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A study on the arrival process of lift passengers in a multi-storey office building

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This article presents a study on the process of how passengers arrive at lift lobbies to travel to their destinations. Earlier studies suggest that passengers arrive at the lift lobbies individually with exponentially distributed inter-arrival times, that is, according to a Poisson process. This study was carried out in a multi-storey office building. The data was collected using a questionnaire, digital video recordings and the lift monitoring system. The results show that, in the studied building, passengers arrive in batches whose size varies with the time of day and the floor utilization. In addition, the batch arrivals follow a time-inhomogeneous Poisson process with piecewise constant arrival rates.

Practical applications: This article contributes to the basic understanding of passenger behaviour, and how people move around in buildings and arrive at the lift lobbies. It is proposed that the model for the passenger arrival process should take into account that passengers do not always arrive individually but also in batches. The passenger arrival process affects the design of elevators. It will also affect the passenger generation in building traffic simulations.

1 Introduction

In multi-storey buildings, the passenger traffic and arrival pattern vary throughout the day. During up-peak, most passengers belong to the incoming traffic component, that is, they travel from the entrance floors to the upper floors. Another typical pattern is the lunch-peak, which is a mixture of incoming, outgoing and inter floor traffic. This article presents an experimental study on the passenger arrivals at the lift lobbies during the morning up-peak and the midday lunch-peak, which are the heaviest traffic periods in office buildings. Hence, this study increases the basic understanding of the passenger arrival process during the most demanding traffic periods.

Alexandris[1] studied the arrivals of individual passengers at the lift lobbies during the morning up-peak and concluded that the inter-arrival times are exponentially distributed, that is, the arrivals follow a Poisson distribution. Some other studies on the passenger arrival patterns in multi-storey buildings cover, for example, passenger arrival rates and waiting times but not the arrival process exactly.[2–5]

More recently, Yu et al.[6] studied the influence of the arrival process on the performance of a lift group by simulations where

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passengers arrived either individually or in batches. They concluded that when passengers arrive in batches, the service times of the lift group become longer. Therefore, it is important to verify whether passengers actually arrive in batches, and to identify the batch arrival process.

A lift group forms a bulk service system for the passengers arriving randomly at the lift lobby. Bailey[7] studied the performance of a single-server bulk queue with Poisson arrivals. Miller[8] considered a similar queuing system except that the arrivals occurred in batches rather than individually. As noted by Miller, the operation of a lift is an example of where the theory based on individual arrivals is not applicable.

Queuing theory can be used to analyse the performance of a lift group in up-peak. For other traffic patterns, for example lunch-peak, the analysis is based on simulations.[9,10] These analyses are based on the assumption that the arrivals occur according to a Poisson process even though the arrival process has been identified only for up-peak. This article studies passenger arrivals also during the office lunch-peak, and thus, its results can be utilized in simulation tools.

Preliminary results on passenger behaviour were obtained from a questionnaire study. The questionnaire study was accompanied by an observational study where passenger arrivals were recorded with digital video cameras. Not only were the individual passenger arrivals at the lift lobby measured but also the batches of passengers were determined. The sizes of the batches and their arrival times were defined by combining data from the video recordings with traffic data obtained from the lift monitoring system (LMS). The data were used to test the hypothesis that the passenger arrival process is a compound Poisson process, that is, the batch arrivals form a Poisson process. For comparison, the analysis was performed also for individual arrivals.

2 Data collection

The study was carried out in a 16-storey office building served by a group of four lifts. The first two floors are entrance floors and there is a canteen on the first floor. There are also stairs between these floors. The upper floors are equipped with conventional up and down call buttons, but the two entrance floors have destination call panels. A destination call panel is a numeric keypad that passengers use to enter the destination already in the lobby, not inside the car. Hence, a destination call combines the origin and the destination of a passenger.

At the time of the study, the building was occupied by two tenants. One tenant occupied 3 floors and the other tenant 11 floors. The population of the whole building was about 300 persons. Because of the low occupancy of the building, the traffic was relatively light even during the peak periods (Figure 1). Based on initial observations, the morning up-peak occurred approximately between 7:30 and 9:30. The lunch-peak occurred between 11:00 and 13:00. The beginning of this period mostly consisted of down-peak traffic and the end mostly of up-peak traffic. Since there is a canteen on the first floor, most of the building occupants travelled between the first and the upper floors during this period. The evening down-peak occurred between 15:30 and 18:00. Traffic between the upper floors, that is, inter floor traffic, was moderate throughout the day except a somewhat heavier period that occurred between the morning up-peak and the lunch down-peak.

