SUCCESS FACTORS FOR JIT MANAGEMENT OF PRIMARY COMMODITY SUPPLY CHAINS IN AUSTRALIA

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Abstract

Supply chains for agricultural commodities with their various constraints such as production lead time, seasonal production, and methods of storage are limited in the extent to which techniques like Just-in-Time (JIT) inventory management can be applied. It is beyond the ability of producers to control harvest time and many agricultural products are perishable so that they can incur exceptional losses in storage if they are not handled correctly. This is a source of additional costs and inefficiency in supply chain management.

The purpose of this study is to reduce or eliminate such sources of loss and inefficiency and to identify success factors for the JIT inventory management system where it can be applied for agricultural products. Where JIT techniques can be applied in supply chain management for agricultural products, costs such as transportation, inventory, and storage losses can be reduced with concurrent increases in efficiency.In the paper, some of the problems associated with applying JIT inventory control methods in supply chain management for agricultural commodities will be reported through a series of case studies.

Keyword: Supply chain management, inventory control, inventory management system, just-in-time management, agricultural commodities, primary industry

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1. INTRODUCTION

There are many sources of cost in the supply chain of agricultural products. The purpose of this study is to reduce or eliminate such sources of loss and inefficiency and to identify success factors for the Just-In-Time (JIT) inventory management system where it can be applied for agricultural products.

Where JIT techniques can be applied in supply chain management for agricultural products, costs such as transportation, inventory, and storage losses can be reduced with concurrent increases in efficiency.

It is beyond the ability of producers to control harvest time for most agricultural products. Many are so perishable that they can incur exceptional losses in storage if they are not handled correctly. The advantage of JIT supply management is that it reduces the cost of holding inventory and changes the cost structure of the supply chain with a consequent improvement in profits.

In this paper, some of the problems associated with applying JIT inventory control methods in supply chain management for agricultural commodities will be reported using a series of case studies.

Using some representative examples of the supply chain for agricultural commodities, such as the production of sugar, tomatoes and apples, we did an analysis of the theory of applying JIT management and found it is necessary to understand the mechanisms that ensure supply is equal to demand in any particular supply chain. To implement JIT supply management principles, it is necessary to identify the elements of the supply system, find the constraints and the problems that occur, and identify any bottlenecks in the supply chain. Supply chain management based on JIT methods will affect the cost structure of the firms that can practice it, adding value to the services they provide, and contributing to the continuing economic development of the nation.

Before looking at the factors that might make JIT inventory management successful with agricultural commodities, it is probably useful to describe some typical agricultural supply chains. Products like tomatoes, apples, and sugar can be used as examples.

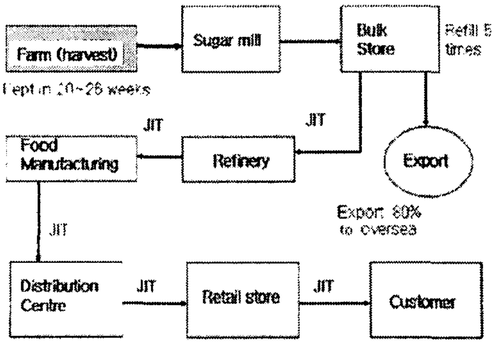
For inventory management of perishable items, Nahmias(1982) provides an excellent review of the research on this topic. Schmidit and Nahmias(1985) consider (S-1, S) inventory policies for perishable items with Poisson demands, and positive replenishment lead times. Ravichandran(1995) analyzes the same system using (s, Q) polices. Chiu(1995) allows for a possitive replenishment lead time and develops approximations for (s, Q) polices.

2. SUGAR AND HORTICULTURE CASE STUDIES

2.1 Supply chain for sugar

The supply chain for Australian sugar is described in Figure 1. Over 85 percent of the sugar produced in Australia is exported and the logistics related to that supply chain are quite different to the domestic sugar using industry. However, both supply chains share the same facilities to some extent which understandably puts considerable pressure on the management of the bulk sugar storages. With an approximately 6-month harvesting period when differences between sugar producing regions are taken into account, the industry needs to provide storage for domestic sugar for up to six months of the year. Thus one of the critical tasks of the marketing authority is to manage domestic stocks and keep enough sugar in store to be used during the non-harvesting period. The ideal situation is to store enoughsugar so that supplies are just depleted at the start of the next harvest. Because of weather variability and the estimated size of the crop to harvest, the start of the crushing season is known with uncertainty. There could be as much as one-month's variation in the starting date of the crushing which would obviously affect the amount of sugar that needs to be stored.

