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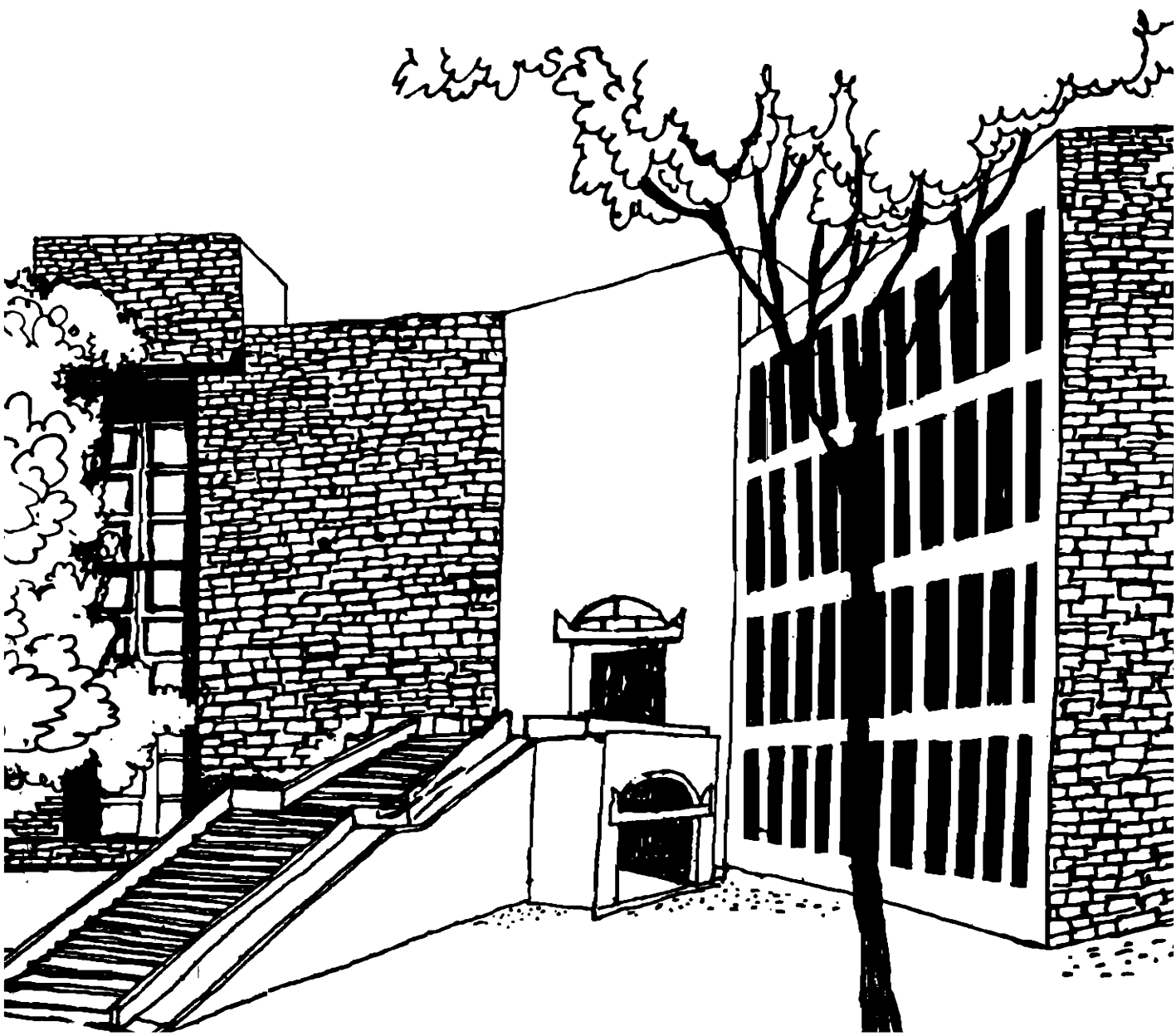

SIMULATION MODEL OF CJ PATEL VEGETABLE AND FRUIT MARKET OF AHMEDABAD

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Abstract

In this paper a simulation model of CJ Patel Vegetable and Fruit Market of Ahmedabad has been presented. Market is viewed as a dynamic, stochastic queuing system. Model was developed to provide a means to analyse vehicle-borne congestion.

