SIMULATION GAME TO MATCH PRODUCTION AND DEMAND OF FRESH FRUIT MARKET

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Abstract

The problem of matching production and demand of fresh fruit produce is actual, and often people do not realise the implication of this issue on supply chain performance regarding profit, food waste, and shelf life.

The objective of the activity was to teach the power of matching orders and demand with production.

Both production and demand have random pattern studied and validated with data from the packing industry. Production is influenced by weather and by cultivation practices (e.g. irrigation, trimming, time of harvesting). Also, fruit size varies a lot. Ordering and demand had their pattern that could be varying by channels and influenced profoundly by promotion.

The authors implement a discrete event model that allows the student to perform some order and demand adaptation to match the production. Actions to modify the demand imply promotion (that double sales but decrease the profit to 20% of the typical case), finding channels for different sizes of the fruits. The model also considers lead times for product packing and transportation and show the effect of the student's choices on supply chain performance regarding supply chain profit, food waste, and shelf life. The model work step by step over a period of 40 days, allowing day by day decision from the user and plotting demand, storage and production day by day, in a stochastic way. Through the use of the model, the user experiences the difficulties encountered in an industrial environment while trying to match production and demand of fresh, perishable products.

The model interface and first students trials are presented in the paper.

Keywords: Simulation, orders, production, demand, matching

1 INTRODUCTION

Quality of food, in general, refers to the way in which the product is perceived by the final consumer, in according to the physical properties of food products. Therefore, beyond microbial aspects, texture and flavour are main aspects.

Commonly fresh commodities have a short shelf life and are characterised by susceptibility from physiological breakdown due to natural ripening processes, water loss, temperature and physical damage, or invasion by microorganisms. The limited shelf life of food products, is influenced by: temperature and humidity, potential interaction effects between products, time windows for delivering the products, high customer expectations, and low-profit margins. These factors make food product distribution management a challenging area that has only in recent times began to receive more consideration in the operations management literature [1].

Freshness loss is one of the main causes of fresh fruit deterioration that reduces the marketability and profitability. As reported in the research of Claudius & Ludivine [2] fruits are susceptible to perishability as a result of their cellular architecture and intensive metabolic activity particularly during the ripening and conservation stages. Therefore especially concerning fresh fruits products which are expected to be more perishable, the problem of matching production and demand is actual, and often people do not realise the implication of this issue on supply chain performance regarding profit, food waste, and shelf life.

On the other hand, shelf life, waste and profit of fresh fruits supply chain are difficult to predict correctly, due to the range and dynamics of the characteristics, storage conditions and market demand of these products.

To evaluate the shelf life Zhang et al. [3] proposed a model that explicitly includes quality degradation of the food product throughout a food supply chain with multiple levels (manufacturers, central warehouses, distribution centres and retailers). They include penalty costs for quality degradation, based on the time during the chain stages. The penalty value depends both on the amount of degradation and the amount of product. In detail, in the model, they introduce a fixed quality degradation parameter for each distribution path from a food manufacturer to a retailer and multiply this with the flow quantity to calculate the penalty costs. At last, they limit the quality degradation permitted during distribution to a maximum.

Simulation models were used to maximise the benefits from capital investment in food preservation facilities under conditions of uncertain production and demand; an example is a model developed by Aleotti et al.[4] for selecting the best design for the postharvest handling of fresh vegetable crops between the harvest and the final market.

A simulation game explicitly developed for managers of businesses that handle fresh fruits and vegetables could help reduce losses and improve the quality of produce available to consumers. In this context, Prussia et all [5] created a simulation game that enables players to design and manage each business in a postharvest chain.

Busato and Berruto [6] designed and developed the FruitGame with an object-oriented simulation language, Extend®, which implement the supply-chain for fresh produce. The model-game provides three partners in the supply-chain: the farmer, the final store and wholesaler. In the case of shortage of products, players are able either to place bigger orders, to buy from other sources (by spending more money), or encounter loss in sales with an associated probability to lose the customer.

The implementation of a real case based discrete events simulation model is moreover useful to assist students to understand properly exposed real problems [7]. A simulation is a tool for operational and strategic planning, and in fact, successful businesses intensively use this technique. Nevertheless as reported in Kljajić et al. [8] simulation models are furthermore used as an explanatory tool for a better understanding of the decision process and learning processes in schools.