2.1 Questionnaire

A questionnaire was sent in the beginning of June 2008 to 198 people regularly working in the building (Appendix A). It consists of four parts each corresponding to one of the following daily routines: arrival at the office in the morning (morning up-peak), going to

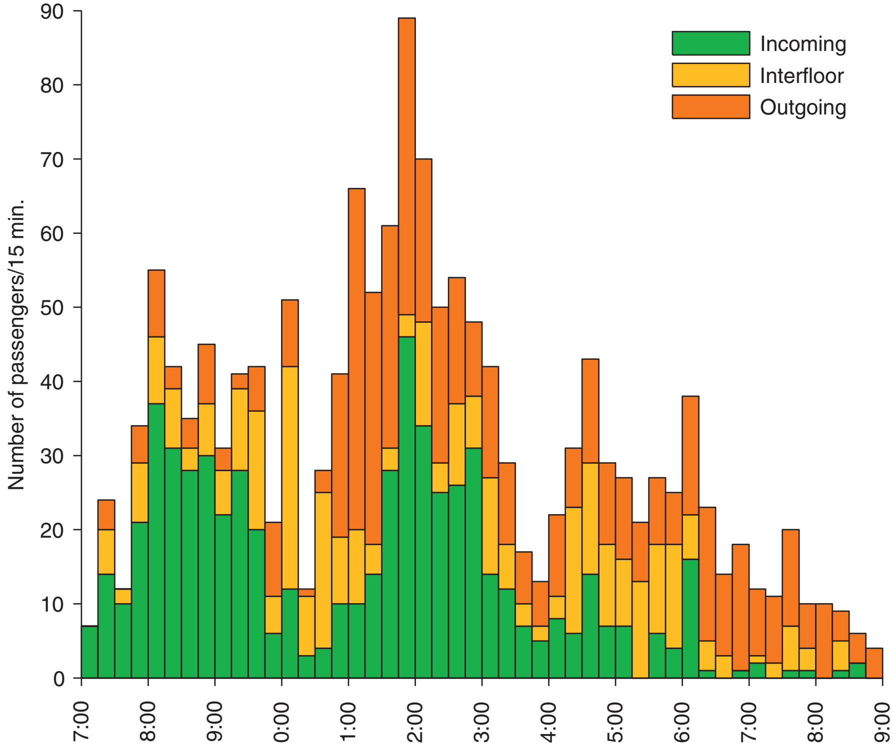

Figure 1 Daily traffic profile measured by the lift monitoring system (LMS)

lunch (lunch down-peak), returning from lunch (lunch up-peak) and departure from the office in the evening (evening down-peak). The questionnaire was used as supporting material in studying the batch sizes during the different peak periods.

It was possible to complete the questionnaire during a 2-week period, and a lottery was used as an incentive to increase people's readiness to respond. In total, 64 people returned the questionnaire. Since some respondents did not use a lift in all of the routines, the response rate varied slightly between them: 29.3% for arrival at the office in the morning, 28.8% for going to lunch, 27.8% for returning from lunch and 28.3% for departure from the office in the evening.

Some respondents answered the question 'Number of people accompanying you in the lift' with a range of numbers, such as 1–3. This is probably because they interpreted the question as 'How many people were there in the lift with you?' This number may vary during the trip of a lift. From the answers given using a range of numbers, the lower limit was selected to avoid the skewing of the answers towards bigger batch sizes.

