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Smart Inventory Management System of Food-Processing-and-Distribution Industry

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Abstract

A food-processing-and-distribution company typically stores products in a warehouse before shipping them to customers. Inventory management is therefore important to the food-processing-and-distribution industry because of the large amount of products typically stored. Large amounts of stored products increase inventory cost and management cost and can reduce warehouse efficiency. Restated, inventory management should be the primary focus of the food-processing-and-distribution industry, especially for perishable foods. This study is therefore important to build up a system to predict possible forthcoming inventory. This study surveyed experts to identify key issues associated with inventory management in the food-processing-and-distribution industry, and analyzed sequential patterns to find rules based on analytical results from the survey. This study also proposed a model for inventory prediction. Through this proposed prediction model, the best accuracy of inventory prediction could reach up to 66.3%. Through the sequential patterns based on expert opinions, the food-processing-and-distribution industry can manage inventory efficiently and accurately.

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Keyword: Inventory Management, Sequential Patterns, QFR

1. Introduction

Accompanying rapid growth in the world’s population, food shortages have become a significant problem. Notably, foods can be putrid while delivering, cooking, and even natural perishing. Through processing, foods are transformed into processed foods. For example, meat is transformed into various meat-based products through processing. Although edible meat parts (e.g., fat) may be trashed on cooking, it is often reserved for food processing. Additionally, processing foods can avoid natural spoilage through use of preservatives. Therefore, through processing, a producer can increase the utility of food and further reduce unnecessary wastage (Connor, 1988; Connor & Schieck, 1997; Smith & Furness, 2006). Additionally, the distribution for a food-processing-and-distribution company is important for processed foods (Akkerman, et al. 2012; Lummus & Vokura, 1999). Without a proper distribution and inventory management, processed foods have a high probability of spoilage.

Therefore, inventory management has become a major problem that affects the efficiency of the food-processing-
and-distribution industry (Arason et al., 2010; Hsiao et al., 2011). Because a food-processing-and-distribution companies need to input and process foods from various sources, a warehouse must store input foods as inventory, the increase in the complexity, and large quantities of foods causes that the inventory is hard to manage (Dennis et al., 1999; Mahalik & Nambiar, 2010). To manage inventory, a company must predict the quantity of input foods at a previous time. Previous studies showed that seasonality analysis (Bátori, 2010; Zhang et al., 2011), a mathematical model (e.g. Markov chain) (Liu & Chen, 2008; Stefanovic & Stefanovic, 2009; Zhang et al., 2011), or data-mining tools (Stefanovic & Stefanovic, 2009; Zhang et al., 2011) can be adopted to predict inventory. In data-mining area, the sequential-pattern analysis is an effective approach to identify repeated patterns of input foods along a time sequence (Hu & Kao, 2011; Ngai et al., 2009). However, factors affecting inventory management of the food-processing-and-distribution industry must be involved in an analysis of the sequential pattern.

To manage inventory efficiently, factors affecting inventory management must be discussed. Previous studies have shown that three factors, food-related, process-related, and operator-related factors, affect inventory management in the food-processing-and-distribution industry (Connor, 1988). The importance of each factor can be identified via the decisions of experts (Cox et al., 2010). The factors could be applied to inventory management based on different business characteristics of various food-processing-and-distribution companies. However, various experts food-processing-and-distribution companies are difficult to touch. Along with evolution of information technology, experts can be touched through a web-based manufacturing system. The inventory can be controlled precisely through information technology.

Therefore, an application composed with expert’s opinions to the factors affecting inventory management of food-processing-and-distribution industry, and the sequential pattern analysis are introduced in this study. The remainder of this paper is organized as follows. Section 2 introduces the factors of inventory management of food-processing-and-distribution industry. Section 3 then details the research method. Subsequently, Section 4 gives analytical results based on an example company. Finally, Section 5 presents concluding remarks.

2. The Factors of Inventory Management of Food-Processing-and-Distribution Industry

In the food-processing-and-distribution industry, a company uses a set of techniques to transform ingredients into foods or to transform foods into other products for consumption by consumers (Connor, 1988). Processed foods are then delivered to destinations via distribution methods (Dennis et al., 1999; Smith & Furness, 2006). The large quantities of raw input foods and processed foods waiting for delivery are difficult to manage in a warehouse because food is perishable (Dennis et al., 1999; Mahalik & Nambiar, 2010). To prevent financial damage caused by rotten foods, inventory management must address food-related, process-related, and operator-related factors.

