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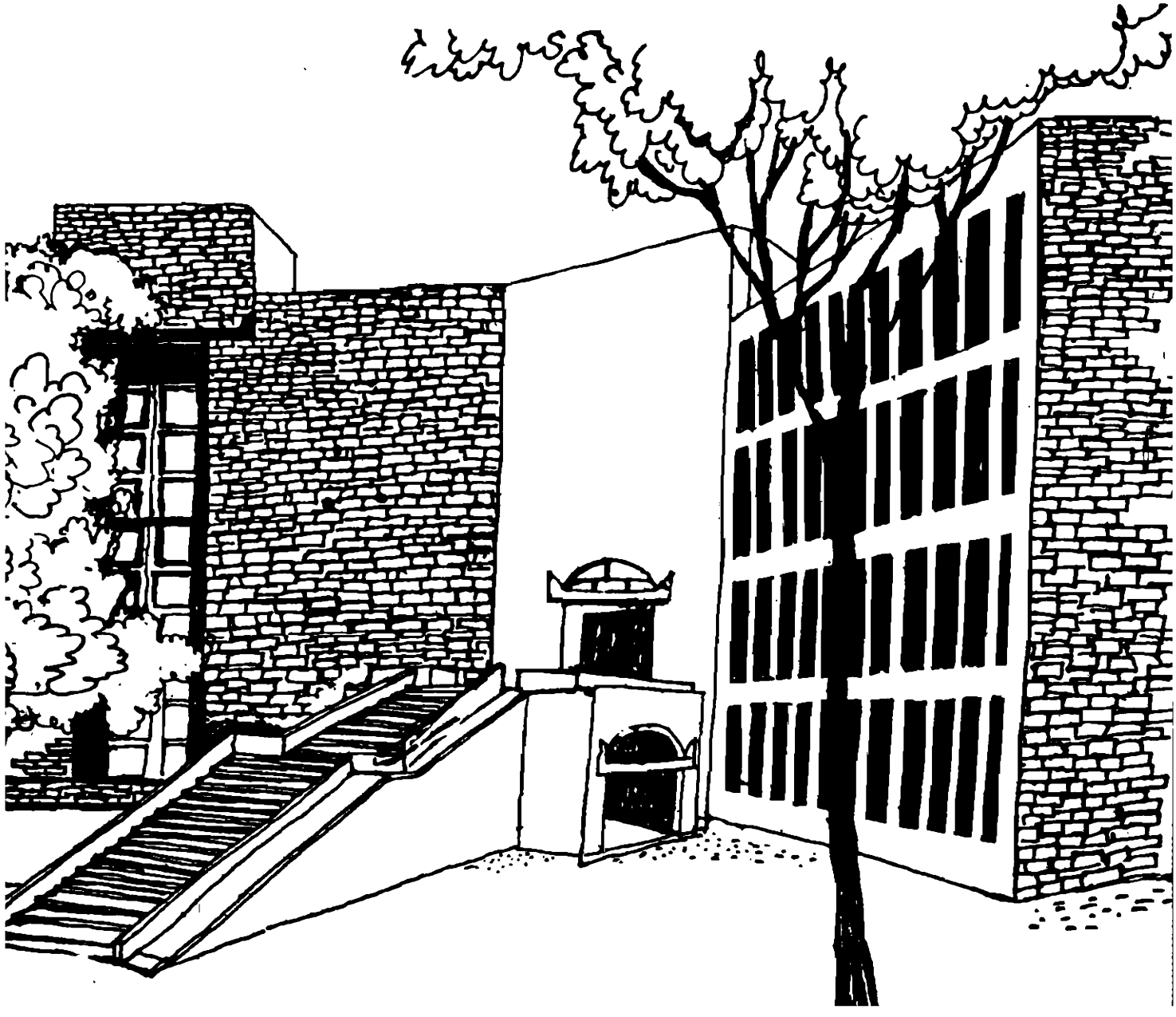
Working Paper



AN ANALYSIS OF CONGESTION IN WHOLESALE VEGETABLE AND FRUIT MARKET OF AHMEDABAD

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W.P. No.1359
March 1997

INDIAN INSTITUTE OF MANAGEMENT
AHMEDABAD - 380 015
INDIA

An Analysis of Congestion in Wholesale Vegetable and Fruit Market of Ahmedabad

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Abstract

Regulated Wholesale Markets in cities are the first destination of vegetables and fruits meant for fresh retailing. Congestion, crowding and litter are the striking features of these markets. Although the produce spends only a few hours here, congestion makes it very likely that mechanical damage will be done, in addition to that already incurred in transit. Yet, management of congestion has not received adequate research attention.