Introduction

Wholesale markets in cities are the key nodes in movement of fresh fruits and vegetables from grower to consumer. Crowding, congestion and litter are the striking features of these markets. Even though the produce spends only a few hours in these, congested and crowded conditions enhance the likelihood of mechanical damage and contamination over and above that incurred in transit. Yet, congestion and consequent damage to produce has not received adequate research attention.

In this paper we present a simulation model that was developed to study congestion in CJ Patel Vegetable and Fruit Market of Ahmedabad. Market is viewed as a stochastic queuing system. 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. Such models can be useful for designing new markets, as also for operational management of existing ones.

Operations of CJ Patel Market are first described. Simulation model is then presented. Using the model, statistics on vehicle-borne congestion is generated and discussed.

CJ Patel Market

This market is located on the outskirts of Ahmedabad city at Vasna. It is built on a plot of about 3 ha and presently handles onion, potato and fruits. Layout is shown in **figure 1**. There are 120 shops for general commission agents [3]. These are of equal size 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. Each shop has a floor area of 13.5 m x 6 m. Ground floor is used to store stock and first floor for office and kitchen. All shops are provided with telephone and intercom facility.

There are three gates in the market. Gates A and B are used for entry and Gate C for exit. Gate A is for vehicles carrying onion & potato and Gate B for those carrying fruits. Presently gate B is not used. Exit gate is common. One way traffic system facilitates easy movement of vehicles.

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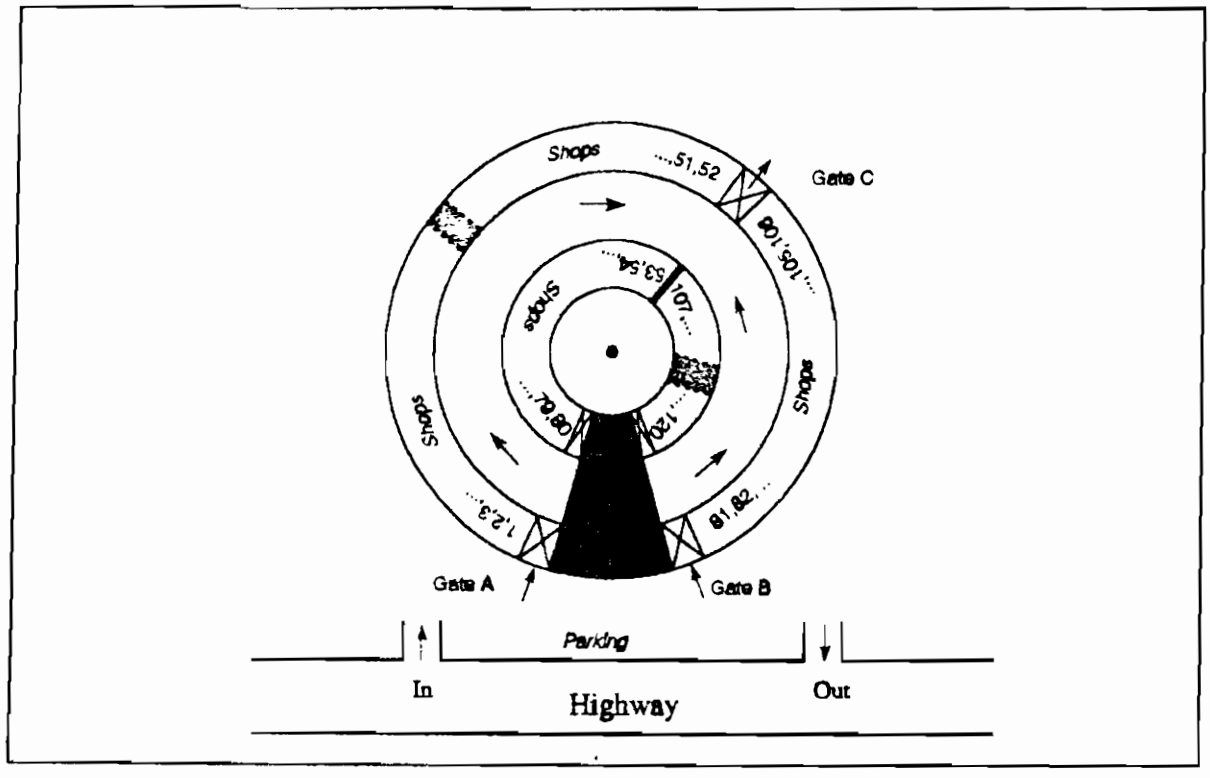
Figure 1: C.J. Patel Market - Layout