2.2 Video recordings and the LMS

The incoming traffic on the entrance floors during the morning up-peak and the lunch-peak period was recorded with digital video cameras on a regular office day, Wednesday, 20 October 2010. A single camera was placed on both of the entrance floors so that it did

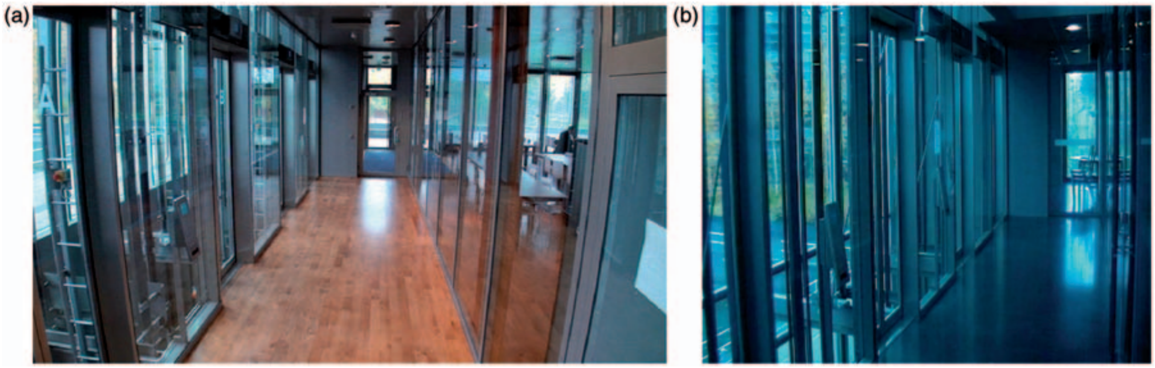

Figure 2 Snapshots of the video recordings showing the lift lobbies and the positions of the cameras; first floor (left) and second floor (right)

not disturb the movement of the passengers. On the first floor, there were two doors that were monitored: one across the lift lobby and another on the right-hand side, as shown in Figure 2. On the second floor, there was only one door on the right-hand side of the camera that was monitored. Because the passengers seemed to completely ignore the video cameras and they were not aware of the LMS, these results are based on undistorted data. This may not be the case with observers who can disturb passengers' movement and skew the data.[1,5]

The arrival times of the passengers were determined on the basis of the video recordings. For the door further away from the camera on the first floor as well as for the only door on the second floor, the arrival time was defined as the time when the passenger crossed the doorstep. Since the other doorstep on the first floor was not visible, the arrival time was taken as the time when the passenger appeared in the picture. The arrival time of a batch was defined as the arrival time of the first passenger to enter the lift lobby.

In addition to the video recordings, traffic data were obtained from the LMS and the group control system. The traffic data of one lift stop consist of, for example, timestamps of the stopping lift's state (e.g., stop time), number of passengers entering and exiting the lift (passenger transfer data) and calls registered by the passengers. The passenger transfer data were obtained by measuring stepwise changes in the load of an electronic weighing device.[11] The other measurements are control system electric signals and lift state data.

2.3 Defining the passenger batches

In this study, a passenger batch consists of passengers who satisfy all of the following rules:

(1) Arrive at the lift lobby at the same time.
(2) Arrive at the lift lobby through the same door or from the same direction.
(3) Enter the same lift.
(4) Travel to the same destination.

Rules (1) and (2) are related to the actual passenger arrivals and the arrival process. Rules (3) and (4) specify this process to subprocesses based on all destinations. This information is important since the number of stops during a lift round-trip has a direct impact on the handling capacity of the lift group.[12] Namely, the more there are batches, the less there are passengers with different destinations, which results in fewer stops during a lift round-trip.

The batches were determined from the video recordings and the LMS data. The procedure was as follows:

(a) On the basis of the video recordings, a number of passengers satisfying Rules (1) and (2) were considered as a potential batch.
(b) Such a potential batch was further separated into several sub-batches based on Rule (3).
(c) Using the stop data obtained from the LMS, each of the sub-batches were checked for Rule (4): first, the destinations of the passengers from the entrance floors were determined from the car and the destination calls registered during the corresponding stop; second, the size of each batch was defined as the number of exiting passengers at the corresponding destination stop.

In the studied building, the traffic was light even during the peak periods and passengers arrived at the entrance floor lift lobbies clearly at different times either individually or in batches. Hence, it was easy to apply the above procedure. In a heavy traffic building, it might be difficult to define passengers' destinations, since there are typically several destination stops at the upper floors. Furthermore, the arrival times of consecutive batches might be difficult to distinguish if the passengers arrive at the lift lobby continuously. In such a case, Rules (3) and (4) actually help in determining the batches correctly.

