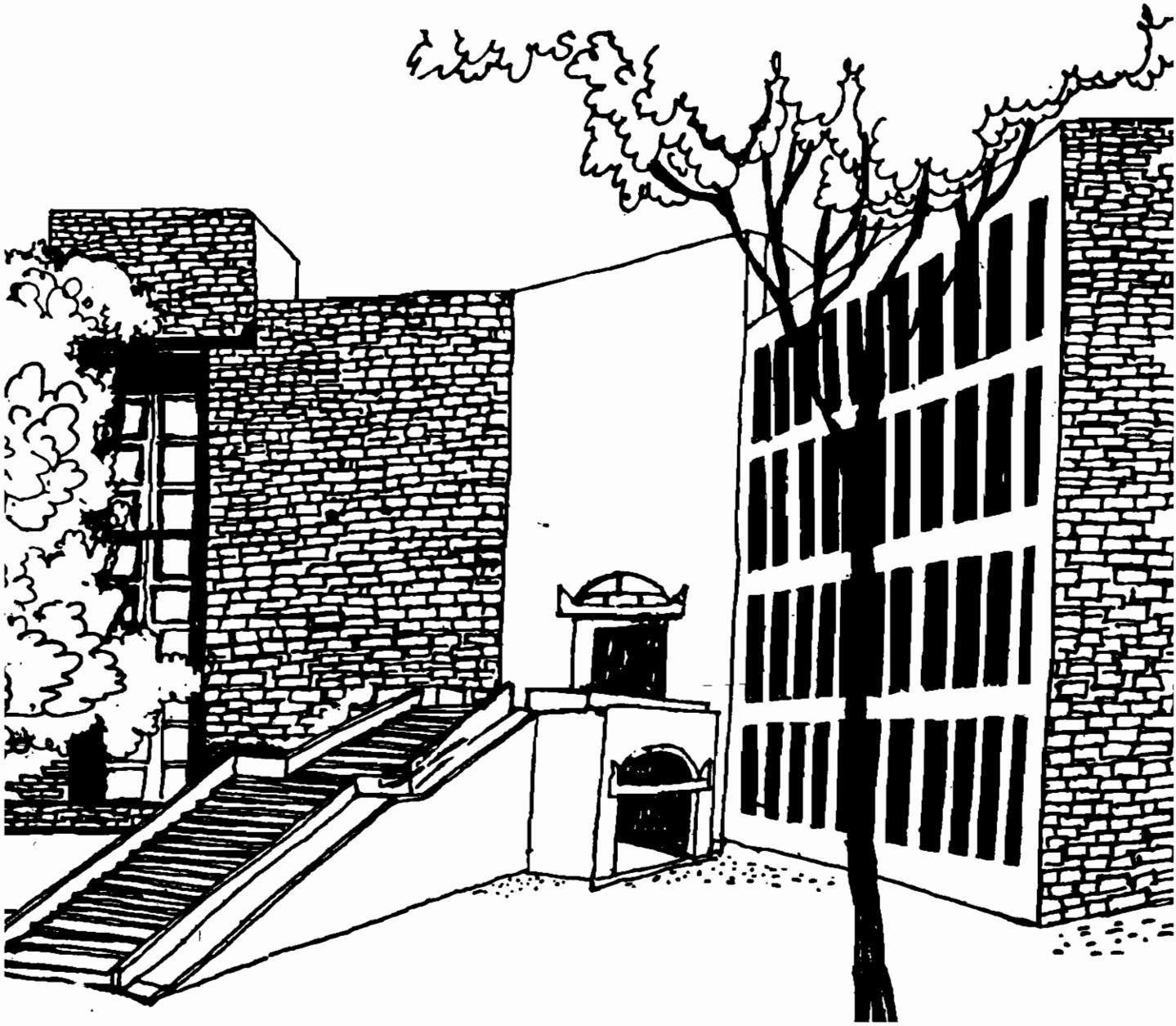
विद्याविनियोगाद्विकासः
IIM
AHMEDABAD

Working Paper



AN OPERATIONAL STUDY OF CJ PATEL VEGETABLE AND FRUIT MARKET OF AHMEDABAD

By

Girja Sharan
T. Madhavan

W.P. No. 1390
September 1997

INDIAN INSTITUTE OF MANAGEMENT
AHMEDABAD - 380 015
INDIA

An Operational Study of CJ Patel Vegetable and Fruit Market of Ahmedabad

Girja Sharan T Madhavan

Centre for Management in Agriculture
Indian Institute of Management,
Vastrapur, Ahmedabad 380 015

Abstract

We present in this paper, an operational study of CJ Patel Wholesale Fruit and Vegetable Market (CJP Market) of Ahmedabad city. The market is viewed as a dynamic queuing system. A simulation model is constructed. Simulations are used to generate statistics on congestion as the volume of trade is increased from the present level to what would be expected by the year 2010 A.D. This market was built in the year 1996 in order to reduce congestion in another older market. While the buildings are designed to last a long time, simulations show that its handling capacity will get saturated much sooner, most likely by the year 2010 A.D.

