511	100,796	4,200
	Unloading	2200-2300	10,293	61,295	2,554
Thursday 13th	Loading	1200-1300	20,065	95,848	3,994
	Unloading	1800-1900	11,456	52,938	2,206
Friday 14th	Loading	1000-1100	16,835	79,774	3,324
	Unloading	0900-1000	14,070	45,819	1,909
Saturday 15th	Loading	1000-1100	20,755	83,461	3,478
	Unloading	1800-1900	11,149	75,203	3,133
Sunday 16th	Loading	1000-1100	18,840	72,343	3,014
	Unloading	1700-1800	27,179	77,499	3,229
	Average Daily Loading			92,697	
	Average Daily Unloading			60,426	

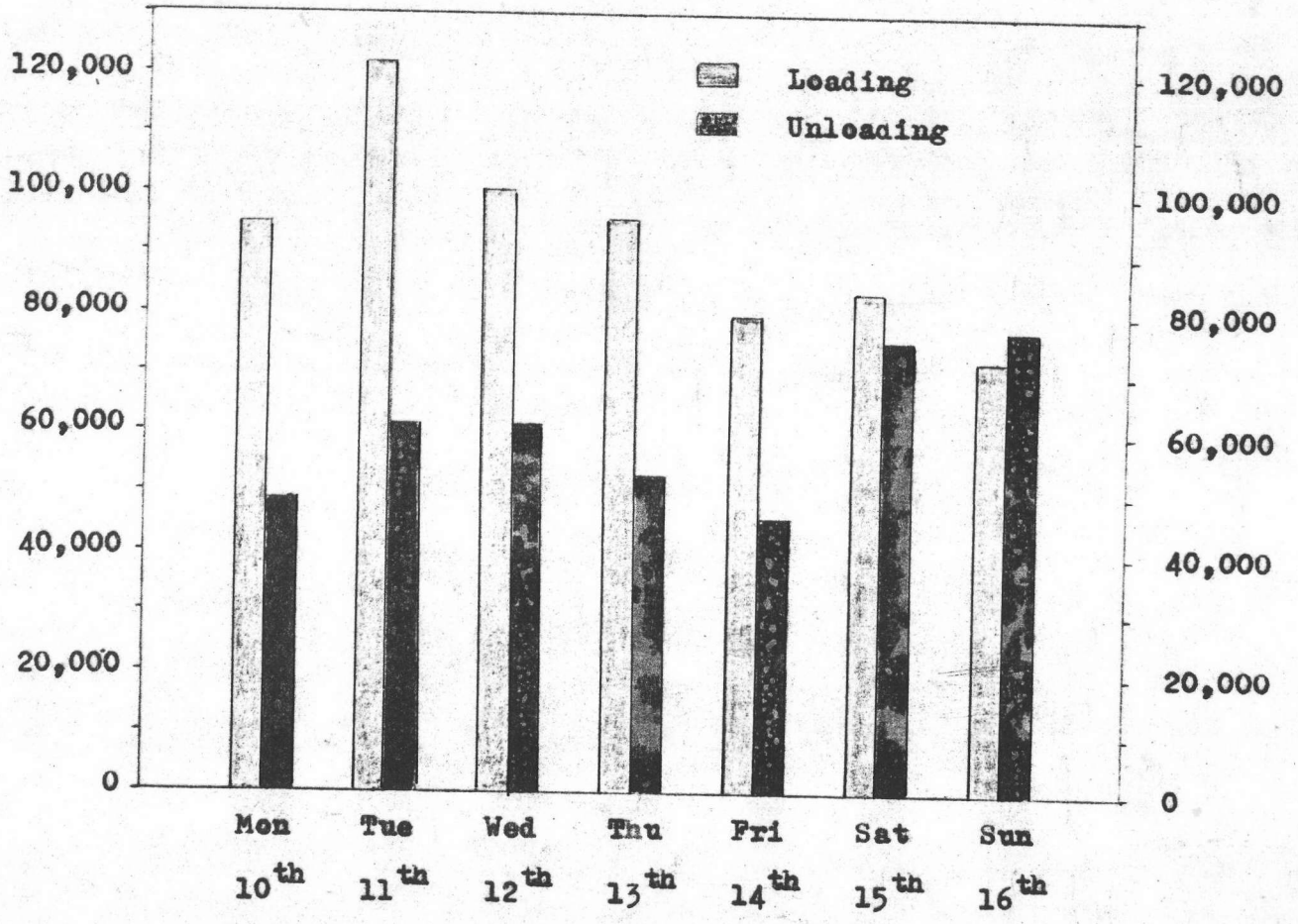


Figure 5.21 Fluctuation of daily flow of air freight during recording period (October 10th - 16th, 1977)