3 Data analysis

3.1 Questionnaire study

According to the questionnaires, the average batch size was 1.5, 3.3, 3.7 and 1.3 passengers for morning up-peak, lunch down-peak, lunch up-peak and evening down-peak, respectively. Table 1 shows how often a passenger travelled in a batch of a given size, that is, the batch size distributions.

Table 1 Batch size distributions according to the questionnaires

Batch size	Morning up-peak	Lunch down-peak	Lunch up-peak	Evening down-peak
1	37	11	10	41
2	13	6	10	12
3	6	10	3	2
4	2	17	7	1
5	0	6	18	0
6	0	5	4	0
7	0	1	1	0
8	0	0	1	0
9	0	0	1	0

Table 2 Batch size distributions for the morning up-peak period according to the video recordings and the LMS

Floor	Batch size	Interval start time							
		7:30	7:45	8:00	8:15	8:30	8:45	9:00	9:15
1st	1	9	8	19	18	12	12	6	14
	2	0	0	2	1	2	1	0	1
	3	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0
2nd	1	1	11	8	9	8	12	12	8
	2	0	1	1	1	2	2	2	2
	3	0	0	0	0	0	0	0	0
	4	0	0	1	0	0	0	0	0
	5	0	0	0	0	0	0	0	0

LMS: lift monitoring system.

Clearly, the batches were smaller in the morning and in the evening than during lunch time. Furthermore, about 70% of the passengers travelled alone in the morning and in the evening but only about 20% during lunch time.

3.2 Video recordings and the LMS

According to the video recordings and the LMS, in total 207 passengers arrived at the entrance floor lift lobbies and about 80% of them arrived alone during the morning up-peak period (Table 2). The average batch size was 1.1 passengers. When returning from lunch, in total 219 passengers arrived at the entrance floor lift lobbies and travelled to the upper floors (Table 3). About 50% of the passengers arrived in batches and 50%

Table 3 Batch size distributions for the lunch-peak period according to the video recordings and the LMS

Floor	Batch size	Interval start time							
		11:00	11:15	11:30	11:45	12:00	12:15	12:30	12:45
1st	1	4	8	14	11	9	12	5	13
	2	0	2	6	7	4	2	1	0
	3	0	0	0	4	1	2	1	3
	4	0	0	0	1	0	0	2	0
	5	0	0	0	0	0	1	0	0
2nd	1	4	2	2	3	6	1	4	6
	2	1	0	0	1	2	1	2	0
	3	0	0	0	0	0	0	0	1
	4	0	0	0	0	1	0	0	0
	5	0	0	0	0	0	0	0	0

LMS: lift monitoring system.

alone. The average batch size was 1.5 passengers. Most of the batches, about 70%, arrived at the first floor where the canteen is located. On the second floor, passengers arrived mainly individually during this period. A possible explanation for these results is that those who work on the same floor often dine together, and thus, people move in bigger batches during lunch time. In addition, most of the people dine in the canteen on the first floor and not elsewhere.

These results show that, in this building, the batch size depends on the time of day and the floor utilization. During lunch time, the number of people arriving at the first-floor lift lobby in batches is nearly three times greater than in the morning.

The questionnaire suggests a larger batch size than the video recordings and the LMS, especially for the lunch up-peak period. This is because the respondents did not necessarily answer the question ‘Number of people accompanying you in the lift’ according to the definition of a batch. Another reason is that the questionnaire concerned mainly the behaviour of the passengers returning from lunch, whereas the data obtained from the video recordings and the LMS consisted of all incoming traffic, for example, visitors and incoming traffic from the main car park on the first floor.

4 Passenger arrival model

Initially, it was assumed that the batch arrivals at the lift lobbies form a Poisson process. This process was chosen on the basis of the natural assumption that the batch arrivals occur randomly in time. If the assumption is true, the passenger arrival process can be modelled with a compound Poisson process,[13] which is a generalization of the ordinary Poisson process.