Based on this work, it is argued that program to modernize loading, unloading and other handling systems must be initiated now. Further, design procedures for such markets need to recognize these as dynamic queuing systems and not just an assembly of buildings and road.

1. Introduction

India ranks second in the world in vegetables and fruits with combined annual production of 60 m tons. Primitive post harvest (PH) system prevents this high ranking in production from being translated into equally impressive presence in market. System is unable to move produce rapidly over long distances without excessive damage and spoilage. Fresh vegetables and fruits are therefore available mostly in the vicinity of growing areas and near the time of harvest.

The Regulated Wholesale Markets in cities are vital nodes of PH system. Growers send their produce daily to these markets for auction. Small traders and retailers buy there for sale to consumers in their areas. Striking feature of these markets is congestion,crowding and litter. Even though the produce spends only a few hours in these markets, significant mechanical damage and contamination occurs in the course of loading, unloading and handling. Modernisation of handling systems in these markets is important if consumers are to get better quality.

Modernisation is imperative from another angle. Demand for fresh produce grows faster than the population in cities. Markets therefore get congested rapidly. Those who run these markets solve

the problems by moving into a bigger place every few years. Take for instance, the case of Ahmedabad city. Regulated wholesale market began functioning here in the year 1948. Annual trade was 0.05 million tons then. It grew tenfolds to 0.5 million tons, by 1995. This growth rate works out to 5.33% per year. In other words, volume doubled every 13 years. The Agriculture Produce Marketing Committee (APMC), the authority which regulates wholesale trade had to build a new market at Jamalpur in 1980. Built on a plot admeasuring 15,000 m^2, this too became highly congested within a few years. In 1996, a second market was built at Vasna named CJ Patel market. This is built on a plot twice as large. The cost of Jamalpur market was Rs. 9 million, that of CJP Market ten times as much, Rs. 90 million. Space is becoming increasingly scarce and expensive in big cities. It will not be easily possible to acquire bigger spaces in future.

Buildings in these markets are designed to last fifty years or more. But their utility as market place diminishes much sooner, because of increased traffic. Passages get occupied with produce, movement of vehicles gets impeded and standards of cleanliness deteriorate. Civil engineers view these markets only as civil structures. In reality, these are dynamic queuing systems. It is important to take this view into account in design procedures.

Simulation models are extensively used for designing and operational management of manufacturing facilities [**1,2**]. Use of such models for vegetable markets is not common. We present in this paper a model of CJP Market viewed as a dynamic queuing system. Such models can be useful in guiding the program of modernisation of handling systems.

Operations of CJP Market are first described. Simulation model is then presented. Statistics on vehicle-borne congestion is generated and discussed.

2. CJP Market

This market is located on the outskirts of Ahmedabad city at Vasna. Trading in onion, potato and fruits has been shifted to this market in order to reduce congestion in the older Jamalpur market. Lay-out is shown in **Figure 1**. There are 120 shops for general commission agents [3]. These are of equal size, 13.5 m x 6 m and arranged in two concentric circles with 78 in the outer and 42 in the inner. A 24 m wide paved road lies between the two circles.

Gate A is for entry of vehicles carrying onion and potato, Gate B for those carrying fruits. Presently gate B is not used. Exit is common through Gate C. One way traffic facilitates easy movement of vehicles.

Operations

Market is open round the clock for vehicles bringing produce for auction. These vehicles are referred to here as seller vehicles (SVs). Date, time of arrival, vehicle number, place of origin, commodity, quantity, commission agent and shop number are noted. An entry fee is charged and a gate pass given.

SVs then go to the shop of the particular commission agent for unloading. Unloading is done from 6 A.M. to 9 P.M. Vehicles arriving after 9 P.M. have to wait over night.

Crew members generally spend some additional time, in the market, their vehicle is being serviced. Those from longer distance tend to spend more than those from nearby. In the model, this is termed as 'extra activity'.

Market opens for auction at 8 A.M. Buyers, who are sub-wholesalers and retailers, begin to arrive by about 7:30 A.M. Usually, a buyer will browse around for a while before finalising a deal. When deal is made, the commission agent (seller) issues an auction-slip to the buyer containing the details of the sale.

Buyer walks to the office at Gate A and obtains gate pass to bring his vehicle into the market for carting. Buyer vehicles(BVs) then enter. Most buyers arrange carting immediately. A small proportion take a little time, perhaps going to town for some other work before returning to pick up the material. This has been termed 'post-purchase activity'.