Food-related factors include classifications and cost of foods (including: oil, sauces, cans, other food-materials), wrapping-up method (Bank et al., 2010; Wang, 2010), waste materials, cleaning products (Connor, 1988; Hsiao et al., 2011), the quantity of stored foods (Akkerman et al., 2010; Hsiao et al., 2011), and buyer’s characteristics (Arason et al., 2010; Dennis et al., 1999; Han et al., 2009). The quantity of stored foods is important in inventory management; for example, a low-cost food that occupies a large space in a warehouse should be carefully allocated (Akkerman et al., 2010; Hsiao et al., 2011). Process-related factors include input/output frequency of the same food (Alfaro & Rábade, 2008; Connor, 1988; Hsiao et al., 2011; Wang, 2010; Zhao et al., 2001), and the distribution quality (Wang, 2010; Zhao et al., 2001). The input/output frequency of the same food can affect inventory quantity (Findiastuti et al., 2011). The recency of input/output food is also important because recent input/output foods affect the recent finance situation (Findiastuti et al., 2011). Finally, operator-related factors include inventory checks, confirmation of input/output goods, and order management (Alfaro & Rábade, 2008; Arason et al., 2010; Hsiao et al., 2011; Lao, 2010). Operator-related factors are important because operators affect warehouse management performance, which is typically labor intensive (Arason et al., 2010; Hsiao et al., 2011; Alfaro & Rábade, 2008; Lao, 2010).
3. Research Methods

The inventory prediction system is the ultimate target in this study. To build up the inventory prediction system, this study identified the key factors through surveying experts for AHP analysis. In this study, the analytic hierarchy process (AHP) was used to weight complex factors that could be adopted to find key factors. The questionnaire’s design was based on the AHP developed by Saaty in the 1970s (Saaty, 1970). The AHP can be applied to solve complex decision-making problems. First, complex systems are decomposed into clearly defined layers of elements. Then, the relative weight and overall order of factors are derived for each layer via pairwise comparisons. In this study, a hierarchy model based on a literature review was established. By analyzing the established model, the importance of each factor can be identified. After identifying key factors, the analysis of sequential patterns should be included to predict forthcoming input foods.

Finding sequence patterns is a goal of data mining, which is concerned with finding statistically relevant patterns between example data, and the values are delivered in a sequence (Jea et al., 2009). Studies usually assume these values are discrete and, thus, time-series mining is closely related (Jea et al., 2009). Through sequential patterns, repeated events can be identified, even when no obvious relationships exist among events (Hu & Kao, 2011). However, not all events are worthy of study. Therefore, for different businesses, the importance of repeated events should be treated based on business requirements. For example, a repeated item may be ignored because of its low cost. In this study, the importance of factors identified in analytical results by the AHP was used as selection criteria for repeated foods. Through AHP analysis and using meaningful criteria for the sequential pattern of goods, the prediction of forthcoming input foods should be found.

In this study, a food-processing-and-distribution company in Taiwan is selected as the case company to show results of the abovementioned composition of research methods. The case company is with capitalization US Dollars $700,000 and revenue $20,000,000 per year stably. She supplied large chain-food restaurants and convenience stores in Taiwan, including: 7-11 Convenience Store (Chen, 2012). This company faced a serious problem on inventory management, because of incorrect prediction on the next-year’s inventory quantity. The weight of each factor affecting inventory could be used to find the urgent problem to inventory management (Saaty, 1970). To understand the weight of each factor affecting inventory management, this study surveys 15 experts using AHP method from the academic and industry areas: professors of food-processing-and-distribution industry, and managers and operators from food-processing-and-distribution companies. Furthermore, this study will apply the analytical results to sequential patterns in order to evaluate the improvement of the prediction of forthcoming inventory. This study used the data from 2004 to 2008 to build up the prediction model and found the possible input foods from 2005 to 2009.