Let $\{N(t),\ t \geq 0\}$ be a Poisson process. The process $\{X(t),\ t \geq 0\}$ is a compound Poisson process if:

$$X(t) = \sum_{i=1}^{N(t)} Y_i, \quad t \geq 0\,, \tag{1}$$

where Y_i, $i = 1, 2, \ldots$, are independent and identically distributed (i.i.d.) random variables and independent of $N(t)$. In this case, $X(t)$ is the number of passengers that arrive at the lift lobby, $N(t)$ is the number of arriving batches and Y_i is the size of the ith batch. The compound Poisson process reduces to the ordinary Poisson process, if the batch size distribution is such that the probability of batches of size one equals one and the probabilities of larger batches equal zero.

Figure 3 shows the observations from the video recordings on the first floor during the

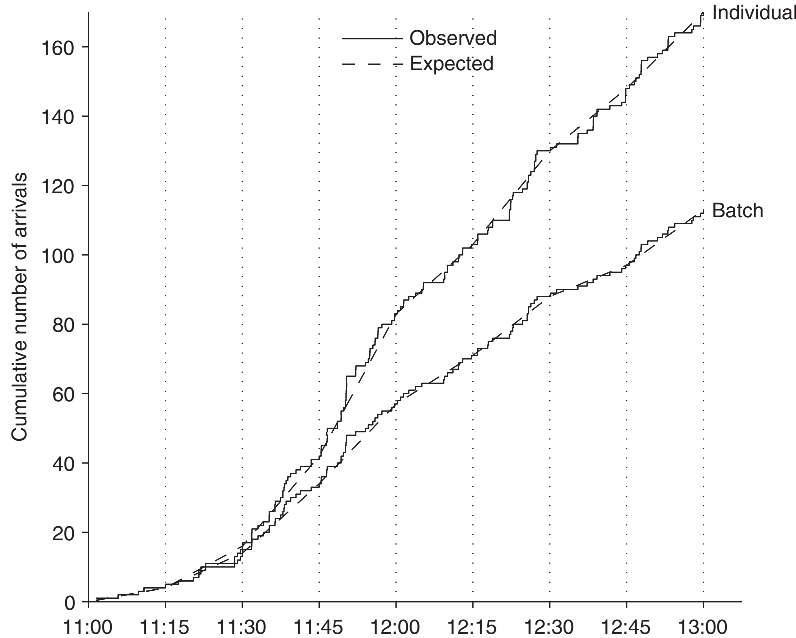

Figure 3 Cumulative number of batch and individual arrivals on the first floor during the lunch-peak period

lunch-peak for both the recorded individual arrivals and the batch arrivals determined using the definitions of Section 2. In addition, the expected cumulative numbers of individual and batch arrivals are shown. The expectations were computed assuming that the arrival process within every 15-min interval is a Poisson process with a constant arrival rate. It seems that the observed arrivals do not notably differ from the expected values either for the batch or the individual arrivals. Nevertheless, the observed individual arrivals vary more around the expected values. This means that the Poisson process might be more suitable for modelling the batch than the individual arrivals within the 15-min intervals.

5 Model validation

5.1 Homogeneity of the batch size distributions

Tables 2 and 3 suggest that the batch size distribution does not notably vary from interval to interval. This section studies whether the batch size distributions of the different intervals can be combined. The χ^2 -test for homogeneity was applied to test the null hypothesis, H_0, that the batch size distribution is the same for every 15-min interval for a given floor within a given period. If the null hypothesis is accepted, the distributions of different intervals can be combined.

Table 4 contains the test results. If the observed value of χ^2 is greater than the critical value $\chi^2_{df,0.95}$, where $df=(n-1)(B-1)$ are the degrees of freedom, n is the number of 15-min intervals within a period and B is the maximum batch size, the null hypothesis is rejected at the 5% significance level and accepted otherwise. Because there were only a few observations of batches from two to five passengers, these were combined into one group.

The null hypothesis is accepted for both entrance floors and peak periods, and thus,

Table 4 Test results for the homogeneity of the batch size distributions

Floor	Period	*n*	*B*	*df*	χ^2	$\chi^2_{df,0.95}$	Accept H_0
1st	7:30–9:30	8	2	7	3.307	14.067	Yes
	11:00–13:00	8	2	7	8.82	14.067	Yes
2nd	7:30–9:30	8	2	7	1.402	14.067	Yes
	11:00–13:00	8	2	7	3.098	14.067	Yes

