INCREASED EFFICIENCY OF RAW TOMATO TRUCKING OPERATION

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ABSTRACT

XYZ is a major food processing company with several canneries located in Western United States. The cannery considered in this analyses contracts to several trucking companies for the transportation of tomatoes from the growing fields to the cannery. This study was conducted for XYZ's Agricultural Operations Department to evaluate the efficiency of the trucking operations. A model was developed to simulate the operating conditions, and the effectiveness of several alternate trucking strategies was developed and evaluated. The results of the study were utilized in performing a detailed economic analysis and specific steps for adoption and implementation were recommended. It is anticipated that significant cost savings will result to the company as a result of the adoption of these strategies.

INTRODUCTION

OBJECTIVE

This study was undertaken to develop an estimate of the equipment needs required to haul tomatoes from the areas where they are grown to one of XYZ's canning facilities. Also, any inefficiencies or bottlenecks in the present system were to be identified and economic methods suggested to alleviate or eliminate them.

DESCRIPTION OF THE PHYSICAL SYSTEM

XYZ subcontracts the transportation of its raw tomatoes to a number of independent trucking companies. These truckers haul the raw tomatoes from the various field supply locations to XYZ's canning facilities. A significant percentage of these field locations are located in the desert regions. The tractors used to haul the raw fruit are of two types - shuttlers and non-shuttlers. In a shuttling operation, the trailers are separated from the tractors upon arrival at the cannery. The tractor is then immediately available for use to haul an empty trailer set. In the case of non-shuttlers, the tractor is never detached from the same set of trailers.

The total harvesting season lasts approximately 14 weeks with the various tomato fields being picked at different times. The cannery operates 22 hours a day for 6½ days per week, with one half day downtime scheduled for Sunday. XYZ's Agricultural Operations (Field) Department coordinates the cannery production schedules with the arrival of tomatoes at the plant. The objective is to keep an 'optimal' inventory of loaded trailers at the cannery. This inventory level should be zero when the plant shuts down on Sunday and should be built up prior to the reopening of the plant twelve hours later. The desired inventory level is a function of the planned cannery capacity for a given week.

The various individual tomato fields that service the Cannery were aggregated into five districts. The tomato availability at each district follows a normal distribution for the length of operation of that district. All districts have given daily times of operation. The tomatoes harvested at the district are to be shipped to the plant, unless the plant's demands have been met, in which case the tomatoes are left in the field.

CURRENT METHOD OF DISPATCHING EQUIPMENT

It was Management's opinion that the current desert trucking operation was particularly inefficient. The Field Department had previously developed some rough guidelines for scheduling the dispatching of equipment up to 10 days in advance of the time the equipment would actually be utilized. There was no central dispatcher who would keep track of the daily equipment movements from the fields to the cannery and back. A gross and simple rule being followed was to assign a given number of tractors and trailers to a given district for one week, thus forcing these tractors and trailers to only haul tomatoes between the plant and their assigned district.

PROBLEM FORMULATION

The trucking problem was formulated as a simulation model. The major assumptions that were made in formulating the simulation model were:
...The tomato availability at each district follows a normal distribution with known mean and variance for each weekly time period;

...Non-shuttler queues have priority while unloading at the cannery or loading in the field;
...The unscheduled shutdown of the cannery has a Poisson distribution and the duration of the downtime has an exponential distribution;
...Trip times are normally distributed;
...An initial number of empty trailers are positioned at the district two days before it starts operating and are removed once the district shuts down. This is to allow shuttling at the districts;
...Opening and closing dates for each district and daily opening and closing times are known.

DESCRIPTION OF THE SIMULATION MODEL

Two days before the first field starts operating, the production levels at all the districts are generated for a one week operating period using a known normal distribution. A comparison is then made with the plant requirements for the same time period. If there is an excess amount available at the districts over the plant requirement, then this excess is divided proportionately among the desert districts currently open and the production at the districts reduced accordingly. This procedure is repeated on a weekly basis until the end of the season.

Finer production adjustments concerning whether a loaded trailer should be dispatched to the plant or left in the field is performed on a daily basis by a central dispatcher and depends on the plant production plan for that day and the current plant inventory of loaded trailers.

For each of the desert districts compute the plant inventory and I_p for the next T_k hours, where T_k is the average trip time from the desert district k.

$$I_p = \sum_{T=1}^{T_k} y_t \; \left(\sum_{i=1}^{n_o} k_i p_i \right) \; \sum_{i+1}^{n_d} d_i \; + l_p - \sum_{t=1}^{T_k} c_t$$

here y_t = 0 or 1 depending on whether district (non-desert) is open or closed;

k_i = a constant and a function of T_k to allow for several roundtrips between the plant and the non-desert district i;

p_i = production rate at district i

d_i = due in at plant from all districts;

l_p = current plant inventory

c_t = hourly plant consumption rate, it is 0 when the plant shuts down for scheduled or unscheduled maintenance;

n_o = non=desert districts;

n_d = desert districts.

If $I_p \geq \sum_{t=1}^{T_k+6} c_t$

then the decision is made to keep the load at the field. Otherwise it is shipped to the plant. Here the desired plant inventory is assumed to be equivalent to 6 hours of production requirements.

For the loaded trailers to be shipped to the plant, the model generates the trip times using a known normal distribution and schedules plant arrivals. At the plant, the model separates the loaded trailers from the tractors (for shuttlers) and places them in the loaded trailer and tractor queues. For non-shuttlers, both tractors and loaded trailers are filed in a priority queue. The loaded trailers are emptied at the plant at the production rate for that day. The empty trailers are filed in a queue of empty trailers.