Correlation Determination

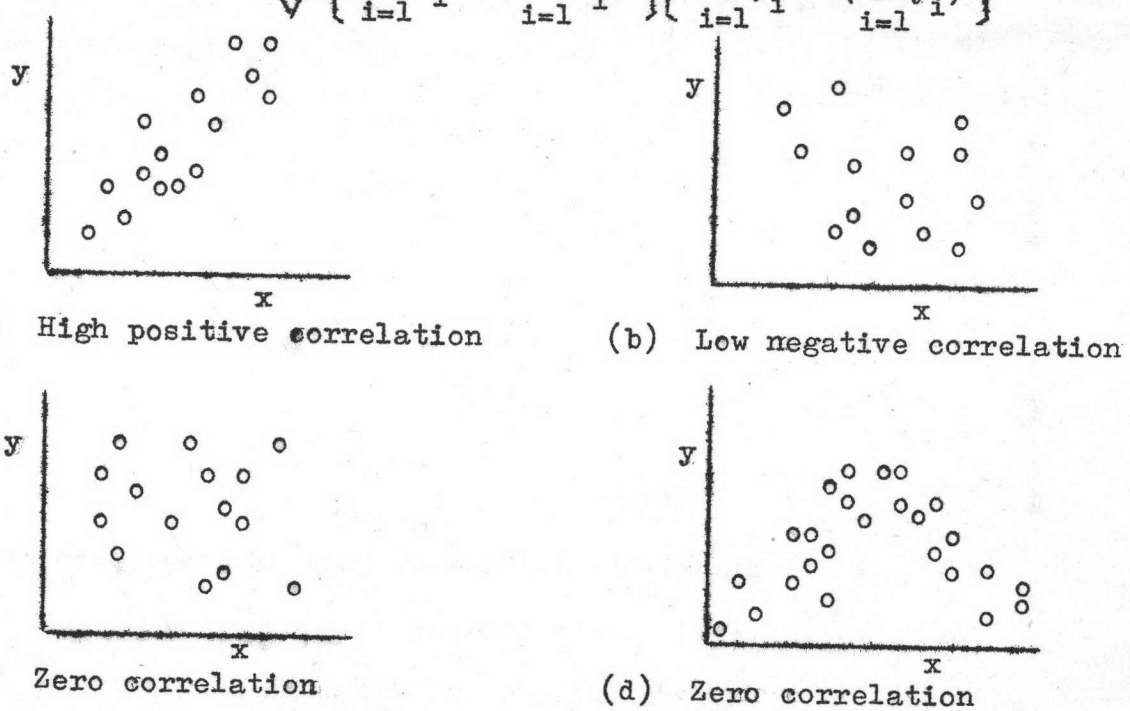
Theory

In dealing with the measurement of the relationship between two more variables , the linear correlation coefficient as denoted by r is used defined as a measure of the relationship between two random variables , X and Y . The variables x and y are assumed to have a bivariate probability distribution . To compute a linear correlation coefficient we first choose a random sample of n pairs of measurements (x , y) . By constructing a scatter diagram for the (x , y) values as shown in Figure 5.22 we are able to draw certain conclusions . When the points follow closely a straight line of positive slope , we have a high positive correlation between the two variables . On the other hand , if the points follow closely a straight line of negative slope , we have a high negative correlation between the two variables . The correlation between the two variables decreases numerically as the scattering of points from a straight line increases . If the points follow a strictly random pattern as in Figure 5.22(c) , we have zero correlation and conclude that no relationship exists between X and Y .

It is important to remember that the correlation coefficient between two variables is a measurement of their linear relationship , and a value of r = 0 implies a lack of linearity and not a lack of association . Hence if a strong quadratic relationship exists between X and Y as indicated in Figure 5.22(d) , we will still obtain a zero correlation to indicate a non-linear relationship .

The most commonly used measure of linear correlation between two variables is called " Pearson product-moment correlation coefficient " , or simply the correlation coefficient as

$$r = \frac{n\sum_{i=1}^{n} x_i y_i - \left(\sum_{i=1}^{n} x_i\right)\left(\sum_{i=1}^{n} y_i\right)}{\sqrt{\left\{n\sum_{i=1}^{n} x_i^2 - \left(\sum_{i=1}^{n} x_i\right)^2\right\}\left\{n\sum_{i=1}^{n} y_i^2 - \left(\sum_{i=1}^{n} y_i\right)^2\right\}}}$$



(a) High positive correlation (b) Low negative correlation

(c) Zero correlation (d) Zero correlation

Figure 5.22 Scatter diagrams showing various degrees of correlation

Loading and unloading of air freight

This evaluation provides for only international air freight according to the completeness of such pair of data . From the recorded data , four periods are divided in interval from 0600-1200 , 1200-1800 1800-2400 and 2400-0600 which total for seven days are twenty-eight periods . The begining values of loading and unloading in the determination are for 0600-1200 of Monday 10th and the last values are for 2400-0600 of Sunday 16th respectively .

From Table 5.20 , we find

$$\sum_{i=1}^{28} x_i = 648.88 \quad , \quad \sum_{i=1}^{28} y_i = 423.00$$

$$\sum_{i=1}^{28} x_i y_i = 11,133.84 \quad , \quad \sum_{i=1}^{28} x_i^2 = 20,605.43$$

$$\sum_{i=1}^{28} y_i^2 = 9,051.10$$

Therefore ,

$$r = \frac{(28)(11,133.84) - (648.88)(423.00)}{\sqrt{[(28)(20,605.43) - (648.88)^2][(28)(9,051.10) - (423.00)^2]}}$$

$$= 0.346$$

A correlation coefficient of 0.346 indicates a poor linear relationship between X and Y or loading and unloading . Since $r^2 = 0.12$, we can say that 12% of the variation in the values of unloading is ac-

Table 5.20 Determination of correlation coefficient for loading and unloading of international air freight