Table 5 Aggregate batch size distributions

Floor	Period	Batch size/absolute					Batch size/%				
		1	2	3	4	5	1	2	3	4	5
1st	7:30–9:30	98	7	0	0	0	93.3	6.7	0	0	0
	11:00–13:00	76	22	11	3	1	67.3	19.5	9.7	2.7	0.8
2nd	7:30–9:30	69	11	0	1	0	85.2	13.6	0	1.2	0
	11:00–13:00	28	7	1	1	0	75.7	18.9	2.7	2.7	0

the batch size distributions of the different intervals can be combined. Table 5 shows the aggregate distributions. It is concluded that during the morning up-peak traffic, 90% of the batches consist of one passenger. The compounding batch size distribution for the lunch-peak traffic on the entrance floors is roughly 70%, 20%, 6% and 4% for batches of one, two, three and more than three passengers, respectively.

5.2 Brown test for a time-inhomogeneous Poisson process

As can be seen from Figure 3, as well as from the observations reported in Tables 2 and 3, the cumulative number of arrivals does not increase linearly. Hence, the arrival rate seems to vary from interval to interval, which indicates that the processes are time-inhomogeneous. The ordinary χ^2-test for the Poisson process assumes a constant arrival rate. Hence, it is not applicable in this case. A test constructed by Brown et al.[14] does not assume that the arrival rates of different intervals are equal nor does it require grouping of data, which is the case in the χ^2-test. Therefore, the Brown test was applied to both the individual and the batch arrivals obtained from the video recordings.

In the Brown test, the test period is first partitioned into relatively short intervals where the arrival rate can be assumed to remain constant. Let I denote the total number of intervals within a period, for example, morning up-peak. Intervals of equal length, $L = 15$ min, were used in the analysis to guarantee a sufficient number of observations for each interval. A 5-min interval might, however, be used in high-occupancy buildings with frequent arrivals. On the other hand, a 5-min interval is considered as the shortest interval that can be used in collecting and analyzing passenger traffic. With shorter intervals, the dynamics related to the movement of passengers and lifts start to become disturbing.[15]

The Brown variable R_{ij} is formed for the jth passenger (or batch) in the ith interval, $i = 1, 2, \ldots, I$. Let T_{ij} denote the arrival time and let J_i denote the total number of arrivals during the interval i. Each arrival time T_{ij} is measured with respect to the beginning of the

Table 6 Test results for the exponentiality of the Brown variables

Arrivals	Floor	Period	n	d_n	$d_{0.95}$	Accept H_0
Batch	1st	7:30–9:30	105	0.089	0.133	Yes
		11:00–13:00	112	0.097	0.129	Yes
	2nd	7:30–9:30	81	0.065	0.149	Yes
		11:00–13:00	37	0.166	0.218	Yes
Individual	1st	7:30–9:30	112	0.137	0.129	No
		11:00–13:00	169	0.285	0.105	No
	2nd	7:30–9:30	95	0.181	0.138	No
		11:00–13:00	49	0.181	0.190	Yes

interval i, and interval start time T_{i0} is defined as zero. The variables R_{ij} are defined as:

$$R_{ij} = (J_i + 1 - j)\left(-\log\left(\frac{L - T_{ij}}{L - T_{i(j-1)}}\right)\right), \quad j = 1, 2, \ldots, J_i. \tag{2}$$

Since the arrival rates between the different intervals vary, the passenger inter-arrival times $T_{ij} - T_{i(j-1)}$ are from different distributions. The variables R_{ij} are used to scale the inter-arrival times to follow approximately the same distribution. If the variables R_{ij} are independent and exponentially distributed, the arrivals form a time-inhomogeneous Poisson process with piecewise constant arrival rates. The model validation consists of the following steps:

(1) Test the exponentiality of the Brown variables R_{ij}.
(2) Test the independence of the Brown variables R_{ij}.