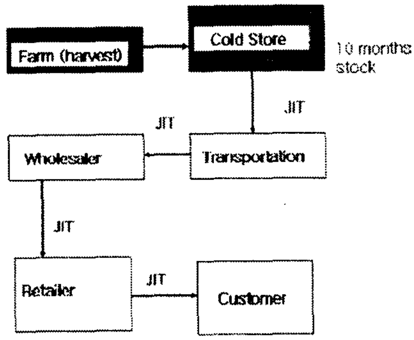
As noted previously, the same storages are used to hold export sugar prior to shipment as well as the domestic stocks and considerable skill is involved in judging the correct amount to hold. With the dynamic nature of the problem to be analyzed in mind, stochastic dynamic programming techniques could be used to shed insights into the best way to manage the storages. Risk management aspects are just as important as cost minimization in an exercise like this.



< Figure 1 > Sugar supply chain process

2.2 Supply chain for apples

Usually, apple harvesting occurs in a two to three month period starting about February-March and extending through into May, depending on variety and area of production. After harvest, it is possible to keep apples in store (controlled atmosphere storage) for up to about 10 months until the next season's fruit is ready.



< Figure 2 > Apple supply chain process

2.3 Difference between agricultural products and general industrial products

The difference between agricultural products and general industrial products are listed in the following table 1.

< Table 1 > Difference between agricultural products and general industrial products

Variables	Agriculture products	General industrial products
Perishability	Easily changed	Not easily changed
Temperature	Highly sensitive	Not sensitive
Supply and manufacturing time	No control of harvest time	Control of manufacturing time
Storage equipment	Need specialized storage, eg. cooling system	No need for controlled atmosphere storage
Price	High variation	Constant
Obsolescence	Depend on time	Not related to time
Information about customer	Insufficient	Sufficient

2.4 Sources of cost along the supply chain in agriculture products

To eliminate any of the costs along the supply chain, it is necessary to identify the kind of losses that exist, and list them in detail. The costs that occur along the supply chain for agricultural products can be grouped into 7 categories.
(1) Transportation and relocation costs
(2) Scrap costs- Defects- Perishability
(3) Waiting costs- Bottlenecks- Waiting time- Delays eg. because of machinery breakdown
(4) Inventory costs- Inventory losses- Holding and ordering costs
(5) Motion Loss- Registration time- Computer data input time- Overlapping work
(6) Inspection costs- Count time- Quality inspection time
(7) Over-stocked inventory- Warehouse cost

One way of viewing the supply chain is as a series of connected activities so that analytical techniques such as minimisation of cost or time or material flows are relevant.

3. JIT SUCCESS FACTORS

The general success factors of JIT

There are many prerequisite condi-tions for JIT inventory management to be successful. These success factors were described by Krajewski *et al.*,1987; They included:
(1) Customer influence
(2) Vender influence
(3) Buffer Mechanisms
(4) Product Structure
(5) Facility Design
(6) Process
(7) Inventory
(8) Other factors

In an industrial setting, such as the study of simulation with Arena, the production factors that influence JIT production models are demand rate, set up time, defect rate, machine breakdown rate, equipment layout, lot size, time lost through bottlenecks in production, etc (Tae Ho KIM, 1996).

These are generally factors that result in interruptions to supply. In an agricultural product setting, they are experienced because of the seasonal nature of farm commodities. Thus production lead time which corresponds to the time taken between sowing the crop and when it becomes available for harvest has a similar meaning in both agricultural and general production. Set up time might be regarded as the time taken to set up machinery for planting, cultural, and harvesting operations. Delays caused by excessive set-up time can cause substantial setbacks to production, especially if they occur at critical times such as planting, pest and disease control, or harvesting.

Likewise, machine downtime has much the same meaning in agricultural applications as it has in the industrial setting. In mechanized farming, plant breakdown can cause serious delays to planting or harvesting operations and so delay delivery of final product (grain or other harvested material) in the same way that it causes delays in the delivery of manufactured products. Agricultural products are subject to quality control and rejection because of being unable to meet quality standards in the same way as manufactured products. Thus the defect rate (or losses due to implementation of grading standards) can reduce the amount of product that is available for distribution. In the agricultural industries, there is often an outlet for second grade products. For example, grain that does not meet the standards for human consumption or export, may be downgraded to feed grade and still be utilized effectively as part of a livestock ration. In the case of an industrial product, items may have to be discarded completely thus incurring disposal costs, or recycled and remade.

Demand concepts are the same irrespective of whether one is dealing with an agricultural or an industrial product. Demand is predominantly influenced by price but other factors such as quality, reliability of supply, advertising and promotion, changes in consumer tastes, etc all have an influence.