We present, in this paper, an analysis of congestion in C.J. Patel Wholesale Market of Ahmedabad. Market is viewed as a dynamic queuing system and a stochastic simulation model constructed. Simulations are done to generate statistics on congestion. Factors responsible as also the ways to reduce it are discussed. Design engineers and market managers can use such models.

Introduction

India ranks second in the world in the magnitude of production of fruits and vegetables. But the primitive technology of our post harvest (PH) system prevents this high ranking in production from being converted into equally impressive presence in market. Availability of fresh produce is mostly limited to near harvest time and near place of production. Presence in overseas market of Indian horticultural produce is insignificant.

PH system is now sought to be modernised. The motivation apparently is the opportunities for export. This is good, even though it is arguable if export can be sustained without first installing modern systems in home markets.

Packaging and transport and their link to mechanical damage has been studied [1]. But mechanical damage inside the market has not been adequately researched. Regulated wholesale markets in cities are the first destination in the movement of vegetables and fruits from farms to consumers. Congestion, crowding and litter are a common sight in such markets. Loading and unloading in congested conditions exposes the produce to further mechanical hazards, above that incurred earlier in transit.

Sardar Patel Market of Ahmedabad, owned by the Agricultural Produce Market Committee (APMC), handles about 1500 tons of produce each day [2]. Up until recently this included potato, onion, tomato and about 50 other items. During business hours (8 A.M. to 1 P.M.) there could be 100-200 vehicles of various types and size in the market, with more waiting outside. Seller vehicles are usually large and medium trucks. Buyer vehicles however, are smaller, more numerous and of many different types including hand-carts, camel-carts, small vans, matadors and trucks. Loading and unloading is hurried. Crates are dragged and pitched about carelessly. Bags containing vegetables manoeuvred with loading (steel) hooks, same as used in grain markets. Visual impression suggests that mechanical hazard could be quite significant.

In order to reduce congestion in this market a new one has now been commissioned. We shall presently describe it in greater detail. It is important to modernise these markets. Specially designed equipment to handle crated and bulk fruits and vegetables needs to be developed. Ways need to be found to reduce congestion, as it leads to enhanced likelihood of mechanical and other damage.

Reducing congestion is important from another point of view. Present day markets tend to use large areas of land, an increasingly expensive item in cities. Expanding the size of market to reduce congestion will not be easily feasible in future. Larger volumes will have to be handled per unit area. In view of its importance and the fact that it has so far not received adequate research attention, a study has been undertaken to find cost effective ways of managing congestion.

Measure of Congestion

We will use the following measure to quantify congestion.

$$C(t) = \frac{n(t)}{N}$$

where

t	time of day
n(t)	number of vehicles present in the market at time t
N	maximum number of vehicles that can conveniently be accommodated in the market

