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Internal relationship modeling and production planning optimization for the manufactured housing

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ABSTRACT

The 'manufacturer-internal relationship optimization model (MIROM)', a schematic framework for internal relationship, is proposed for the manufactured housing (MH) factory. This model emphasizes the relationship between customer order from retailers (i.e., customized MH) and the production process, indicating that these elements are not mutually exclusive. In particular, through surveys and site visits, the planning of the product mix and sequence in the MH factory is considered the most critical area of the MIROM framework. This paper aims to convey how these areas can be elevated to the planning level with innovative changes and optimization. A product mix optimization model with linear programming was developed and a sequence optimization model was created by incorporating just-in-time (JIT) approaches. The proposed strategic MIROM framework and the specific optimization models can contribute to achieving significant improvement in the internal MH production planning. It can be applied for the site-built housing industry with similar industrialized environments depending on the scale of the operation.

1. Introduction

From the point of view of a manufacturer producing manufactured housing (MH), all supply chain activities belong to one of three macro processes — customer relationship management (CRM), internal supply chain management (ISCM), and supplier relationship management (SRM). For a supply chain to be successful it is crucial that the three macro processes are well integrated. However, for many MH manufacturers, CRM, ISCM, and SRM processes have little communication and the lack of integration hurts the supply chain's ability to match supply and demand effectively, leading to dissatisfied customers and high production costs [6].

In particular, the ISCM process aims to fulfill the demand generated by the CRM process in a timely manner and at the lowest possible cost. ISCM processes include the planning of internal production and storage capacity, preparations of demand and supply plans, and internal fulfillment of actual orders [4]. However, in terms of ISCM of MH industry, it was found through survey and site visits that production planning procedure is not standardized in a systematic way and the insufficient use of modern analysis tools are preventing smooth production flow in the facility. Specifically, there was difficulty in controlling the house order demand. The production level was different each month fluctuating seasonal backlog so that it was difficult to estimate actual delivery time exactly when the retailer makes a house order. Also, it was observed that in spite of producing various sizes of house models, there was no standardized sequence scheduling rule considering mixed model assembly. Many production managers used 'rules of thumb' to select actual production sequence and tried to sequence larger house models spaced out between smaller house models if possible. Under such an environment, it is necessary to develop a new capacity planning and new production scheduling method.

Therefore, this paper describes the framework of an industry-specific internal relationship management solution for the MH industry and suggests a new paradigm for the MH production planning process. The main objectives of this paper are to (i) propose an MH industry — specific framework of internal relationship management at a macro level and (ii) develop an optimal product mix and sequence model for an operational level of production planning at a micro level. The proposed strategic MIROM framework and the specific optimization models will contribute to achieve significant improvement in the internal MH production planning and it will contribute to improve overall efficiency and cost-effectiveness of all types of site-built housing as well.

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2. Framework of Manufacturer-Internal Relationship Optimization Model (MIROM)

Following an analysis of the current status of internal relationship in the manufactured housing factories, a new internal supply chain management solution was created, called "manufacturer-internal relationship optimization model (MIROM)". MIROM is focused on internal operations to the factories and includes all processes involved in planning for fulfilling a customer order. As shown in Fig. 1, the framework of MIROM consists of eight critical building blocks (e.g., market demand planning, facility location planning, facility layout planning, etc.) that can be combined to form a complete MH industry-specific internal relationship management supporting system. MIROM is also composed of two main sub-systems: strategic planning and operational planning. Thus, the MIROM can be formulated conceptually as follows:

$$\text{MIROM} = f(\text{SP}, \text{OP}) \tag{1}$$

where SP = strategic planning and OP = operational planning

$$\text{SP} = f(\text{m}, \text{l}, \text{d}) \tag{2}$$

where, m = market demand planning, l = facility location planning, and d = facility layout (design) planning

$$\text{OP} = f(\text{i}, \text{p}, \text{m}, \text{t}, \text{s}) \tag{3}$$

where, i = inventory planning, p = production planning, m = manufacturing, t = transportation, and s = field service.

This model emphasizes the interrelationship between end product (i.e., MH) and production planning, indicating that these elements are not mutually exclusive.