Loading, ton. x_i	Unloading, ton. y_i	x_i^2	y_i^2	$x_i y_i$
9.68	13.25	93.70	175.56	128.26
23.36	14.05	545.69	197.40	328.21
58.35	16.74	3,404.72	280.23	976.78
3.50	4.80	12.25	23.04	16.80
47.92	21.33	2,296.33	454.97	1,022.13
24.22	15.12	586.61	228.61	366.21
24.19	24.28	585.16	589.52	587.33
25.44	0.67	647.19	0.45	17.04
41.20	9.11	1,697.44	82.90	375.33
28.35	25.53	803.72	651.78	723.78
22.50	24.17	506.22	584.19	543.82
8.75	2.48	76.56	6.15	21.70
15.95	16.23	254.40	263.41	258.87
29.48	9.88	869.07	97.61	291.26
27.97	24.47	782.32	598.78	684.42
22.45	2.37	504.00	5.62	53.21
25.72	20.12	661.52	404.81	517.49
11.30	8.35	127.69	69.72	94.36
33.15	17.32	1,098.92	299.98	574.16
9.60	0.03	92.16	0	0.29
48.71	27.63	2,372.66	763.42	1,345.86
4.13	18.63	17.06	347.08	76.94
26.00	27.82	676.00	773.95	723.32
4.62	1.12	21.34	1.25	5.17
37.42	13.61	1,400.26	185.23	509.29
15.99	20.90	255.68	436.81	334.19
13.80	38.88	190.44	1,511.65	536.54
5.13	4.11	26.32	16.89	21.08
Σ 648.88	423.00	20,605.43	9,051.10	11,133.84

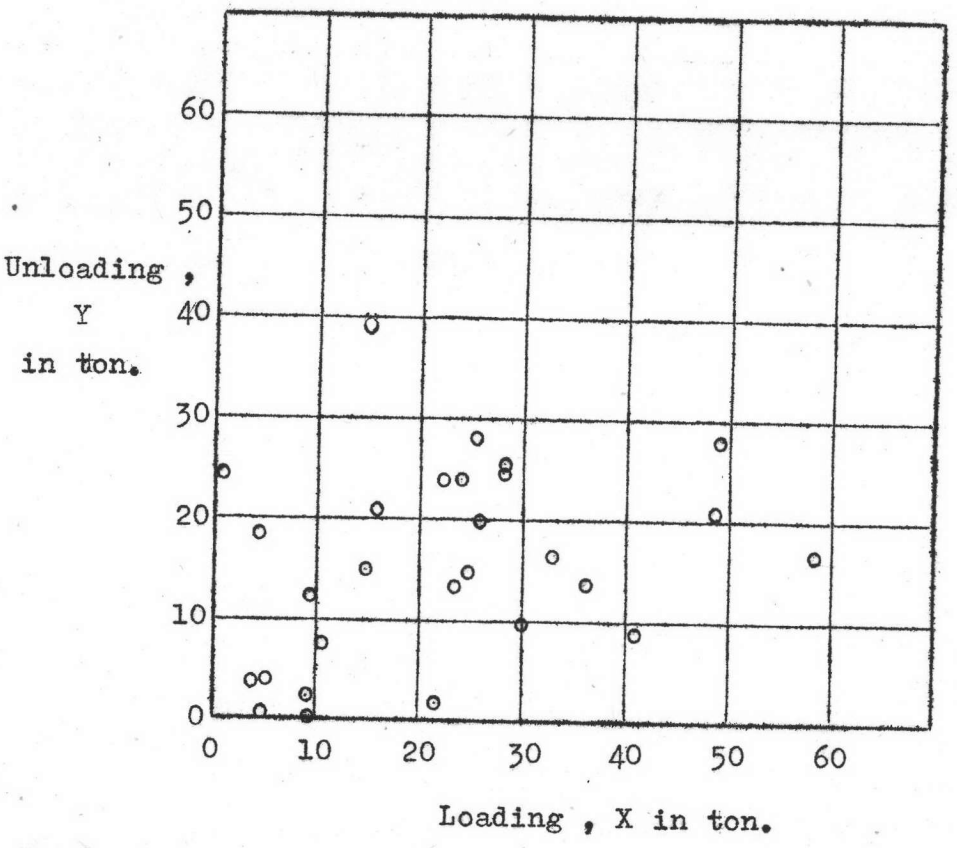


Figure 5.23 Scatter diagram of loading and unloading of international air freight

counted for by a linear relationship with loading . Figure 5.23 is to show scatter diagram of loading and unloading of international air freight for recorded data .

Air freight and aircraft movements

Generally , it has to be thought that volume of air freight have to be actually varied according to number of aircraft movements , but the truth was not fully followed this . Some aircrafts provided more volume of loading or unloading of cargo while some arrived or departed with very little or without loading or unloading of air freight . Data from the observation are adjusted as that of the determination of loading and unloading . Again , this evaluation is only for international flights , for domestic flights number of aircraft movements seem to be very few and without fluctuation which it seems to be unreliable for the evaluation .

The evaluation is divided as inward and outward flow which are written as unloaded air freight and arrived aircrafts , loaded air freight and departed aircrafts . Volumes of air freight are denoted by X and number of aircraft movements are as Y .