In a dynamic industrial environment, demand can fluctuate considerably and production lead time is not stable due to the production factors such as machine breakdown.Therefore it is possible to introduce traditional JIT production systems that do give acceptable results in a static environment.Some of these techniques include Signal Kanban, adding a supplement to WIP (Work-in-process) absorbs the production factors such as long set up time and changes in demand to extract the advantage from Pull system in a dynamic environment.system has the advantage of both Pull and Push system such as control of WIP and reduction of production lead time.

Any dynamic industry must buffer the ups and downs of extremely variable production circumstances. This is a characteristic feature of most agricultural production systems. There-fore, rather than the traditional JIT production system, Signal Kanban system is suitable when the set-up time and the transfer time are long. CONWIP which combines the Push system and Pull system is advisable when there is fluctuation indemand, quality of the product is unstable, or equipment is easily broken [Tae Ho Kim, 1996]. These are situations that occur widely in agriculture.

4. JIT success factors in agricultural products

The success in applying JIT inventory control to agricultural products can be attributed to the following factors:

(1) Distance : depot, wholesale, retailer
(2) Lead time
(3) Information flows
(4) Inventory levels
(5) Minimize cost
(6) Maximize profit
(7) Accuracy of forecasting
(8) Economic control- Supply control- Market Information system- Adjustment of selling time- Cropping decisions, particularly in regard to area sown
(9) Keeping quality - transport trucks with cooling
(10) Market size and price setting; uniformity of price
(11) Post harvest treatments
(12) Variations in demand
(13) Variations in supply
(14) Cool storage facilities
(15) Price
(16) Storage technology
(17) Environmental elements

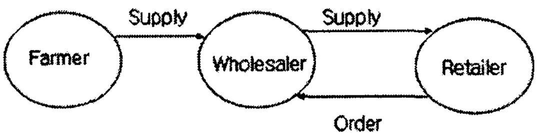
This list included factors that influence both "cost" and "price" side of the profit equation. Analysts need to consider what is the appropriate objective when dealing with analysis of the supply chain as a composite of these factors. It may be profit but it is more likely to combine profit with other objectives, such as meeting environmental standards.

5. JIT SUPPLY CHAIN SYSTEM

5.1 The flow of information under the JIT system

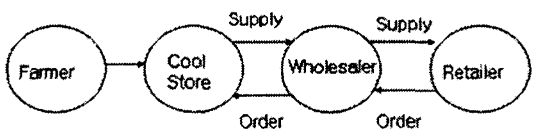
The general system

The push system regularly supplies product to the next stage in the product stream, regardless of its inventory level. This action may therefore cause an excess inventoryat the next stage. This is the situation that often occurs with the production of a crop like tomatoes. At the peak of the season, many growers may all send their harvest to the wholesale markets at much the same time,One of the few mechanisms that the agent has to bring supply and demand into balance is transact sales at reduced prices.



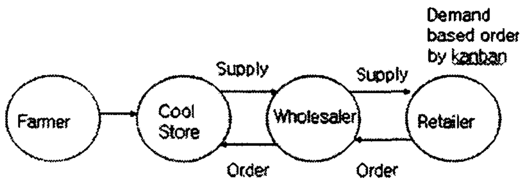
< Figure 3 > General supply chain system

In the case of a perishable product that is able to be stored for lengthy periods, we could envisage a modified system such thatthe product moves from the farm into cool storage and then flows to the wholesale market or the wholesale distributor as required.



< Figure 4 > JIT supply chain system

The JIT system is designed to hold a minimum inventory at each stage of the supply chain.



< Figure 5 > Kanban system

Ideally, this would involve orders from the wholesaler being passed to the farmer as supplies are required but the nature of agricultural commodities does not permit this to happen unless there is a storage facility located in the supply chain between the farmer and the wholesaler.

For storable agricultural products such as apples or sugar, that can be stored successfully for several months, it would be possible to implement a JIT inventory control system for at least part of the supply chain, using the store to provide a buffer between supplies from the farm and demand from the consumers via the retail outlets.

The inventory is controlled by the Kanban card. When inventory reaches a re-order point, this is automatic and an order will be given to the cool store. . Kanban system is a demand based-ordering system.

5.2 JIT supply inventory model

The JIT inventory model can be represented by the EPQ (economic production quantity) model in the manufacturing environment. JIT controls the maximum and minimum inventory using Kanban. Therefore, it is explained by the inventory model (S, s). In the supply chain, the EPQ inventory model should be replaced by ESQ (economic supply quantity) which includes aspects of the JIT concept.