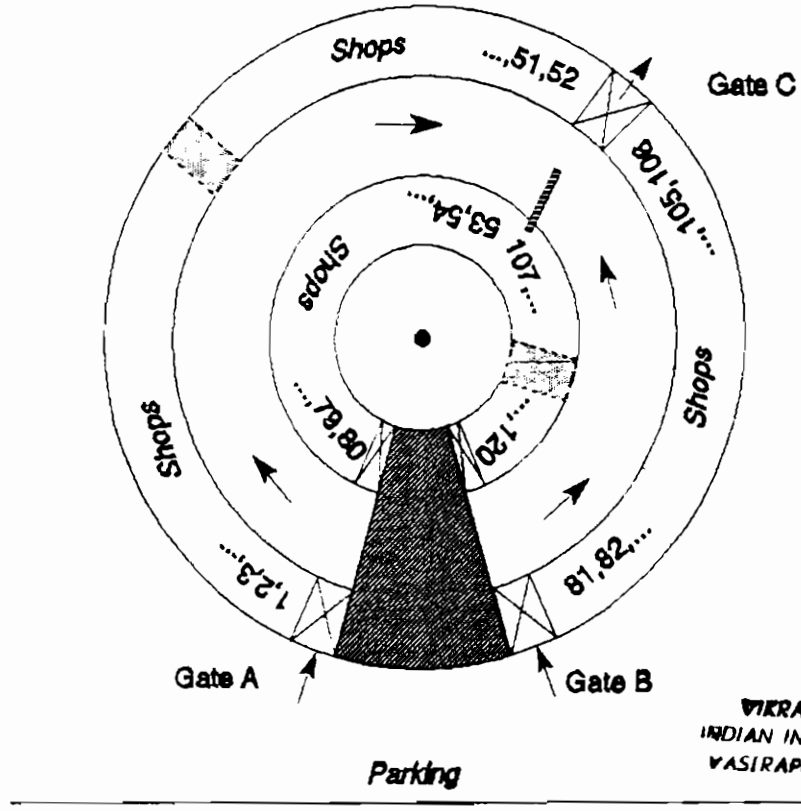
Note, n(t) is sum of several terms - number of vehicles, inside market waiting in queues for loading or unloading; number of vehicles at loading platforms being served; number of vehicles in queue at exit gate on way out, number of vehicles at exit gate being served. Congestion is also created by presence of people, but presently we shall leave this out of account.

We selected **C.J. Patel Fruit and Vegetable Wholesale Market, Vasna, Ahmedabad** for this study. We shall first describe its physical lay-out and operations. Based on the description, a queuing model will be made. Simulations will be made using this model to generate statistics of the number of vehicles in the market, n(t), on a typical day. This will enable us to quantify degree of congestion, at various times in the day. Finally, ways to reduce congestion will be discussed.

C.J. Patel Market

As stated earlier, the APMC built this new market at Vasna to reduce congestion in the Sardar Patel Market at Jamalpur. It began operating in July 1996. Its design is essentially similar to that of Sardar Patel Market, only bigger in area and circular in plan. A lay-out is shown in **figure 1**. Potato, onion and fruit trade has been transferred from Jamalpur to this market. There are 120 shops for general commission agents. Shops are of equal size, arranged in two concentric circles with 78 in the outer and 42 in the inner. There is a 24 m wide road between the two circles. The first 80 shops are for onion and potato and the rest 40 for fruits. Market is built on a three hectare plot.

Figure 1: C.J. Patel Market (Vasna): Lay-out



Each stall 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.

Three gates are provided in the market. Gates A & B are used for entry and Gate C for exit. Gate A is used only for onion & potato and Gate B for fruits. Exit gate is common. One way traffic system facilitates easy movement of vehicles. There are two parking lots. The one outside is for vehicles carrying goods, inner one for vehicles of customers, market personnel and visitors.

Vehicles bringing goods can enter the market round the clock. Auctioning takes place from 8 A.M. to 1 P.M. Market regulation stipulates that auctioned goods be weighed before 5 P.M. and carted by 7 P.M. Trading is closed on Sundays.

Seller vehicles are generally big trucks. Buyer vehicles include hand pulled *cart* camel carts, small carriers, vans, medium and (some) big trucks. Vehicles generally seen i the market and their pay load capacity are given in **tables 1 & 2.**

Table 1
Mix of Vehicles

Seller Vehicles		Buyer Vehicles	
Big trucks	95%	Medium trucks	40%
Others (matadors)	5%	Matadors	40%
		Three-wheelers	15%
		Carts (camel, hand)	5%

Table 2
Pay Load

	Capacity (tons)	Potato (bags)	Onion (bags)	Loading Time (sec/bag)	Unloading Time (sec/bag)
Big Trucks	10	125	160	14±6	11±5
Medium Trucks	3	40	50	18±6	
Matadors	1.5	20	25		
Tempos	0.75	10	12	34±13	
Carts	0.75	10	12		

Arrivals

When a seller vehicle (SV) reaches the gate. date & time of arrival, vehicle number, place of origin, commodity and quantity, and agents name and shop number are noted. An entry fee is charged and a gate pass given. Gate pass is to be returned at the exit gate.