Operations

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

After gate formalities, SVs go to the shop of their respective commission agent for unloading. Unloading is restricted to a period from 6 A.M. to 9 P.M. Vehicles arriving after 9 P.M. have to wait over night. Unloading is done by hamals (haulers, loaders). Vehicles, especially those coming from long distances may spend some time in rest and refreshment before departure.

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, which has on it date, shop number, name and address of the buyer, item, quantity and price.

Buyer goes to Gate A with this slip to get a gate pass to bring in vehicle to cart the purchase. Buyer vehicles waiting outside, then enter the market, and go to the particular shop for loading. Most buyers arrange their carting immediately. A small proportion do so after a certain delay. These people perhaps go to town for some other work before returning to pick up the material.

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 one at a time. Regulations stipulate that auctioned goods be weighed before 5 P.M. and carted out by 7 P.M.

SVs are generally 7 to 10 ton trucks. Buyer vehicles include hand-carts, camel carts, rickshaws, vans, medium and trucks. All vehicles depart through Gate C. Gate pass and auction slip have to be deposited at the gate. Vehicle may also be checked occasionally.

Let us recapitulate. All vehicles entering the market form one common queue at the entrance gate. After gate formality, this common queue breaks into several parallel streams, each headed for the shop of its respective commission agent. At the shops, these are serviced (loaded, unloaded) on first-cum-first-served basis. After this vehicles proceed to exit gate, forming one common queue again and depart.

Resume' of Simulation Model

Modelling required discovering (a) the distribution underlying arrival of seller vehicles, (b) arrival of buyers, (c) service times at gates A and C, (d) loading and unloading time. Data used was acquired from records as well as by direct observations spread over several days.

For reasons of space, we will not present details. Data was plotted into frequency diagrams, whose examination suggested the likely theoretical distributions. These were tried and goodness of fit test was used to select the satisfactory ones, listed below. In order to simplify the task, it was assumed that all commission agents have equal share of trade.

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.

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
Unloading time, empirical
Extra activity time for seller vehicle crew U (60, 420)
Departure