The total inventory cost is the sum of the holding and ordering costs;

TC = annual ordering cost + annual holding cost

$$TC = \frac{D}{Q} \cdot S_c + (s-d) \cdot \frac{QH}{2s}$$

$$= \frac{D}{Q} \cdot S_c + \frac{QH}{2}\left(1 - \frac{d}{s}\right) \text{ ---------- } Eqn.1$$

s = daily supply rate

d = daily demand rate

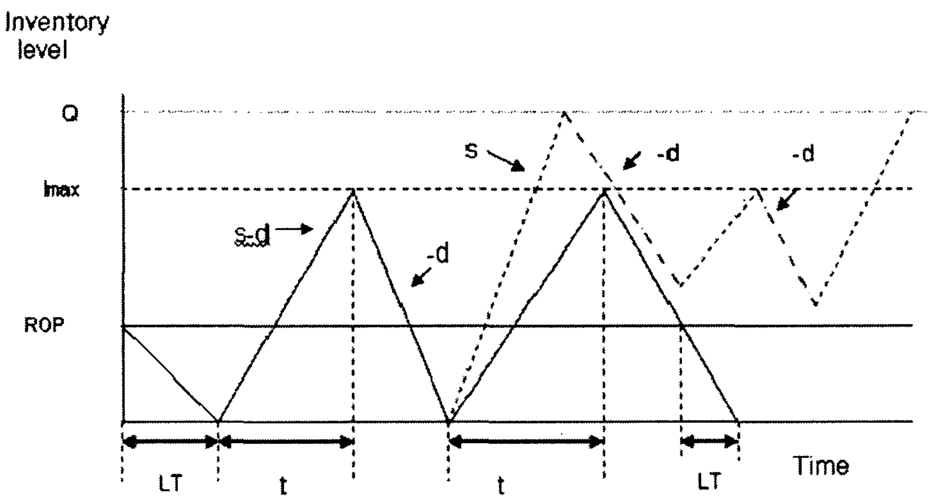
t = supply time
LT = lead time
Q = order quantity
D = annual demand
Sc = order cost
H = holding cost
ROP = re-order point

Solving the equation for Q, the ESQ formula is obtained:

$$Q=\sqrt{\frac{2DS_c}{H}}\sqrt{\frac{s}{s-d}} \text{--------------- Eqn. 2}$$

The model applicable to general industry with a regular daily supply of product is illustrated in Figure 3 where the solid line represents stock levels and ROP isthe re-order point. New stock should be re-ordered when stock reaches the safety level in order to achieve a service level of customer requirements of 100%.

The dotted line in Figure 3 represents the situation typical of an agricultural industry where daily supply is likely to be variable for a number of reasons. When supply is fluctuating, it is desirable to set the re-order point so that customer requirements can be met some set proportion of the time, eg. 90 percent of the time.



< Figure 6 > JIT supply inventory model

6. CONCLUSION

The reasons for not using JIT inventory control in the supply chain of agricultural products may be due to various problems and constraints that exist with such a supply chain. However, the similarities between agricultural supply chains and industrial chains are quite striking, except for the fact that agricultural commodities usually result from seasonal production. That may not be any different from manufactu-ring industries where single products may be produced intermittently, giving production runs long enough to provide economies of scale, but incurring storage and inventory holding costs so that JIT inventory control can only apply to the rest of the supply chain.

It seems that many of the techniques of JIT inventory management can be applied to part, at least, of some agricultural supply chains.

Each chain represents a profit mak-ing structure which could possibly be improved by the introduction of JIT inventory control. Through some of the methods discussed earlier in this paper, the cost elements that are relevant to some of our important agricultural supply chains may be reduced and an efficient JIT system can be applied to the supply chain.

Some of the factors that will help implement efficient supply chain management include:

(1) Multi-product transport
(2) Supply smoothing
(3) Multi cycle supply
(4) Signal Systems
(5) Evaluatingsupply chains by a management index based on Balanced Score Card principles
(6) Generate Supply Index, equate supply with market size
(7) Removal of bottlenecks in production
(8) Find economically optimal size and location for distribution depots
(9) Adjustment of inventory levels by ESQ procedure
(10) Packing methods (close to production point or close to customers)
(11) Use techniques such as Kanban system (Signal Kanban, CONWIP)
(12) Make extensive use of information technology.

JIT inventory control can be achieved easily using the internet. The principles of SCM can integrate the total system and control inventory costs by using the powerful advantage of Information Technology.

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