Loading and carting continues throughout the day. Weighing is done by market *tolats* (weight recorders and helpers), commonly on tripod balances. Bags are carried on backs by hamals (loaders) one at a time (**Figure 2**). Regulations stipulate that auctioned goods be weighed before 5 P.M. and carted out by 7 P.M. the same day.

SVs are mostly 7 to 10 ton trucks. BVs include hand-carts, camel carts, rickshaws, vans, medium and large trucks. All vehicles depart through Gate C, where gate pass and auction slip have to be returned. Vehicle may also be inspected occasionally.

A special feature of fruit and vegetable markets is that whatever is brought into the market is sold the same day. It is rare to find inventories in the shops. Daily arrival of stock does vary seasonally, but within a narrow band. It averages to 650 tons, which can go up to 800 tons during

peak month (January) and reduce to a low of 500 tons during lean month (July).

3. Modeling Tasks

Pattern underlying the following processes needs to be discovered. These are independent inputs.

1 Arrival of SVs,
2 Arrival of Buyers, browsing and buying
3 Arrival of BVs

In addition, time taken to complete the gate formalities at the entrance and at the exit, time taken to load and unload various vehicles need to be determined. It is also necessary to identify relative market share of the 120 commission agents.

Data was acquired from records as well as by direct observations. Analysis of pattern typically involves construction of frequency diagrams, trying out promising distribution and testing goodness of fit. For reason of space, we shall illustrate only one such analysis, namely the arrivals of SVs.

Inter-arrival Distribution of SVs

Seller Vehicle (SV) arrival data was acquired from records for seven consecutive days, September 1-7,1996. Number of arrivals at hourly interval is shown in **Figure 3**. Although, arrivals occur round the clock, there are two peak periods. The first is three hours long (5-8 hours) and the second, five hours (17-22 hours). It was decided therefore to divide the day in three parts-part one (5-8 hrs), part two (17-22 hrs), and the rest as part three. Analysis of inter arrival time density was done separately for each of these parts.

Time of arrival of each vehicle is available from gate records. However, records tend to be inaccurate due to two reasons. Only an approximate time of arrival is important to market management which it needs to determine the parking fee. Arrival and departure time need only be exact to an hour. Second, entry is made when the vehicle reaches the counter, ignoring the time spent in queue. Thus, the records will include a random and unknown waiting time.

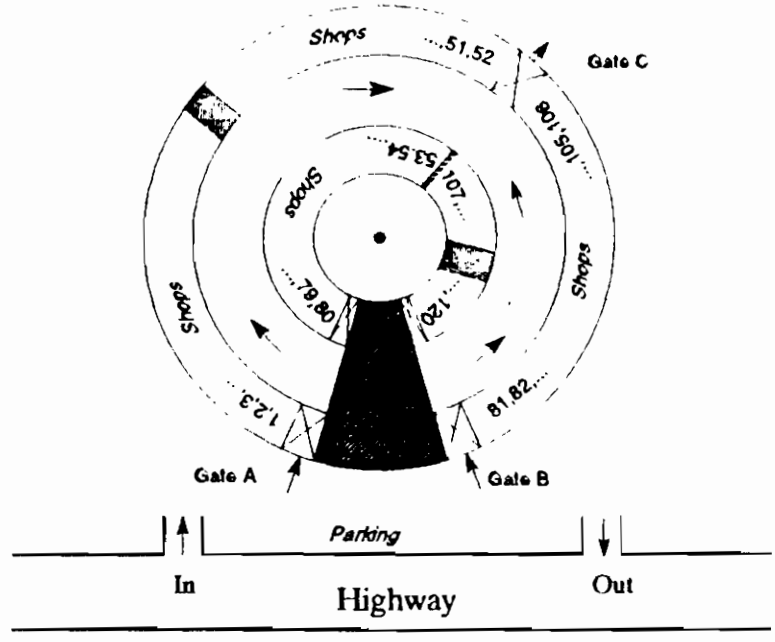
Inaccuracy is less at nights, when arrivals are fewer and queue mostly empty. We, therefore, made our own observations of inter arrival (IA) time during the day and relied on records for the nights.

Two-parameter gamma distribution was tried. The density of the gamma distribution is given by

$$f(x)=\frac{1}{\Gamma(\alpha)\beta^{\alpha}}\exp\left[-\frac{x}{\beta}\right]\ x^{\alpha-1}\quad ;\quad x>0$$

Parameters were estimated using method of moments (**table 1**).