For inward flow , from Table 5.21 we find

$$\sum_{i=1}^{28} x_i = 423.00 \quad , \quad \sum_{i=1}^{28} y_i = 379.00$$

$$\sum_{i=1}^{28} x_i y_i = 6,637.47 \quad , \quad \sum_{i=1}^{28} x_i^2 = 9,051.10$$

$$\sum_{i=1}^{28} y_i^2 = 5,667.00$$

Therefore ,

$$r = \frac{(28)(6,637.47) - (423.00)(379.00)}{(28)(9,051.10) - (423.00)^2 \quad (28)(5,667.00) - (379.00)^2}$$

$$= 0.763$$

For outward flow , from Table 5.22 we find

$$\sum_{i=1}^{28} x_i = 648.88 \quad , \quad \sum_{i=1}^{28} y_i = 382.00$$

$$\sum_{i=1}^{28} x_i y_i = 9,737.02 \quad , \quad \sum_{i=1}^{28} x_i^2 = 20,605.43$$

$$\sum_{i=1}^{28} y_i^2 = 5,732.00$$

Therefore ,

$$r = \frac{(28)(9,737.02) - (648.88)(382.00)}{\sqrt{[(28)(20,605.43) - (648.88)^2][(28)(5,732.00) - (382.00)^2]}}$$

$$= 0.520$$

For inward flow , a correlation coefficient of 0.763 indicates a medium linear relationship between volumes of air freight and number of aircraft movements and as $r^2 = 0.58$, it can be said that about 58% of the variation in the volumes of unloading is accounted for by a linear relationship with number of arrived aircrafts .

For outward flow as the evaluation gives the result of a correlation coefficient equal to 0.520 , it may be classified that the linear relationship between volumes of air freight and number of aircraft movements was rather poor . For $r^2 = 0.27$, it can be said that about 27% of the variation in the volumes of loading was accounted for by a linear relationship with number of departed aircrafts .

Scatter diagrams of both pairs of correlation determination are as shown in Figure 5.24 and Figure 5.25 as for inward and outward flow respectively .

Table 5.21 Determination of correlation coefficient for unloaded air freight and arrived aircrafts of international flights

Volume, ton. x_i	No of aircraft y_i	x_i^2	y_i^2	$x_i y_i$
13.25	14	175.56	196	185.50
14.05	18	197.40	324	252.90
16.74	15	280.23	225	251.10
4.80	8	23.04	64	38.40
21.33	13	454.97	169	277.29
15.12	14	228.61	196	211.68
24.28	19	589.52	361	461.32
0.67	9	0.45	81	6.03
9.11	13	82.99	169	118.43
25.53	18	651.78	324	459.54
24.17	16	584.19	256	386.72
2.48	7	6.15	49	17.36
16.23	15	263.41	225	243.45
9.88	19	97.61	361	187.72
24.47	15	598.78	225	464.93
2.37	6	5.62	36	14.22
20.12	12	404.81	144	241.44
8.35	13	69.72	169	108.55
17.32	18	299.98	324	311.76
0.03	4	0	16	0.12
27.63	12	763.42	144	331.56
18.63	14	347.08	196	260.82
27.82	21	773.95	441	584.22
1.12	9	1.25	81	10.08
13.61	12	185.23	144	163.32
20.90	21	436.81	441	438.90
38.88	15	1,511.65	225	583.20
4.11	9	16.89	81	36.99
423.00	379	9,051.10	5,667	6,637.47

Σ

Table 5.22 Determination of correlation coefficient for loaded air freight and departed aircrefts of international flights

Volume, ton. x_i	No of aircraft y_i	x_i^2	y_i^2	$x_i y_i$
9.68	16	93.70	256	154.88
23.36	17	545.69	289	397.12
58.35	16	3,404.72	256	933.60
3.50	8	12.25	64	28.00
47.92	21	2,296.33	441	1,006.32
24.22	15	586.61	225	363.30
24.19	12	585.16	144	290.28
25.44	6	647.19	36	152.64
41.12	13	1,697.44	169	535.60
28.35	19	803.72	361	538.65
22.50	17	506.22	289	382.50
8.75	8	76.56	64	70.00
15.95	9	254.40	81	143.55
29.48	22	869.04	484	648.56
27.97	19	782.32	361	531.43
22.45	8	504.00	64	179.60
25.72	14	661.52	196	360.08
11.30	11	127.69	121	124.30
33.15	17	1,098.92	289	563.55
9.60	6	92.16	36	57.60
48.71	15	2,372.66	225	730.65
4.13	11	17.06	121	45.43
26.00	16	676.00	256	416.00
4.62	9	21.34	81	41.58
37.42	14	1,400.26	196	523.88
15.99	17	255.68	289	271.83
13.80	13	190.44	169	179.40
5.13	13	26.32	169	66.69
648.88	382	20,605.43	5,732	9,737.02