After this the vehicle goes to its destination shop, for unloading. Licensed hamals (loaders) are available from 6 A.M. to 9 P.M. A vehicle arriving after 9 P.M. has to wait over night. Usually one, when necessary two, trucks can be placed at the loading platform in front of each shop at a time.

Auction

Buyers (small traders, sub-wholesalers) begin arriving slightly before 8 A.M. Trading hours are from 8 A.M. to 1 P.M. Buyers spend some time browsing. When the deal is made he goes to get a pass. Seller issues an auction-slip to the buyer, which has on it date, shop number, name & address of the buyer, item, quantity and price. Buyer goes to Gate A to get a gate pass for vehicle to cart the purchase. Buyer vehicles (BVs) wait outside, until gate pass is obtained by the buyer. BVs then enter the market, to cart the purchase out.

Loading

Loading and carting is allowed from 8 A.M. to 7 P.M. Weighment is done by market Tolats (weight recorders and helpers). Tripod balances are the common equipment for weighing.

Departure

All vehicles depart through Gate C. Gate pass and the buyer slip have to be deposited at the gate. Vehicles may also be inspected occasionally.

Daily record of business is kept for each shop. Daily tally of arrivals, sales and prices are published. The Statistical Officer of APMC analyses the data and issues the necessary press note.

Handling Equipment

Equipment for transport, haulage, handling, waste disposal, weighment are the same as in the older markets. Data entry, storage and retrieval is manual as in others. No additional facilities such as for clearing, grading, quality assessment are envisaged.

Data Base

Modelling involves identification of the time pattern underlying various processes, measurement of time taken in various activities. Necessary data was collected by direct observation spread over several days. Some data was also obtained from APMC records. Main processes and the data base used are listed below.

(a) Inter-arrival density of seller vehicles

Data base consists of time of arrival of seller vehicles round the clock for seven days; direct observations were made during the day, gate records were used for the night arrivals.

(b) Service time at gates A and C (B is presently not in use)

Data base consists of direct clocking for one whole day each at the two gates.

(c) Time to load and unload vehicles

Three observations were noted for each type of vehicle visiting the market including trucks, vans, carts etc.

(d) Arrival patten of buyers. time taken to browse

Buyers can enter and exit freely. It is not possible to note inter-arrival time as it is difficult to tell who is a buyer and who is not. Presently, therefore, we have assumed a pattern which, we think, is realistic.

(e) Inter-arrival density of buyer vehicles

Data base same as in (a)

(f) Estimate of volume of daily trade; from APMC records.

Simulation Model

Let us recapitulate the market operations briefly. SVs arrive round the clock, join the queue at Gate A, to get their gate pass. After that they proceed to their destination shop. Arrivals during the day are serviced (unloaded) immediately. Those arriving at night wait at their destination shops until hamals arrive and service begins. Vehicles depart from gate C after unloading.

Buyers begin to arrive slightly before 8 A.M. They look around for a while going from shop to shop. When a deal is finalised, they procure a gate pass and bring their vehicles for carting. A small proportion of buyers (15%) call in their vehicles after lapse of a certain time. This has been termed post-auction activity in the model. Auction closes at 1 P.M. Carting continues till 8 P.M. Buyer vehicles also depart from Gate C.

Assumptions

To simplify the modelling task, we shall assume the following:

(a) All general commission agents, have an equal share of trade. This assumption will not jeopardise the main statistic--total number of vehicles in the market--in which we are interested presently. It will only misrepresent queue lengths in front of each individual shop, not of interest presently.

(b) Daily demand and daily supplies are nearly equal. This assumption is quite realistic; inventories in fresh markets are usually small or none.

Input Density Functions and Parameters

Sequence of analysis typically followed in developing input distributions is as follows [3]. Raw data, say the inter-arrival time of seller vehicles, was plotted in the form of frequency diagram. Visual inspection often suggested the likely form of underlying distribution. That form was then tried and goodness of fit test done. The form that proves satisfactory in test is accepted as the distribution underlying that process. Input distribution underlying the processes in C.J. Patel market are summarised below.