Figure 1: C.J. Patel Market Vasna - Layout



Unloading by Hamal

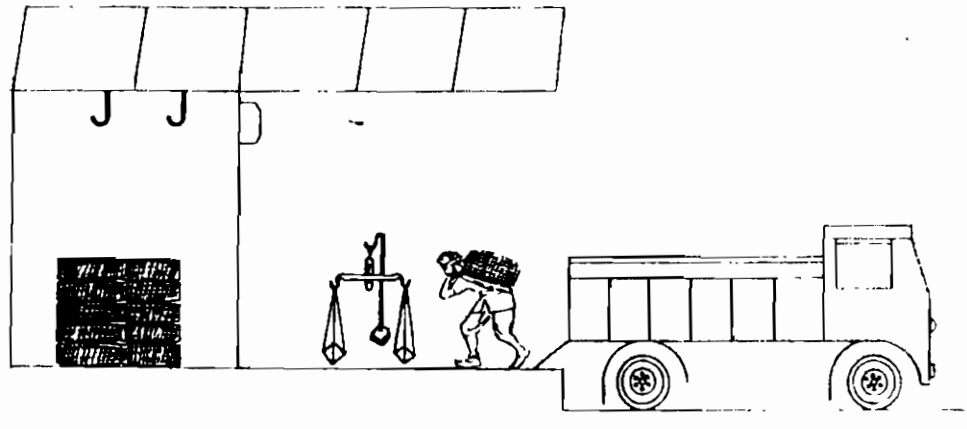


Figure 2

$$\hat{\beta}_i = \frac{\sigma_i^2}{\bar{x}_i} \qquad \hat{\alpha}_i = \frac{\bar{x}_i}{\hat{\beta}_i}$$

where

$\hat{\beta}_i$ is scale and $\hat{\alpha}_i$ shape parameter;

σ_i^2 variance and $\bar{x}_i$ mean

i designates the period.

Fit was good for the first and the third time period. **Figure 4** illustrates the frequency diagram for period one. Data of period two was taken for further investigation. An outlier was detected. That observation was removed. Truncated gamma distribution was tried, which yielded good fit (χ^2 (computed) 6.191).

Table 1
Statistical Parameters

Time period	Mean (mts)	Variance	β_i	α_i	d.f.	χ^2 computed	χ^2 critical
05 - 08 hrs	16.48	765.82	46.467	0.355	4	9.811	11.143
17 - 22 hrs	13.99	762.86	54.514	0.257	4	21.382	11.143
Rest	37.47	1740.36	46.445	0.807	5	10.440	12.833

Test and Refinement

SV arrivals were generated for 7 days using above distributions. Simulated results were compared with the empirical data, on two counts, (a) total arrivals in a day and (b) hourly arrival during the day.

It was found that observed and simulated values of total arrivals did not match. In order to refine the parameters further, a linear transformation was done using mapping as below.