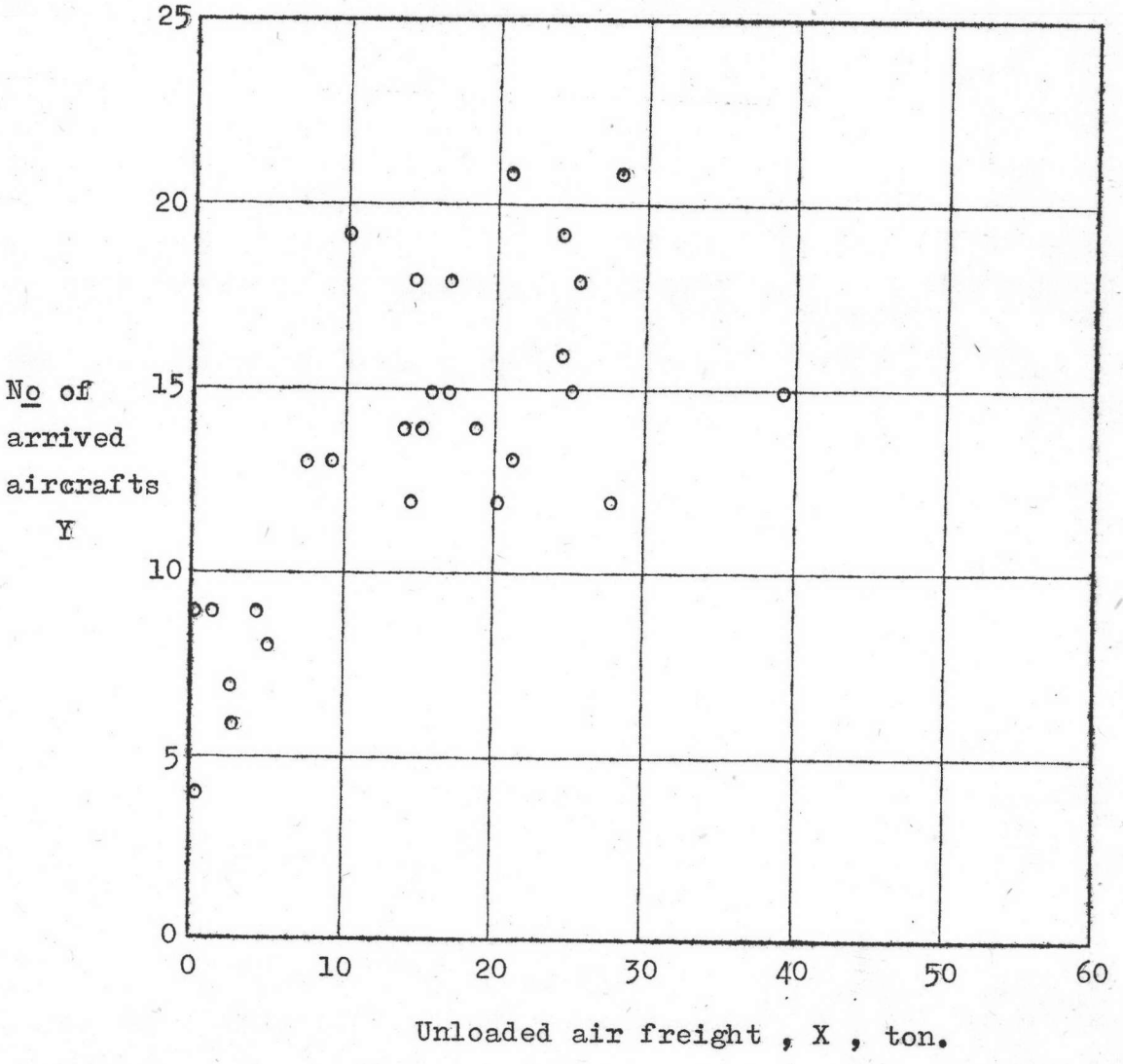


Figure 5.24 Scatter diagram of unloaded air freight and number of arrived aircrafts for international flights