4. Analytical Results and Prediction Model

The analytical results of AHP method show that the quantity of stored foods, the input/output frequency of the same food, and the recency of input/output food are with the high weighted values (Table 1). Restated, the importance of factors shows that quantity, frequency, and recency (QFR) are the most concerns for inventory management. It is similar with the recency, frequency, and monetary model (RFM) (Chen et al., 2009). The RFM is famous on customer relationship management, but monetary is not considered in the inventory management.
Table 1. Weights of Factors of Inventory Management

<table>
<thead>
<tr>
<th>Factors</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Food-related Factors</strong></td>
<td></td>
</tr>
<tr>
<td>Classifications and cost of foods</td>
<td>0.0088</td>
</tr>
<tr>
<td>Oil</td>
<td>0.0138</td>
</tr>
<tr>
<td>Sauces</td>
<td>0.0122</td>
</tr>
<tr>
<td>Cans</td>
<td>0.0092</td>
</tr>
<tr>
<td>Other food materials</td>
<td>0.0011</td>
</tr>
<tr>
<td>Cleaning products</td>
<td>0.0067</td>
</tr>
<tr>
<td>The quantity of stored foods</td>
<td><strong>0.0261</strong></td>
</tr>
<tr>
<td>Wrapping-up method</td>
<td>0.0092</td>
</tr>
<tr>
<td>Buyer’s characteristics</td>
<td>0.0155</td>
</tr>
<tr>
<td><strong>Operator-related Factors</strong></td>
<td></td>
</tr>
<tr>
<td>Confirmation of input/output quantity</td>
<td>0.0192</td>
</tr>
<tr>
<td>Inventory checks</td>
<td>0.0154</td>
</tr>
<tr>
<td>Order management</td>
<td>0.0173</td>
</tr>
<tr>
<td><strong>Process-related Factors</strong></td>
<td></td>
</tr>
<tr>
<td>The input/output frequency of the same food</td>
<td><strong>0.0282</strong></td>
</tr>
<tr>
<td>Distribution quality</td>
<td>0.0217</td>
</tr>
</tbody>
</table>

In order to apply QFR to inventory prediction (IP), the weight of QFR \( (W_Q, W_F, W_R) \) should be normalized. The original value set of IP \( (0.0261, 0.0282, 0.0282) \) should be changed to IP \( (0.3164, 0.3418, 0.3418) \). That is, IP \( (0.3164, 0.3418, 0.3418) \) is the weight to calculate the importance of food to inventory management. Applying QFR to sequential pattern analysis, the valuable highlighted products could be found. In this study, the manager of the case company defined the QFR as follows (Table 2). The value of Q will be set to 5 if the net weight of the food is larger than or equal to 40 Kg. The value of F will be set to 5 if the food appeared more than or equal to 20 times over the past one year. The value of R will be set to 5 if the latest time of occurrence is smaller than or equal to 50 days ago. The weight value of QFR is \( QW_Q + FW_F + RW_R \). Therefore, the value of QFR is 4.3418, if the net weight of sunflower oil is 32 kg, input 18 times over the past one year, and the latest time of occurrence is 10 days ago.

Table 2. Rules of QFR

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Rules</th>
<th>Normalized Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantity (net average weight per input)</td>
<td>5 4 3 2 1</td>
<td>0.3164</td>
</tr>
<tr>
<td>Frequency (times/over the past year)</td>
<td>≥40kg 20kg 20kg &lt;10kg</td>
<td>0.3418</td>
</tr>
<tr>
<td>Recency (the latest time of occurrence)</td>
<td>≥60 days ago 90 days ago 120 days ago &gt;150 days ago</td>
<td>0.3418</td>
</tr>
</tbody>
</table>

To reveal the improvement of prediction, this study compares the original inventory prediction proposed by the case company and the method proposed by this study. The original inventory prediction method of the case company is simply to set the forthcoming input/output foods as the input/output foods in previous year. The results show that accuracy of prediction of forthcoming foods in each year (from 2005 to 2009) is from 33.4% to 66.3% (Fig.1).
5. Conclusion

Inventory management is important to the food-processing-and-distribution industry because of the large amount of products typically stored. In this study, a prediction model composed with factor analysis tool and a prediction tool is proposed. Through AHP method, the factors could be found through surveying experts. The survey results could be applied to sequential-pattern analysis to predict the forthcoming materials in an inventory. This study surveyed 15 experts and found that the quantity of stored foods, the recency of input/output foods, and the input/output frequency of the same foods are three major concerns of a food-processing-and-distribution company. This study summarized the above mentioned factors as QFR (quantity, frequency, and recency), and weighted each factor to calculate the importance of each material in inventory. Through this proposed prediction model, the best accuracy of inventory prediction could be 66.3%. It is useful for a company to adopt as the inventory prediction.

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References