Arrival of buyers

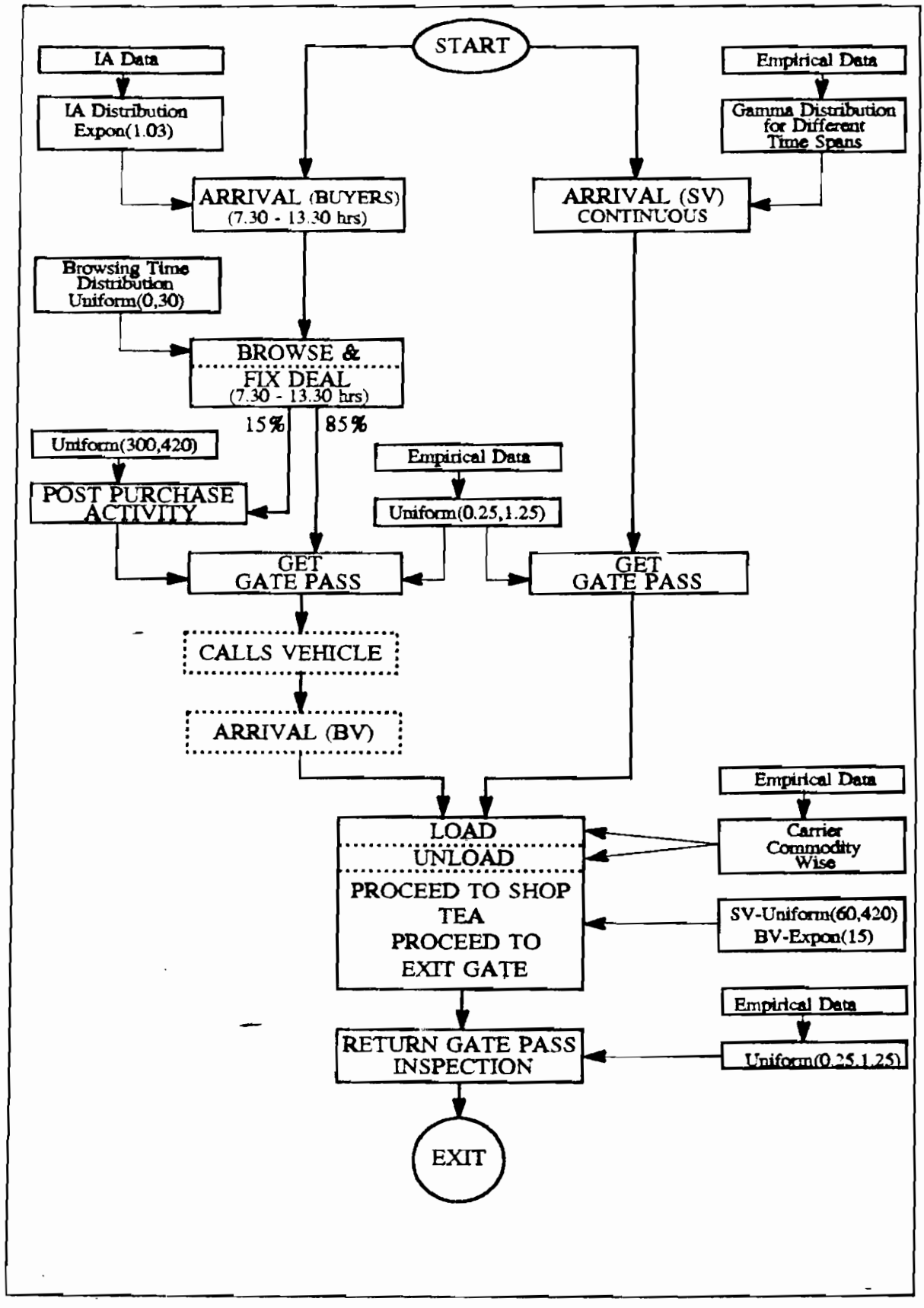
Exponential (λ = 1.03), 0730 - 1330 hours
Time-to-browse U (0 - 30 mts)
Time to get gate pass U (0.25 - 1.25 mts)
Post-purchase activity U (300, 420), only in case of 15% of the buyers

Arrival of buyer vehicles

Buyer vehicles enter when called by buyers with gate-pass
loading time, empirical
Extra activity time for buyer vehicle crew Exponential (λ = 15)
Departure

Model was coded in SLAM-II network module. **Figure 2** shows the flow diagram of the program. Source listing is available with the authors.

Figure 2 Schematic Diagram of Simulation Program



Validation

Satisfactory prototype model was completed in March 1997. It is now undergoing validation, which will continue for a year. Each month we shall observe the market for seven consecutive days and compare these with simulated statistics on number of vehicles in the market and length of queues at entrance and exit. So far data has been collected for the month of April, which is presented below.

Number of vehicles in market observed over 7 days at hourly interval in the month of April (1997) is shown in **table 1**. The magnitude of arrivals in April 1997 during the days of observation averaged 750 tons/day. Model parameters were customised for this level of daily arrival and simulations done.

Runs were made of 15 days at a time. Ten such replications were made. Each run of 15 days started with empty market initially. Stream of random numbers used on each run was different. These results are also given in **table 1**.

Table 1
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	62
9	75	38	63	95	30	59
10	71	35	59	81	34	55
11	75	38	55	75	35	52
12	63	32	50	76	24	44
13	56	33	45	60	24	39
14	51	22	34	45	17	30
15	24	7	16	51	12	30
16	24	9	16	46	14	26
17	23	9	16	37	11	19
18	28	13	20	21	9	15
19	32	17	25			

Figure 3 shows the graph of mean number of vehicles, observed and simulated. It is seen that the pattern is similar and the magnitudes also very close.