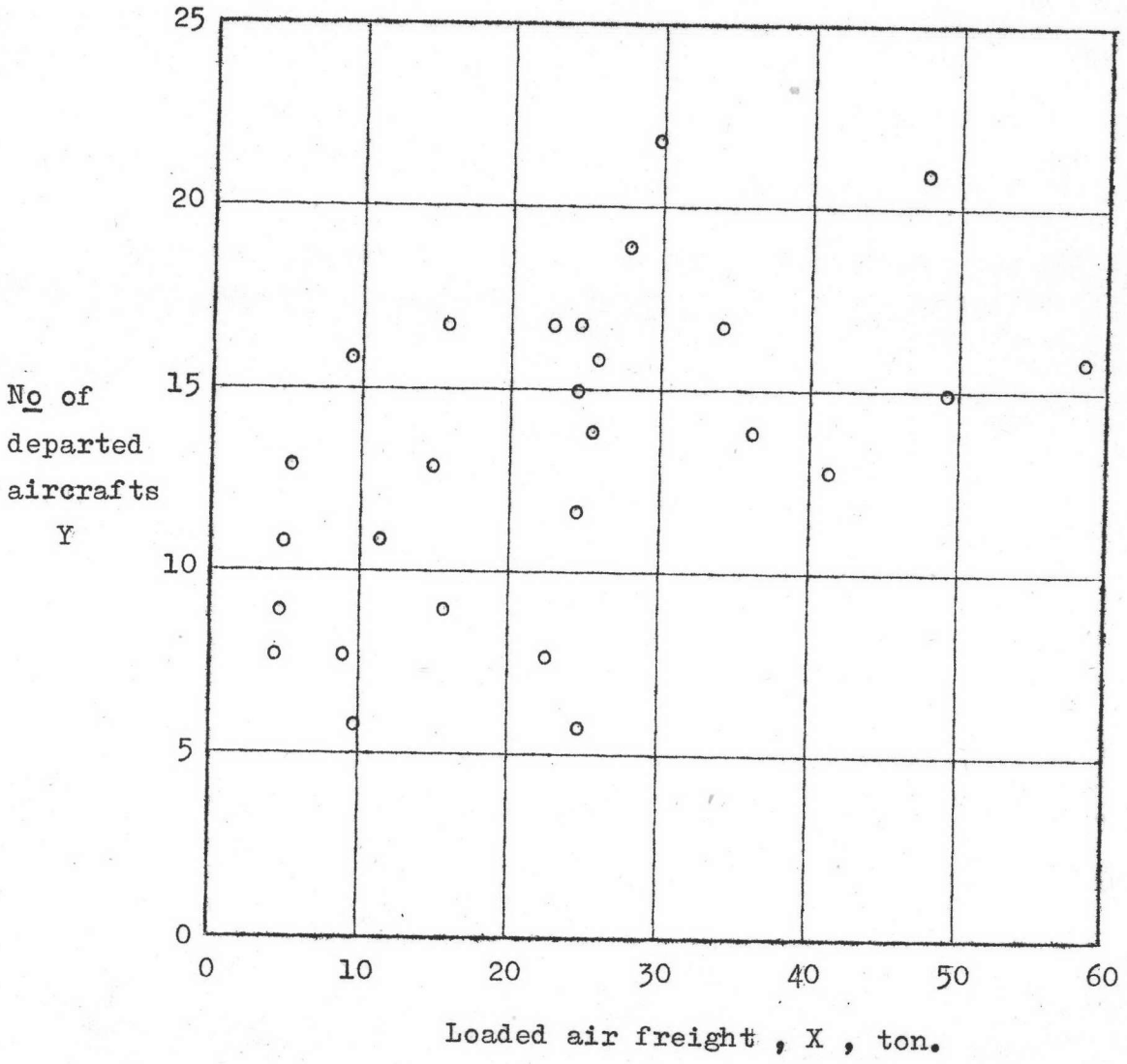


Figure 5.25 Scatter diagram of loaded air freight amd number of departed aircrafts for international flights

Air freight and passengers

Don Muang International Airport is netting over one hundred millions baht income for the government due to services and fees . In the past , only budgets for passengers facilities were provided for the improvement of this airport and only recently that budget for air freight were allocated . This move was the result of the realization by the government that Don Muang was loosing its income due to the improvement of other neighbour international airports such as in Singapore and Malaysia in air freight business .

The relationship between air freight and passengers at this international airport is evaluated for only international flights as volumes of air freight and passengers for domestic flights seem to be not large and frequent enough to be determined . The data are grouped as those evaluated before and it is also divided as inward and outward flow . Volumes of air freight are denoted by X and numbers of passenger are as Y .

For inward flow , from Table 5.23 we find

$$\sum_{i=1}^{28} x_i = 423.00 \quad , \quad \sum_{i=1}^{28} y_i = 26,250$$

$$\sum_{i=1}^{28} x_i y_i = 492,449.43 \quad , \quad \sum_{i=1}^{28} x_i^2 = 9,051.10$$

$$\sum_{i=1}^{28} y_i^2 = 31,117,330$$

Therefore ,

$$r = \frac{(28)(492,449.43) - (423.00)(26,250)}{\sqrt{\left[(28)(9,051.10) - (423.00)^2\right]\left[(28)(31,117,330) - (26,250)\right]}}$$

$$= 0.732$$

For outward flow , from Table 5.24 we find

$$\sum_{i=1}^{28} x_i = 648.88 \quad , \quad \sum_{i=1}^{28} y_i = 25,715$$

$$\sum_{i=1}^{28} x_i y_i = 646,185.09 \quad , \quad \sum_{i=1}^{28} x_i^2 = 20,605.43$$

$$\sum_{i=1}^{28} y_i^2 = 27,513,734$$

Therefore ,

$$r = \frac{(28)(646,185.09) - (648.88)(25,715)}{\sqrt{\left[(28)(20,605.43) - (648.88)^2\right]\left[(28)(27,513,734) - (25,715)\right]}}$$

$$= 0.341$$

We may find that the value of coefficient of correlation of volumes of air freight and numbers of passenger for inward flow is about double of that of outward flow , this may be according to more fluctuations of outward air freight while numbers of passenger seem to be no so much varied for both directions of flow . From values of r as evaluated , it may be classified that for inward flow the linear relationship between volumes of air freight and numbers of passenger is at me-

dium level while for outward flow is at poor level . Scatter diagrams showing the correlatiom of such evaluation for both directions of flow are as shown in Figure 5.26 and Figure 5.27 .

Table 5.23 Determination of correlation coefficient for unloaded air freight and disembarked passengers of international flights