$$\mu_E = a + b.\ \mu_M$$

$$\sigma_E = b\ .\ \sigma_M$$

where E - empirical and M - model

i.e. $57.57 = a + b\ (57.02)$ and $20.35 = b\ (1.27)$

Hence $a = -854.03$ and $b = 15.99$

Now, frequency in each class in simulated result is given by

$$f_M' = a + b.\ f_M$$

Figure 3

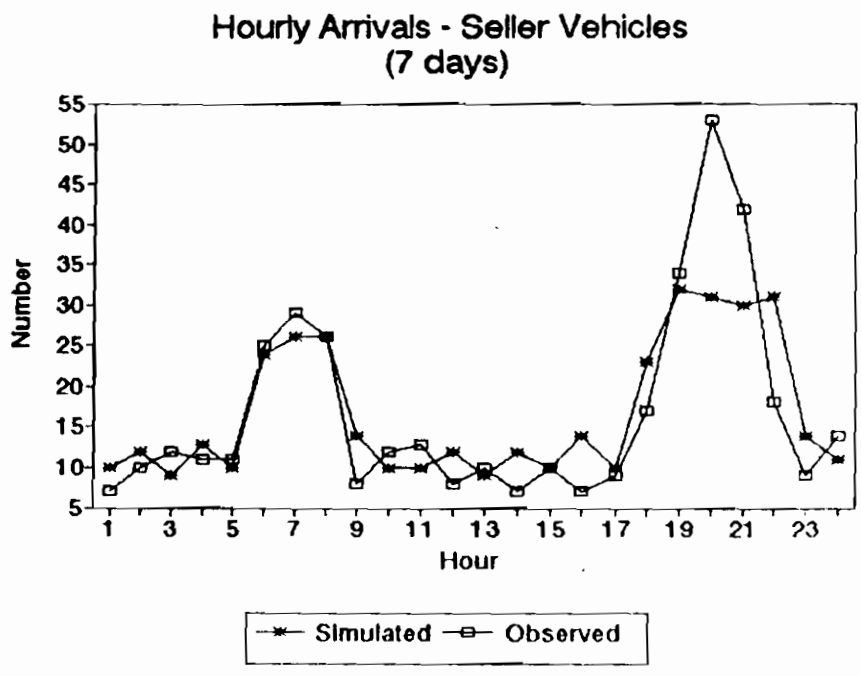
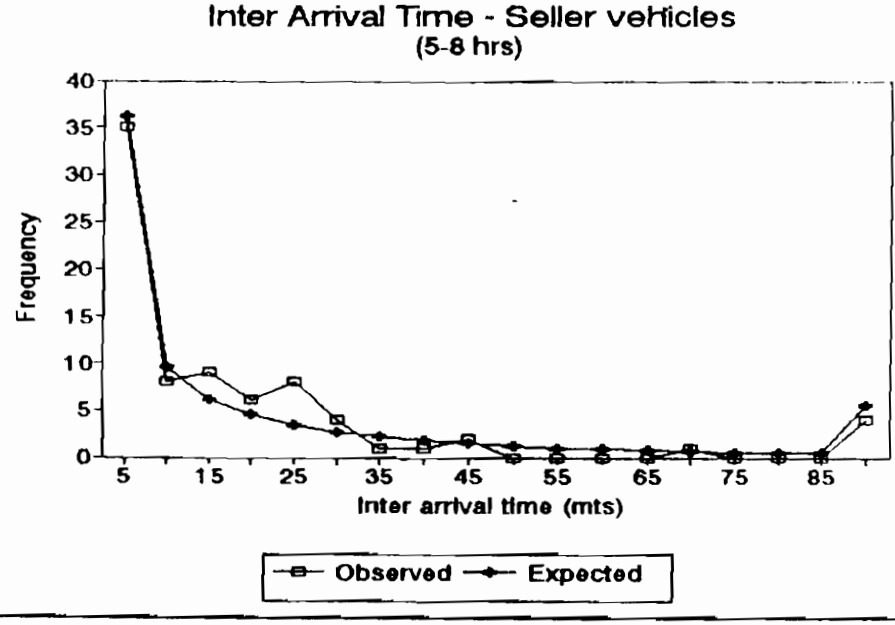


Figure 4



Comparison of frequency diagram of transformed results and empirical data showed good agreement. Number of hourly arrivals is shown in **Figure 3**. Kolmogorov-Smirnov (K-S) test was used to check the goodness of fit. The K-S statistic works out to 0.053 against a tabulated value of 0.061 at 10% level of significance. Hence the fit is good. Visual examination also shows that division of day in three periods did not distort the pattern of arrival. Parameters shown in the summary of representations below are refined ones.

Representations of other processes were similarly developed. These are summarized below.

Summary of Representations

Arrival of SVs

	Gamma (0.355, 46.47); 5 to 8 hours
	Gamma (0.371, 33.77); 17 to 22 hours
	Gamma (0.807, 46.45); all other times

Gate formalities	U (0.25-1.25)
Unloading time	empirical **(table 2)**
Extra activity time	U (60, 420)
Departure	

Arrival of buyers

	Exponential (λ = 1.03); 0730 - 1330 hours
Time-to-browse	U (0 - 30 mts)
Time to get gate pass	U (0.25 - 1.25 mts)
Post-purchase activity	U (300, 420), in case of 15%

Arrival of BVs

BVs enter when called by buyers with gate-pass

Gate formalities	U (0.25 - 1.25 mts)
loading time	empirical **(table 2)**
Extra activity	Exponential (λ = 15)
Departure	

Table 2 Loading Unloading Time		
Vehicle	Loading Time (sec/bag)	Unloading Time (sec/bag)
Heavy trucks	14 ± 6	11 ± 5
Medium trucks	18 ± 6	-
Three wheeled vans and others	34 ± 13	-
Note: Heavy : Leylands Medium : Eicher Canter, DCM Toyota, Tata 407 etc.		

4. Simulation Model

A simulation model was built and coded in SLAM-II network module. **Figure 5** shows the flow diagram of the CJP market simulation program. Source listing is available with the authors [4].

Prototype model was tested and refined. This was done by simulating the operations of the market for seven consecutive days and comparing the results with observations, specially collected for this purpose and not earlier used in model construction. This was done in the month of December (1996). Tests revealed the need for modification of some parameters which was made. Satisfactory prototype model was completed in March 1997.

5. Validation

Model is now undergoing validation, which began in April and will continue for a year. Each month we make observations over a 7 day period. On each day, number of vehicles in market, queue length at the gates are recorded at hourly interval from 8 AM to 6 PM. We also note the quantity of produce arriving for auction.