To teach the power of matching orders and demand with production, in this paper, we propose a discrete event simulation model intended to reproduce warehouse management considering a real practical market. Both production and demand have random pattern studied and validated with data from the packing industry. Production is influenced by weather and by cultivation practices (e.g. irrigation, trimming, time of harvesting). Orders and demand had specific patterns that could be variable and influenced profoundly by promotion: in fact, the students have to manage the sales, with a constant production quantity, considering the best time for launching a promotional campaign to decrease fruit quantity stored in warehouse consequently reducing shelf life costs penalties.

The models developed in this research can clarify to the students the behaviour of real-life operational processes and illustrate the decision-making problems that are faced by warehouse managers in realistic operational processes, thereby aiming to support decision-making on supply chain management to maximise total performances.

2 METHODOLOGY

The simulation model was developed using the ExtendSim® programming environment (Imagine That Corporation, San Jose, CA, USA). ExtendSim is a professional, powerful, user-friendly tool for simulating processes. In particular, this tool helps to understand complex systems and produce better results faster. In fact, ExtendSim is particularly worthwhile to: predict the course and results of specific actions, gain insight and stimulate creative thinking, visualise processes logically or in a virtual environment, identify problem areas before implementation. Users could explore the potential effects of modifications in real systems, optimise system operations, evaluate ideas and identify inefficiencies understand why observed events occur, evaluate the integrity and feasibility of plans [7], [9].

The basic ExtendSim® software package contains 90 pre-built blocks. Users can also build their own block libraries and hierarchical blocks. Standard blocks and custom blocks were used to build a discrete event model that allows the student to perform some order and demand adaptation to match the production.

Regarding the data acquisition, to acquire realistic data for the development of the discrete event model, both production and demand have random pattern studied and validated with data from the packing industry. Specifically, we collect data during field trials through a collaboration with an actual fresh fruit packer warehouse “Agrifrutta Soc.Coop. Agricola”, located in Beinette, Piedmont, Italy.

The simulation model considers two different calibres of the same variety of nectarines: calibre A and calibre AA of yellow nectarines. Regarding the economic values used to calculate final profit, we considered market prices retrieved from “ISMEA” (an Italian public institute of services for the agri-food market).

To estimate the shelf life values to be integrated into the simulation we referred to the work elaborated in Zhang et al. [3]. Hence we have included penalty costs for quality degradation, based on the time during the chain stages.

For shelf life calculation we considered both on the amount of degradation and the amount of product in the warehouse flows. In detail, in the model, we introduced a fixed quality degradation parameter and multiplied this with the flow quantity to calculate the penalty costs. The maximum penalty value equals the nectarine sell price.

3 RESULTS

The authors implement a discrete event model that allows the student to perform some order and demand adaptation to match the production. Actions to modify the demand imply promotion (that double sales but decrease the profit to 20% of the typical case), finding channels for different sizes of the fruits. The model also considers lead times for product packing and transportation and show the effect of the student’s choices on supply chain performance regarding supply chain profit, food waste, and shelf life. The model work step by step over a period of 40 days, allowing day by day decision from the user and plotting demand, storage and production day by day, in a stochastic way.

The game goal is to maximise the profit using the promotion only when needed. The game stops and the user loses the game if stock out condition arises for at least one of the two calibres considered, or a negative profit occurs at the end of the game.

3.1 Model interface

The game interface was designed using ExtendSim® dedicated tools.

The Input screen (Figure 1) is designed to make as smooth as possible the inclusion of user input. This screen is divided into two sections: the base data for the simulation and the promotion.