5.2.1 Exponentiality of the Brown variables

To test the exponentiality of the Brown variables R_{ij}, the Kolmogorov-Smirnov test for goodness of fit was applied.[16,17] The null hypothesis, H_0, is that the variables R_{ij} are exponentially distributed over a given period. Let n denote the total number of arrivals in a given period:

$$n = \sum_{i=1}^{I} J_i. \tag{3}$$

Define R_k as the kth ordered R_{ij}. Let $F(x;\ \lambda)$ denote the cumulative distribution function of the exponential distribution with rate parameter λ, which here represents the mean of all R_k. If the statistic:

$$d_n = \max_{1 \le k \le n} \left\{ \frac{k}{n} - F(R_k; \lambda), F(R_k; \lambda) - \frac{k-1}{n} \right\}, \tag{4}$$

is greater than the critical value $d_{0.95}$ obtained from the Kolmogorov's distribution, the null hypothesis is rejected at the 5% significance level, and accepted otherwise. For $n \le 100$, the critical values tabulated by Miller[18] were used, and for $n > 100$, the approximation $d_{0.95} = 1.36/n$.[16]

The results are presented in Table 6. For the batch arrivals, the null hypothesis that the Brown variables R_{ij} are exponentially distributed is accepted for both floors and peak periods. For the individual arrivals, it is accepted only for the second floor and the lunch-peak period, and the most significant departure from the null hypothesis is obtained for the first floor and the lunch-peak period. The reason for this is that during the lunch-peak period about 50% of the arrivals occurred in batches.

Figure 4 shows the observed and the expected cumulative distribution functions for the R_k from both the batch and the individual arrivals on the first floor during the lunch-peak period. The reason why the null

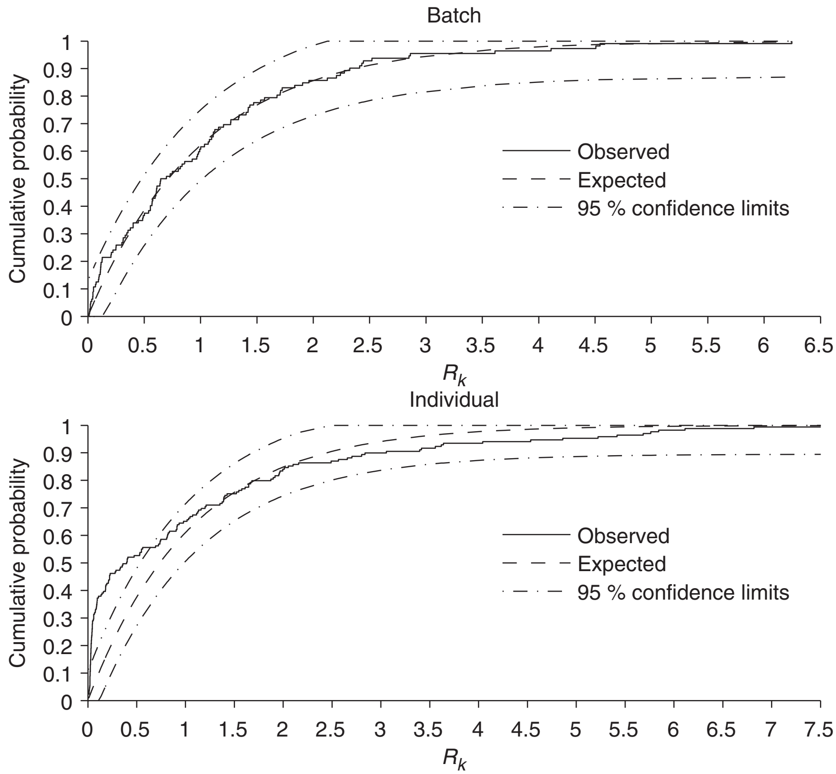

Figure 4 Observed and expected cumulative distributions for the R_k from the batch and the individual arrivals on the first floor during the lunch-peak period

hypothesis for the individual arrivals is rejected can be seen when the observed values pass outside the upper 95% confidence limit immediately for small values of the R_k and stay there until the value 0.6, approximately. This means that there were too many short inter-arrival times for the individuals to form a Poisson process.

It may also seem surprising that the null hypothesis is rejected for the individual arrivals on both floors during the morning up-peak period, even if during this period only 20% of the arrivals occurred in batches (Table 2). For the second floor, the null hypothesis is rejected even at the 1% significance level (p-value = 0.003), whereas for the first floor, it can be accepted (p-value = 0.028). One reason for this outcome is that on the second floor about 27% of the passengers arrived in batches, whereas on the first floor, only about 13% arrived in batches.