During the days of observation in April, arrivals averaged 750 tons/day. Model parameters were customised for this quantity. Simulation runs were made of 15 days at a time. Ten such replications were made. Each run started with empty market, at 6 AM on the first day. Results are given in **table 3**.

Mean number of vehicles in the market during the days is shown in **Figure 6**. It can be seen that the pattern is similar and the magnitudes are also very close. In anticipation of the model being found satisfactory when validation is completed, we will use it to study some operating characteristics, particularly the vehicle borne congestion.

Figure 5 Schematic Diagram of Simulation Program

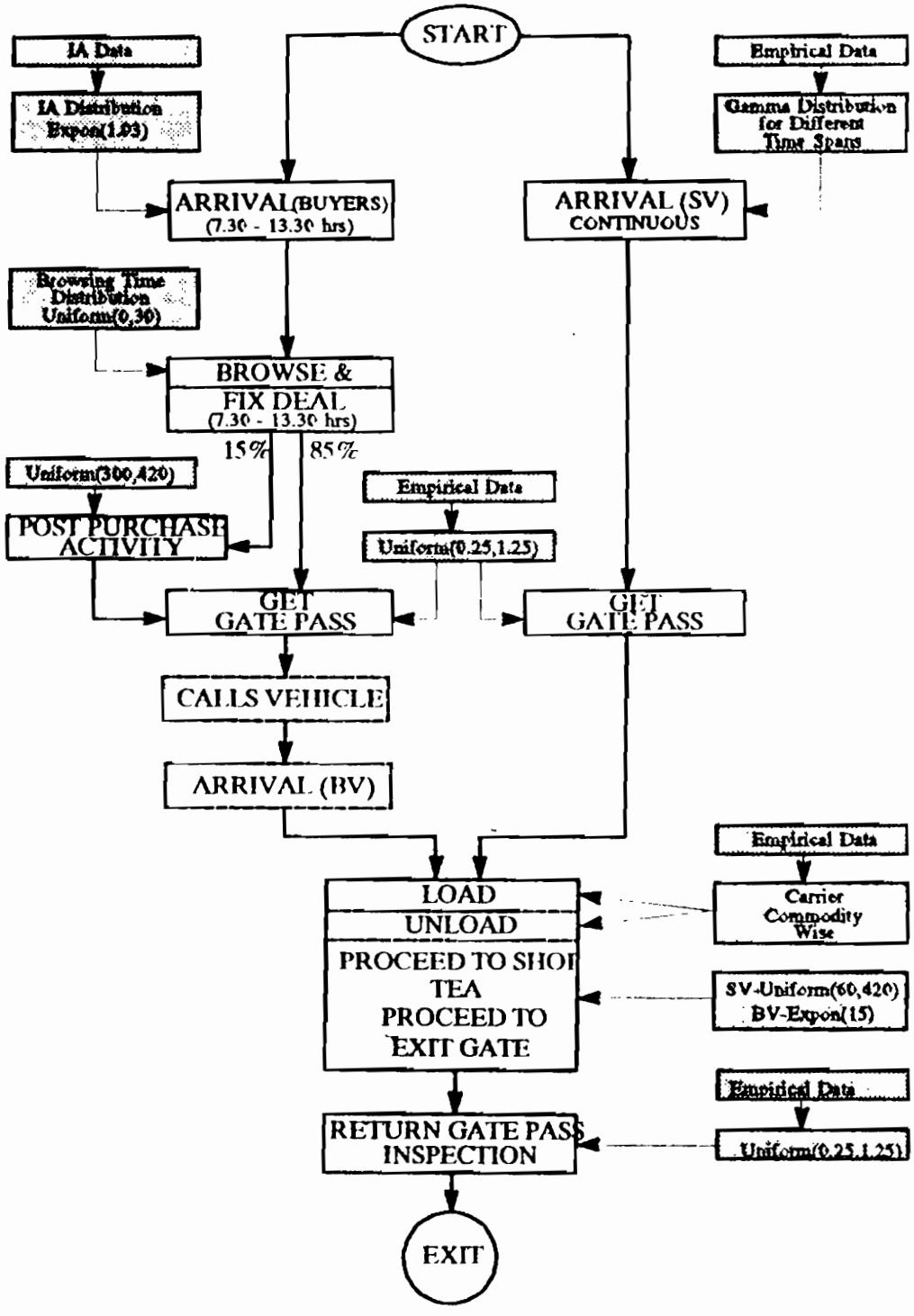
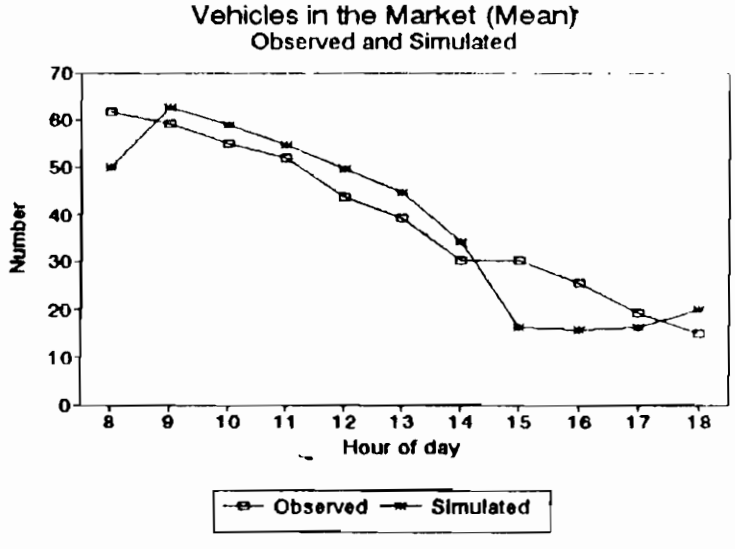