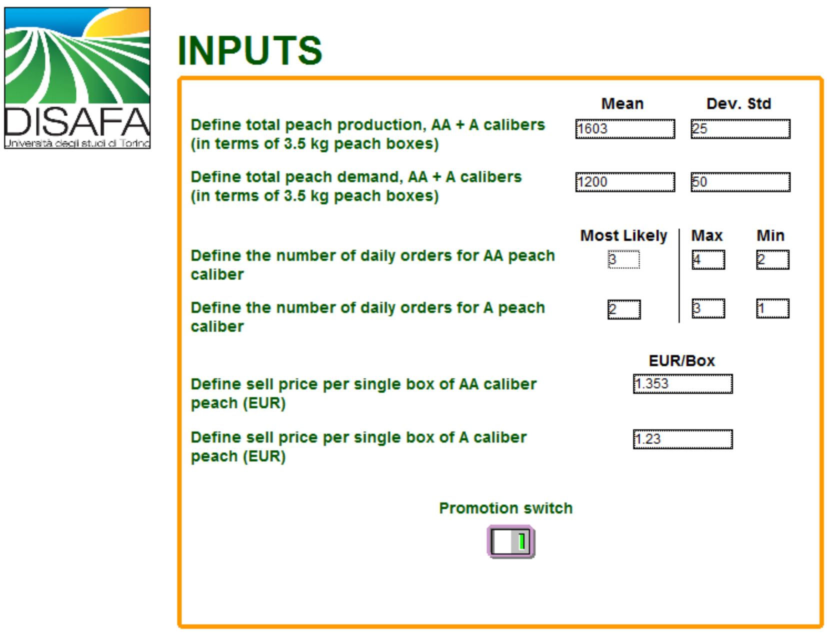

Figure 1. Simulation game interface.

In the base data section, the user can see all the data related to the real case simulation which are used by the model. The production, the demand for the sales points and the prices of nectarines are displayed.

In the promotion section, the user can press the dedicated button to start the promotion.

3.2 Model outputs

The outputs of the model are shown step by step (each day of simulation) to the users. The outputs allow the user to understand the simulation trend and therefore if is suitable to start a promotion or not.

Particularly, the outputs give the values of the total income, the shelf life (representing potential lost earnings) and the warehouse waste cost (representing the lost sales of the warehouse). The values mentioned above are shown for each calibre independently.

An extract of the results given by the game is listed in Table 1.

Table 1. Results available in the game.

Primary results	Secondary results
Total income	Total AA nectarines sold
	Total A nectarines sold
Shelf life lost earnings	Average waiting time in warehouse for AA nectarines
	Average waiting time in warehouse for A nectarines
Warehouse waste costs (lost sales)	Total AA nectarines residual in warehouse
	Total AA nectarines residual in warehouse

Another output of the model is the graph of the total profit (Figure 2) which shows the profit of the warehouse for each step of the simulation. It supports users in the decision-making process and acts as the final result at the end of the simulation.

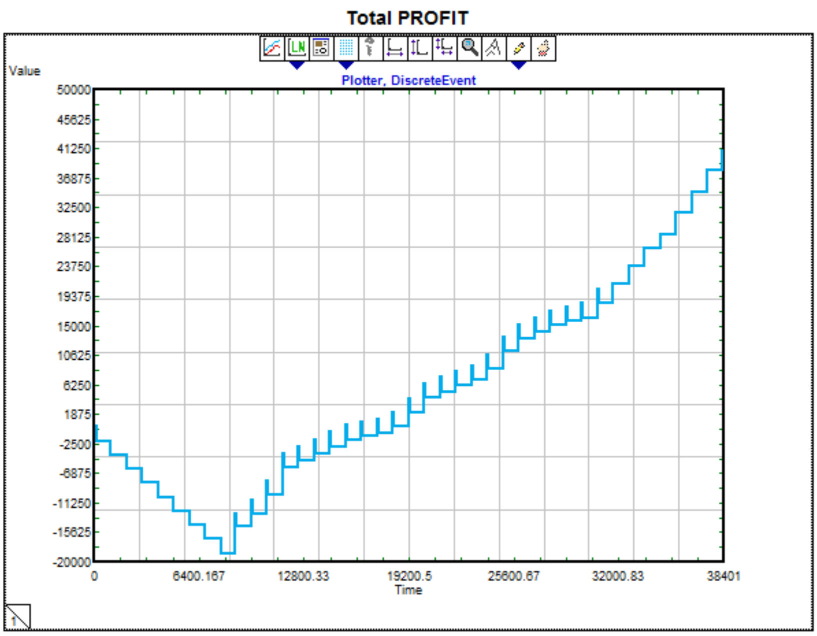

Figure 2. Total profit graph.

4 CONCLUSIONS

The authors of the present research have developed a simulation game. The aim was to allow the students to perform some order and demand adaptation to match the production. The game simulates a real case scenario of a warehouse in the fresh fruit supply chain.

Discrete events simulation model based on real cases are proved to be useful to assist students to understand, while adequately exposed, real problems. A simulation is a tool for operational and strategic planning and in fact, is used as an explanatory tool for a better understanding of the decision process and for learning processes in schools, as indicated in others research.

The game outputs show the effect of the student's choices on supply chain performance regarding supply chain profit, food waste, and shelf life. Through the use of the presented simulation game, the user experiences the difficulties encountered in a warehouse environment while trying to match production and demand of two different calibres of nectarines.

The future direction is to collect the responses of the first student's trials in order to improve the game accordingly and see the impact of such of a model on the student’s learning curve.

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