An empirical relationship is used in deciding the priority ordering amongst the open district to which empty trailers are dispatched. Find district D* such that:

$$D^* = \max_i \{(p_i + l_i - d_i - r_i)t_i\} \quad i = 1,\ldots,n$$

where n is the number of currently open districts

p_i is the remaining daily production at district i

l_i is the number of loaded trailer sets at district i

d_i is the tractors due in at district i

r_i is the number of tractors currently at district i

and t_i is the one way average trip time to district i

At the end of the season for a given district, dispatch tractors only to the district that has closed to return the 'initial trailers' to the plant.

OUTPUT FROM THE MODEL

Weekly and total season reports were printed for each of the districts and the plant. The model provided the plant with an arbitrarily large number of tractor and trailer sets; for the attached example it was 700 and 950, respectively. Then, if from these two numbers we subtract the minimum queue sizes at the plant, we get the requirements for that time period. (Yield losses from tomatoes were estimated by tracking the average and the

FIGURE I
EQUIPMENT REQUIREMENTS OVER THE HARVESTING SEASON

Shuttlers To Non-Shuttlers

50 - 50

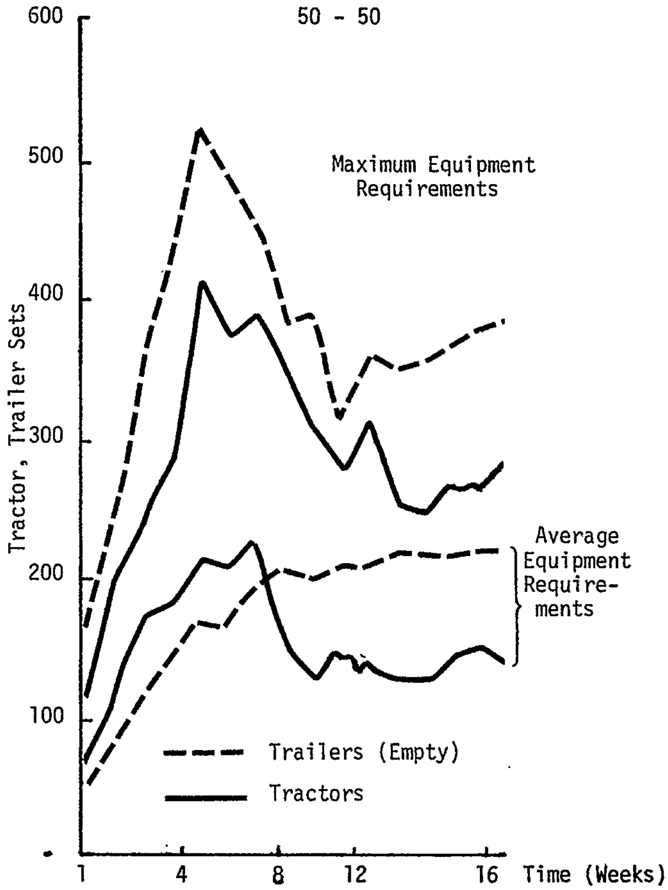

TABLE 1: WEEKLY PRODUCTION BY DISTRICTS

Field Location in Production		BR	BR BL	BR BL	BR BL KN	BR BL KN	BL KN OR	KN OR	KN OR	KN OR VT	KN OR VT	KN OR VT BU	KN OR VT BU	KN OR VT BU	KN OR VT BU	KN OR VT BU	KN OR VT BU
(a) Production by Districts (In Trailer Sets)	Total Prod'n	320	400	800	1300	1300	1450	1350	1050	1100	1300	1400	1400	1550	1500	1500	1250
	Non Desert	-	-	-	-	-	50	350	350	500	800	800	1200	1400	1400	1400	1200
	Desert	320	400	800	1300	1300	1400	1000	700	600	500	400	200	150	100	100	50
Time in week after season begins		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

(a) The numbers are purely exemplary and bear no resemblance to the actual data.

maximum time that elapsed between tomatoes being loaded at the district and unloaded at the plant.) A graph of the equipment requirements over the harvesting season is shown in Figure 1.

The results presented in the attached graph were based on the assumption that a central dispatcher would monitor the movements of the equipment both at the plant and the districts. At the plant, the decision has to be made concerning which district the equipment should be shipped to; at the desert districts, it is to decide whether or not some loads should be left in the field to keep the plant inventory at a desirable level.

For one case that was run without a central dispatcher and 100% shuttling, the equipment requirements increased about 20%.

IMPLEMENTATION OF THE RESULTS

The model output, particularly equipment needs and performance, was compared to actual equipment numbers and performance. From this, it was identified that one particular area was only 50% efficient (actual performance was one-half of that predicted by the model). Other areas, however, were shown to be 80% efficient and since these areas were known to be efficient operations, it was concluded that the model was a good predictor of potential performance. Further comparisons of model assumptions and actual operations identified the following differences as problem areas:

1. Lack of central control;
2. Slow response time (communications)
3. Limited shuttle (drop-trailer)

These items were corrected in the 1976 season by increasing control of harvest and trucking activities (increased personnel), increasing communications by adding more radio equipment and increasing the drop-trailer activities, all resulting in a significant drop in equipment requirements for the desert haul. No cost savings were reflected in the first year as hauling rates were already negotiated. However, it is expected that a rate increase will be avoided due to increasing revenue to the truckers by improving their performance. The company has proposed to extend this study to its other canneries.

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