Table 3 Number of Vehicles in Market						
Hour of Day	Simulated (Arrival 750 tons/day)			Observations (April 1997)		
	Max	Min	Avg	Max	Min	Avg
7	37	6	33			
8	63	21	50	84	38	
9	75	38	63	95	30	
10	71	35	59	81	34	
11	75	38	55	75	35	
12	63	32	50	76	24	
13	56	33	45	60	24	
14	51	22	34	45	17	
15	24	7	16	51	12	
16	24	9	16	46	14	
17	23	9	16	37	11	
18	28	13	20	21	9	
19	32	17	25			

Figure 6



6. Daily Arrival and Congestion

As stated, daily arrivals in CJP Market presently vary from 500 to 800 tons/day. Given the fact that volume has risen by 5.33 per cent per year, it is likely that peak arrivals will grow to 1000 tons/day by year 2000 A.D. and further to 1200 tons/day by 2005 and 1500 tons/day by 2010.

We customised the parameters for arrivals of 1000, 1250 and 1500 tons/day. **Table 4** shows the results for the first two levels.

Table 4
Vehicles in Market: Simulated Results

Hour of Day	Daily Arrival (1000 tons)			Daily Arrival (1250 tons)		
	Max	Min	Avg	Max	Min	Avg
7	37	8	31	31	9	25
8	65	30	53	59	29	50
9	78	44	67	72	46	63
10	82	45	64	71	48	61
11	75	47	61	68	48	58
12	70	45	57	69	46	57
13	66	43	51	68	44	54
14	60	36	48	63	40	52
15	61	33	47	58	43	51
16	60	16	34	63	42	51
17	45	14	23	60	40	50
18	40	20	28	70	31	53
19	46	25	33	72	34	47

Results are also shown graphically in **Figure 7**. The figure has the graph also of daily arrivals of 500 tons/day. Effect of rising volume of arrival on operational congestion can be seen from this figure.

Buyers in the market are retailers who need to return to their own shops as early in the day as possible. It is seen that by 2:00 P.M., there will be on an average 48 vehicles in the market, at arrival of 1000 tons/day. It will rise to 52 at arrival of 1250 tons/day. Simulation program identifies each vehicle. Most of the vehicles in the market at this time are buyer-vehicles (BVs). These are waiting for loading. Even by 7:00 P.M., the stipulated closing time for carting, as many as 33 and 47 vehicles are stranded respectively with the arrival of 1000 and 1250 tons/day. This clearly points to the need to speed up the system of loading and unloading.

A most interesting aspect came to light when we tried to run the simulation at arrival of 1500 tons/day. Number of vehicles continued to rise with each successive day (**Figure 8**). In other words,

loading and unloading becomes so strained that arrivals of one day will get carried over to the next and the vehicles waiting for service will go on increasing. In fact this tendency begins to arise just above 1250 tons/day.