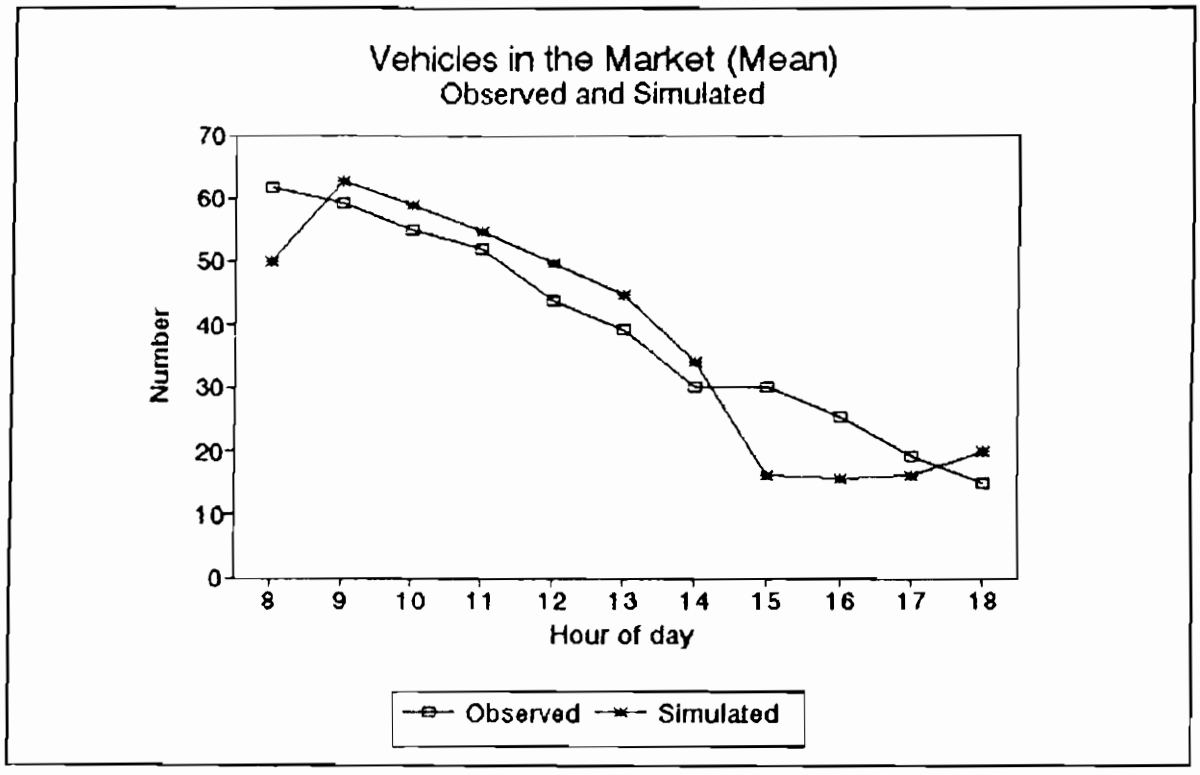
In anticipation of the model being found satisfactory when validation is completed, we will use it to study the operating characteristics of this market, particularly the vehicle borne congestion.

Operating Characteristics

Wholesale trade in vegetables has grown at the rate of 5.33 per cent per year in Ahmedabad in the past 50 years. This means that by about 2010, this market may expect arrivals of about 1,500 tons/day. We will exercise the model to see the effect of increased trade on congestion.

We customised the parameters for arrivals of 1000, 1250 and 1500 tons/day. **Table 2** shows the number of vehicles in market. It is seen that the peak number of vehicles will not rise significantly.

Figure 3



But operational congestion will become significant. By 7 p.m., there could be as many as 40 to 50 vehicles still to be serviced. These are peak values and may occur only once in a while.