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) Rest

Arrival of buyers

- exponential (λ = 0.85), 8 - 13 hours
- purchase quantity - empirical distribution
- time-to-browse Uniform (0 - 30 mts)
- time to get gate pass Uniform (0.2 - 1.25 mts)
- post-auction activity Uniform (300, 420), only in case of 15% of the buyers
- buyer vehicles arrival - triggered by buyers with gate pass
- loading and unloading time - empirical measurements (**table 2**)

Model was coded in SLAM-II network module [4]. Source listing is available with the authors.

Sample Simulation Run

A sample run of 24 hours was made.

Initial conditions

a. All Queues are empty.

b. No vehicle is waiting for unloading or loading at any of the shops.

Run length: 1440 minutes (1 day)

Table 3 shows a summary of results. At 6 A.M., as stipulated in the initial conditions, there are no vehicles in the market. All queues are empty. In the next one hour, five seller vehicles arrived, three of these got unloaded and left. Two are being unloaded. Those waiting to be loaded or unloaded are shown in column (6). Those actually being serviced are shown in column (7). Column (8) shows the number of vehicles in queue at exit gate.

Until 8 A.M. only SVs are entering the market. BVs begin entering after 8 A.M. Column (1) and (2) show the cumulative count of vehicles entering the market. Column (4) shows the vehicles exited the market. The difference is the number inside, which for instance is 19 at 9 A.M.

SLAM-II output reports can be generated at any desired interval. In this run the reports were generated at hourly interval. On this day, a total of 81 SVs arrived at the market. A total of 427 BVs came during the market hours.

In this market there is a place to accommodate a maximum of 120 trucks. It is seen that the maximum of vehicles in the market on this day did not exceed 40. Thus there would not have been serious congestion.

Validation

This model is in the process of being validated. Fresh observations were made for a week, for use in validation. These included number of vehicles inside the market, size of queue at entrance and exit gates. We intend to make 500 replications of 24 hour simulation like the one shown above. Simulated statistics will then be compared with the actual observations. This work is likely to be completed by the end of March 1997.

Table 3
State of Market on A Typical Day: Simulation

Time (hr)	Vehicles Entered		Veh. Left	Veh. in Market	Veh. Waiting for L/UL	Veh. Being L/UL	Exit Gate Queue	Veh. Waiting for Entry Pass	Hamal duty status
	SV	BV							
6	0	0	0	0	0	0	0	0	On
7	5	0	3	2	0	2	0	0	On
8	9	0	7	2	0	2	0	0	On
9	12	49	42	19	2	11	6	0	On
10	14	130	120	24	5	10	9	0	On
11	18	206	196	28	10	13	5	0	On
12	20	287	272	35	15	12	8	0	On
13	23	365	356	32	16	12	4	0	On
14	26	427	433	20	17	2	1	0	On
15	29	427	437	19	17	2	0	0	On
16	31	427	440	18	17	1	0	0	On
17	34	427	444	17	17	0	0	0	On
18	39	427	447	19	17	2	0	0	On
19	43	427	451	19	17	2	0	0	On
20	47	427	455	19	17	2	0	0	On
21	52	427	460	19	17	2	0	0	Off
22	56	427	462	21	21	0	0	0	Off
23	59	427	462	24	24	0	0	0	Off
24	63	427	462	28	28	0	0	0	Off
1	66	427	462	31	31	0	0	0	Off
2	69	427	462	34	34	0	0	0	Off
3	72	427	462	37	37	0	0	0	Off
4	75	427	462	40	40	0	0	0	Off
5	78	427	462	43	43	0	0	0	Off
6	81	427	462	46	46	0	0	0	Off

Conclusions

C.J. Patel Wholesale Vegetable and Fruit Market of Ahmedabad located at Vasna was modelled as a stochastic, dynamic queuing system. Model was coded in SLAM-II Network Module. A sample simulation run has been done. Validation of the model is in progress. Such models can be used by engineers designing fruit and vegetable markets and managers running these.

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