5.2.2 Independence of the Brown variables

To test the independence of the Brown variables R_{ij}, a test based on Pearson's correlation coefficient was applied. The null hypothesis, H_0, is that the correlation coefficient is zero, that is, the variables R_{ij} are linearly independent at lag one. Recall that n denotes the number of R_{ij} within a period. The unordered R_{ij} are partitioned into two subsets, $\{x_i\}$ and $\{y_i\}$, such that the last and the first R_{ij} is discarded, respectively. Let r_{xy}

Table 7 Test results for the independence of the Brown variables

Arrivals	Floor	Period	df	r_{xy}	t	$t_{df,0.975}$	Accept H_0
Batch	1st	7:30–9:30	102	−0.037	0.371	1.984	Yes
		11:00–13:00	109	0.013	0.137	1.982	Yes
	2nd	7:30–9:30	78	0.192	1.727	1.991	Yes
		11:00–13:00	34	0.179	1.063	2.032	Yes
Individual	1st	7:30–9:30	109	−0.076	0.797	1.982	Yes
		11:00–13:00	166	−0.007	0.087	1.974	Yes
	2nd	7:30–9:30	92	0.053	0.512	1.986	Yes
		11:00–13:00	46	0.126	0.864	2.013	Yes

be an estimate of Pearson's correlation coefficient for the subsets $\{x_i\}$ and $\{y_i\}$. If the variables R_{ij} are independent, the statistic:

$$t = \frac{r_{xy}\sqrt{(n-1)-2}}{\sqrt{(1-r_{xy}^2)}}, \tag{5}$$

follows approximately Student's t-distribution with $df = n - 3$ degrees of freedom.[19] If the observed absolute value of t is greater than the critical value $t_{df,0.975}$, the null hypothesis is rejected at the 5% significance level, and accepted otherwise.

Table 7 shows the test results. The null hypothesis is accepted, that is, the Brown variables R_{ij} are independent, in all cases. By combining this result with the results from Section 5.2.2, it is concluded that the batch arrivals formed a time-inhomogeneous Poisson process with a constant arrival rate for every 15-min interval on both floors during both peak periods, whereas the individual arrivals did this only when the proportion of batch arrivals was small, namely, on the first floor during the morning up-peak period.

6 Conclusions

In this article, a study of the process of how passengers arrive at lift lobbies is presented. The study was carried out in a multi-storey office building with two tenants. Passenger arrivals on the entrance floors during the morning up-peak and the lunch-peak period were measured. A questionnaire as well as automatic measuring devices, such as digital video cameras and traffic data from the LMS, were used to collect data.

The results show that the portion of passengers arriving in batches is about 20% during the morning up-peak and 50% during the lunch-peak period. According to the statistical tests, the arrival process during the peak periods can be modelled with a time-inhomogeneous compound Poisson process with piecewise constant arrival rates. The compounding batch size distribution depends on the time of day and the floor utilization. Indeed, the results demonstrate that the Poisson process with batch arrivals models the passenger arrivals better than the generally used Poisson process with individual arrivals.

Further research is needed to generalize the results of this study. Similar data should be collected from other office buildings, as well as from other types of buildings such as hotels and residential buildings. Special lift arrangements typical for transfer floors in buildings, for example sky lobbies, increase the bunching of people arriving at the lift lobbies. Also, external factors such as bus or underground stations close to the building entrances increase the number of passengers arriving in batches at buildings and lift lobbies. Another research subject is to compare lift traffic simulations based on individual and batch arrivals.

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Appendix A

1. Date: ______________

2. Name (fill in if you want to participate to the lottery): ___________________________

3. Age: 20–30___ 30–40___ 40–50___ 50–60___ 60–70___

4. Gender: Female___
Male ___

5. Position: Management ___
Operative ___
Staff ___

6. Diary:

Arrival to the office	
Did you use public transportation to/from office (Y/N)	
Arrival time to the office (e.g. 8:00)	
Number of people accompanying you in the lift (number of people in your group)	

Going to lunch	
Time when leaving for lunch	
Number of people accompanying you in the lift	

Returning from lunch	
Time when returning from lunch	
Number of people accompanying you in the lift	

Departure from the office	
Departure time from the office	
Number of people accompanying you in the lift	

Figure 1A Questionnaire of people movement