Table 2
Vehicles in Market: Simulated Results

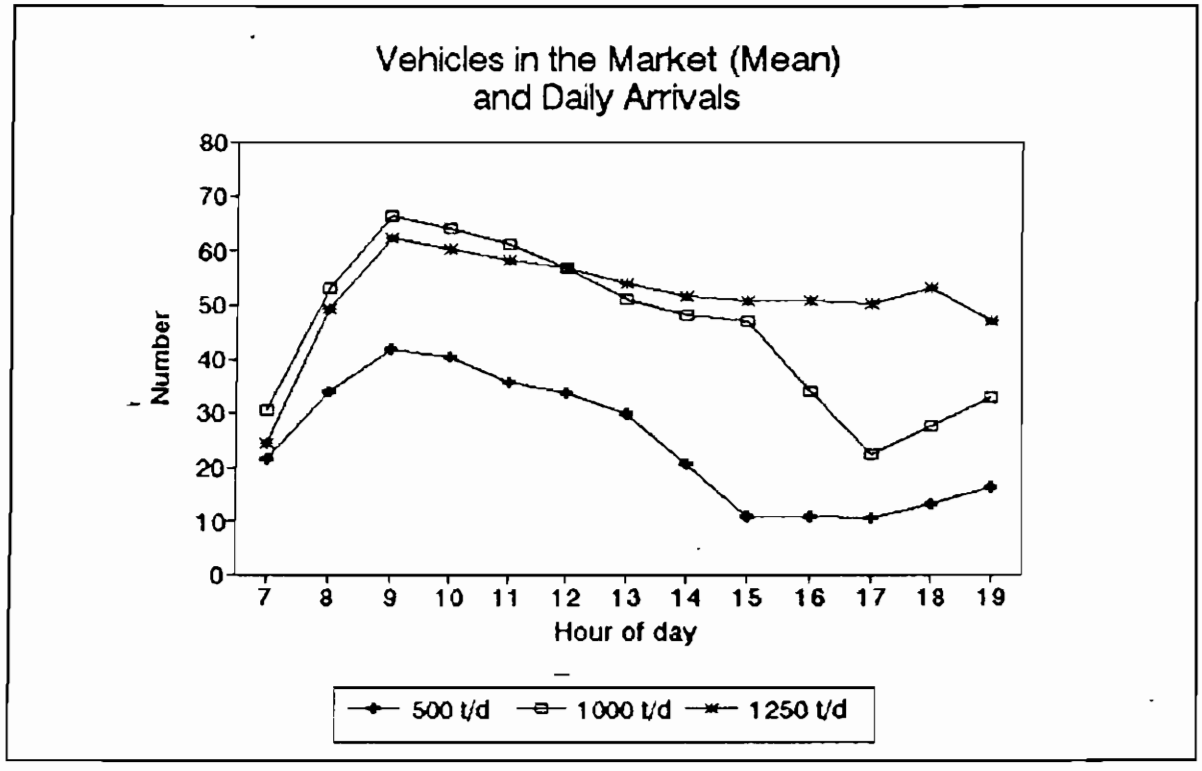
Hour of Day	Daily Arrival (1000 tons)			Daily Arrival (1250 tons)		
	Max	Min	Avg	Max	Min	Avg
7	37	8	31	31	9	25
8	65	30	53	59	29	50
9	78	44	67	72	46	63
10	82	45	64	71	48	61
11	75	47	61	68	48	58
12	70	45	57	69	46	57
13	66	43	51	68	44	54
14	60	36	48	63	40	52
15	61	33	47	58	43	51
16	60	16	34	63	42	51
17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

More relevant may be the mean values which are shown in **figure 4**. The figure shows that by 7 p.m. there will be on an average about 16 vehicles waiting for service at current level of arrivals (~~750~~ 500

tons/day). When it grows to 1000 tons, this number will increase to 33; and further to 47 when the volume grows to 1250 tons. This will mean that a large number of buyers will be unable to cart their material till late in the night. This would not be acceptable in market that deals with produce meant for fresh retail. It will be necessary to adopt measures to speed-up operations of loading, unloading and transfers.

A most interesting aspect came to light when we tried to run the simulation at arrival of 1500 tons/day. **Figure 5** shows a run of seven-day duration. Number of vehicles continued to rise with each successive day. In other words, this market as a queuing system becomes unstable. Loading and unloading is 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 of arrival.