Volume, ton. x_i	No of passenger, y_i	x_i^2	y_i^2	$x_i y_i$
13.25	819	175.56	670,761	10,851.75
14.05	1,310	197.40	1,716,100	18,405.50
16.74	873	280.23	762,129	14,614.02
4.80	354	23.04	125,316	1,699.20
21.33	736	454.97	541,696	15,698.88
15.12	1,123	228.61	1,261,129	16,979.76
24.28	1,221	589.52	1,490,841	29,645.88
0.67	185	0.45	34,225	123.95
9.11	904	82.99	817,216	8,235.44
25.53	1,622	651.78	2,630,884	41,409.66
24.17	889	584.19	790,321	21,487.13
2.48	105	6.15	11,025	260.40
16.23	962	263.41	925,444	15,613.26
9.88	1,496	97.61	2,238,016	14,780.48
24.47	1,129	598.78	1,274,641	27,626.63
2.37	125	5.62	15,625	296.25
20.12	691	404.81	477,481	13,902.92
8.35	1,359	69.72	1,846,881	11,347.65
17.32	1,031	299.98	1,026,169	17,545.16
0.03	118	0	13,924	3.54
27.63	1,127	763.42	1,270,129	31,139.01
18.63	1,237	347.08	1,530,169	23,045.31
27.82	1,609	773.95	2,588,881	44,762.38
1.12	520	1.25	270,400	582.40
13.61	1,330	185.23	1,768,900	18,101.30
20.90	1,619	436.81	2,621,161	33,837.10
38.88	1,529	1,511.65	2,337,841	59,447.52
4.11	245	16.89	60,025	1,006.95
423.00	26,250	9,051.10	31,117,330	492,449.43

Table 5.24 Determination of correlation coefficient for loaded air freight and embarked passengers of international flights

Volume, ton. x_i	No of passenger, y_i	x_i^2	y_i^2	$x_i y_i$
9.68	1,399	93.70	1,957,201	13,542.32
23.36	922	545.69	850,084	21,537.92
58.35	933	3,404.72	870,489	54,440.55
3.50	190	12.25	36,100	665.00
47.92	1,307	2,296.33	1,708,249	62,631.44
24.22	998	586.61	996,004	24,171.56
24.19	631	585.16	398,161	15,263.89
25.44	403	647.19	162,409	10,252.32
41.20	1,392	1,697.44	1,937,664	1,697.44
28.35	1,381	803.72	1,907,161	39,151.35
22.50	776	506.22	602,176	17,460.00
8.75	123	76.56	15,129	1,076.25
15.95	820	254.40	672,400	13,079.00
29.48	1,295	869.04	1,677,025	38,176.60
27.97	1,122	782.32	1,258,884	31,382.34
22.45	350	504.00	122,500	7,857.50
25.72	1,483	661.52	2,199,289	38,142.76
11.30	857	127.69	734,449	9,684.10
33.15	889	1,098.92	790,321	29,470.35
9.60	169	92.16	28,561	1,622.40
48.71	1,645	2,372.66	2,706,025	80,127.95
4.13	820	17.06	672,400	3,386.60
26.00	1,441	676.00	2,076,481	37,466.00
4.62	220	21.34	48,400	1,016.40
37.42	1,562	1,400.26	2,439,844	58,450.04
15.99	1,270	255.68	1,612,900	20,307.30
13.80	850	190.44	722,500	11,730.00
5.13	467	26.32	218,089	2,395.71
648.88	25,715	20,605.43	27,513,734	646,185.09