Figure 7

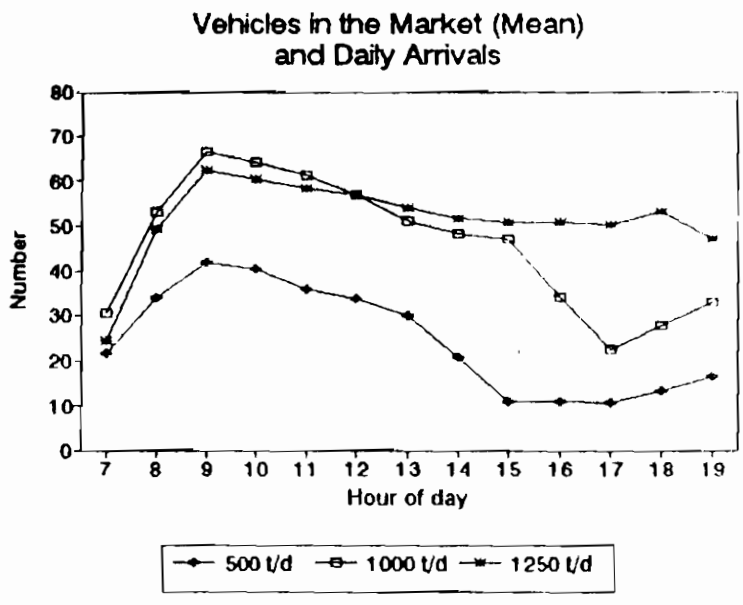
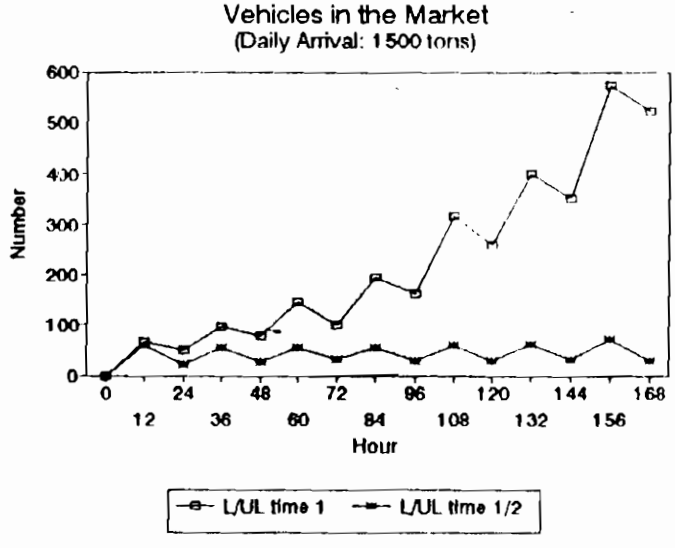


Figure 8



Unlike manufacturing facilities, ways to control congestion in fresh produce markets such as this are limited. One of the ways is to mechanise loading, unloading operations. Simulation showed

that instability can be removed by speeding up the loading and unloading operations. When we reduced the loading and unloading time to half the present values instability was completely removed **(Figure 8)**.

7. Conclusions

Design of wholesale fruit and vegetable market continues to be based on the view that these are just buildings and roads. While the buildings last a long time, their utility, as a market place, diminishes much sooner. This is because it becomes difficult to cope with traffic which grows with volume of trade.

Land has become scarce and expensive in cities. It will be infeasible in future to develop large conventional markets. It would be necessary instead to raise the handling capacity per unit space. Handling systems must be modernized and design procedures modified recognizing the fact that these markets are dynamic queuing systems. A model of CJP Market viewed as such was developed. Simulations yielded the following insights.

At present the daily arrivals in peak period is about 800 tons/day. At this level, no congestion is experienced. All work of carting and loading gets over by late afternoon, as stipulated.

Simulations suggest that situation will change significantly in next 5 to 10 years. By that time, peak arrivals could be 1000 to 1250 tons/day. Number of vehicles at peak hours would still be manageable. But operational congestion will become real. Carting and handling will then extend late into evenings. Buyers would find it unacceptable.

As the level of arrival goes beyond 1250 tons/day, CJP Market will just not be able to cope with the traffic. All the vehicles that arrive on a day will not be serviced the same day. This perhaps is the upper limit of the handling capacity of this market. This level of arrival is likely to reach by the year 2010. By then it would become necessary either to mechanise the operations or move to a new market.

Simulations also showed that instability was eliminated when loading and unloading time was reduced by half i.e. the operations were speeded up twice. This suggests the need of mechanising some of the manual operations.

Models such as this can be useful in designing new fruit and vegetable wholesale markets.

These can also be used to guide the program of modernization as well as operational management of the existing ones.

Acknowledgement

We thank Agriculture Produce Market Committee (APMC), Ahmedabad for letting us study the market operations and for providing data. We also thank Centre for Management in Agriculture (CMA), Indian Institute of Management, Ahmedabad for use of facilities.

References

1. Pritsker A.A.B. Introduction to Simulation and SLAM-II John Wiley, NY, 1986.
2. Law A.M. and Kelton W.D. Simulation Modelling and Analysis, McGraw-Hill 1991.
3. The Agricultural Produce Market Committee, Sardar Patel Market Jamalpur, Ahmedabad, 1981.
4. Sharan G., T. Madhavan, SCB Siripurapu, M Krishna Kumar, and SH Gabani. An Operational Study of CJ Patel Vegetable and Fruit Market of Ahmedabad. CMA Monograph (Mimeo), Indian Institute of Management, Ahmedabad. April 1997