Figure 4



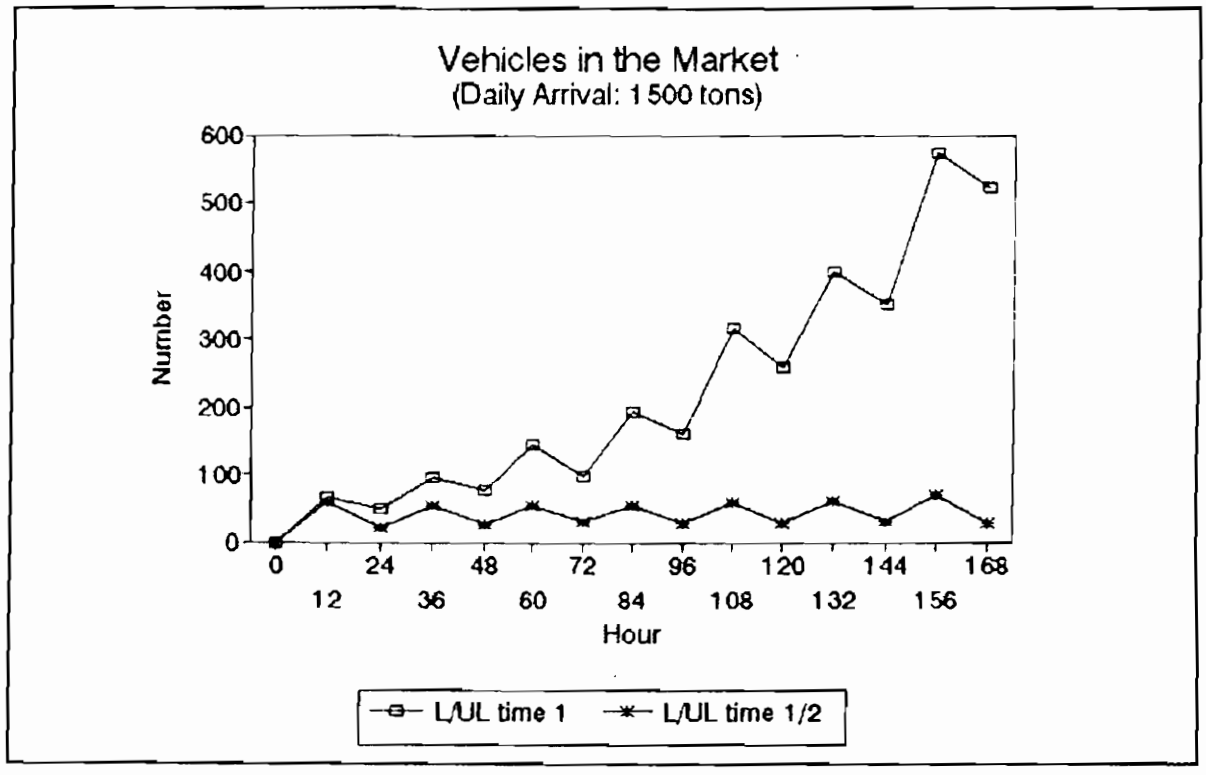
Unlike manufacturing facilities, ways to control congestion in fresh produce markets such as this are limited. One of the ways is to mechanise loading, unloading operations. Simulation showed that instability can be removed by speeding up the loading and unloading operations. When we reduced the loading and unloading time to half the present values instability was completely removed (**figure 5**).

Conclusions

Simulation runs using the model of CJ Patel Market yielded the following insights.

At present the daily arrivals vary from 500 tons around August to about 750 tons/day around March-April. At these levels, the peak number of vehicles in market does not exceed 60. And all the work

Figure 5



of carting and loading gets over by late afternoon, as stipulated by the market regulations. Thus, presently no congestion is observed. Simulation results also are in conformity with this.

Situation will change significantly in next 3 to 4 years. By that time arrivals could be 800 to 1000 tons/day. Number of vehicles at peak hours would then be 80 or more. This will not cause difficulty in terms of space, but could cause operational congestion.

Carting and handling will then extend late into evenings, necessitating extension of duty hours of hamals. But extending the hours will not be a satisfactory solution. Buyers would not like to wait that long to return to their own shops for sale. Mechanisation of some of the operations will be desirable.

A very significant finding of this study is that when levels of arrival go up beyond 1250 tons/day, CJ Patel 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. As a consequence the number of vehicles in market will grow steadily. In queuing theory this phenomena is called instability.

This occurred when simulations were made at arrival rate of 1300 tons/day. 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 to twice the present pace. This demonstrated the desirability of mechanising some of the manual operations.

Models such as this can be useful in designing fruit and vegetable wholesale markets. These can also be used to guide the program of modernization to reduce congestion and consequent damages to produce.

Acknowledgement

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