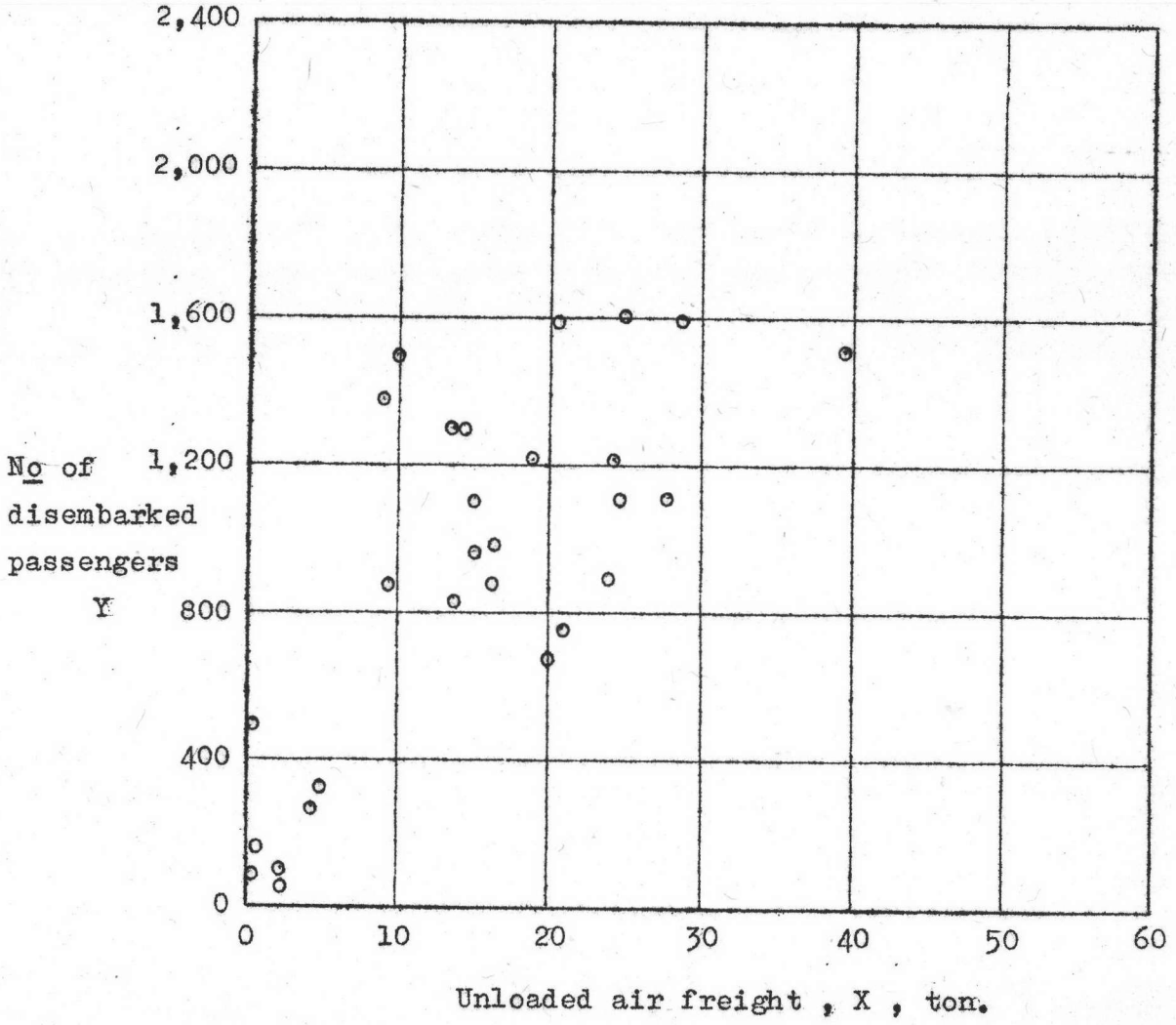


Figure 5.26 Scatter diagram of unloaded air freight and disembarked passengers of international flights

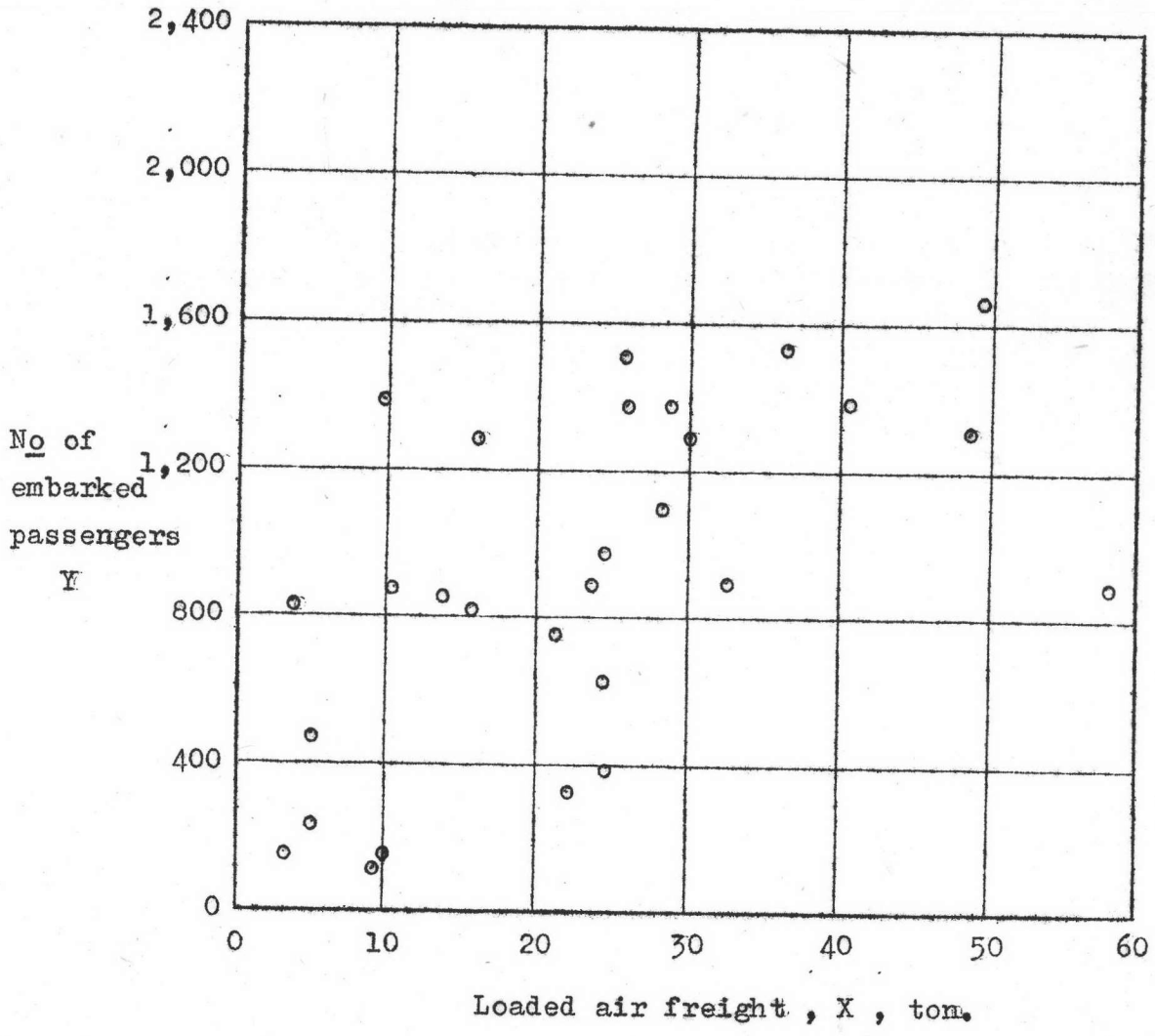


Figure 5.27 Scatter diagram of loaded air freight and embarked passengers of international flights