2.1. Market Demand Planning Module

The goal of this module (refer to Fig. 1) is to strategically plan resource availability in the supply chain network. One of the decisions made in this module include what markets to serve from each facility. This module facilitates the analysis of strategic plans under uncertain future environment and provides the appropriate outputs by going through the following steps:

(1) Understanding and defining the objective of forecasting,
(2) Integrating demand planning and forecasting throughout the supply chain,
(3) Understanding and identifying customer segment,
(4) Identifying the major factors that influence the demand forecast such as seasonality, supply, and product-related phenomena,
(5) Determining the appropriate forecasting technique,
(6) Establishing performance and error measures for the forecast.

In addition to forecasts, demand forecasting also includes decision to manage demand, such as promotions planning. This module should provide the factory to come up with a demand plan accounting for marketing and promotional efforts.

2.2. Facility Location Planning Module

The decisions made in this module (refer to Fig. 1) include the strategic location of plants and warehouses. Location decisions have a significant impact on competitive advantage, investment requirements, operating costs and revenues, and operations itself. A poor choice of location might result in excessive transportation costs, a shortage of qualified labor, and inadequate supplies of raw materials. The general procedure for making location decisions usually consists of the following steps [9]:

(1) Decide on the criteria to use for evaluating location alternatives
(2) Identify important factors such as location of markets or raw material availability,

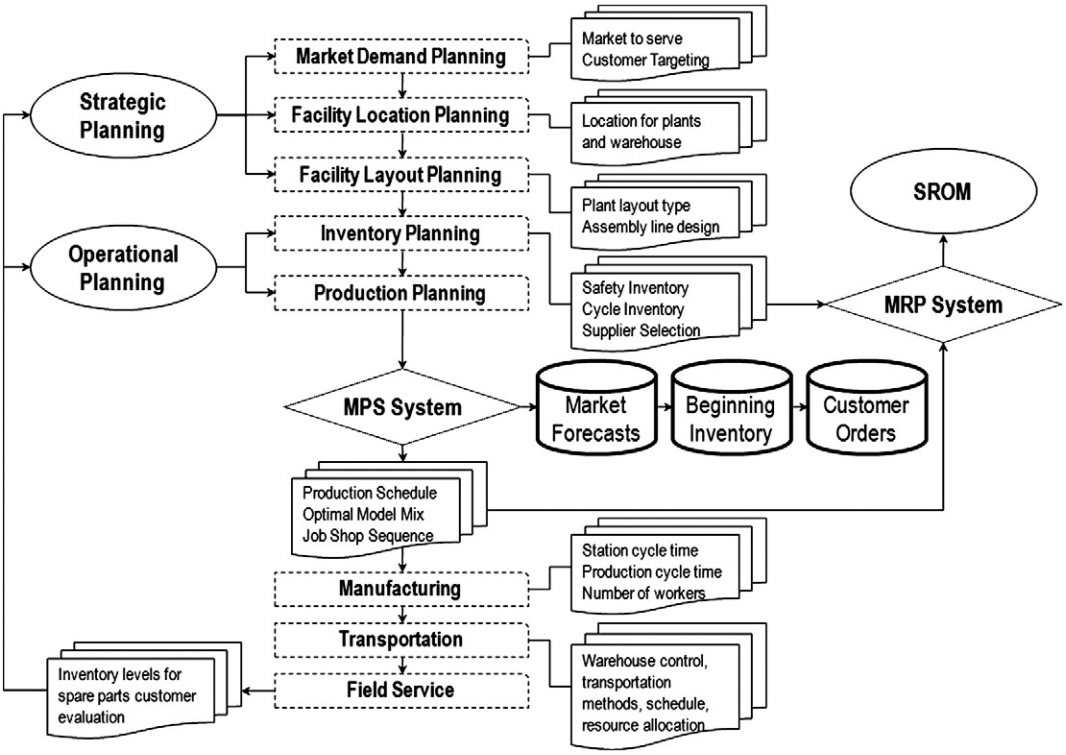

Fig. 1. MIROM Framework Overview.