Warehouse Planning

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Abstract
The effective management of warehouses within the context of a supply chain constitutes a fundamental challenge for enterprises that engage in large-scale operations. To address this challenge, we have developed a planning model that integrates both temporal and numerical factors. This hybrid model captures the key aspects of warehouse stock management, encompassing multiple warehouses, vehicles, and item types, with the ultimate aim of maximizing profits. Our planner's efficacy has been evaluated through performance testing on diverse configurations of warehouse management. We conclude that warehouse management can... (to be continued once full model has been implemented and tested)

1. Introduction

A supply chain denotes a complex network of interconnected facilities, modes of transportation, and processes designed to enable the sourcing, manufacturing, warehousing, and transportation of materials and products. An optimally designed supply chain ensures that goods and materials are efficiently and effectively delivered to the end customer.

Warehouse planning plays a pivotal role in the optimization of the supply chain, primarily due to the finite storage capacity of warehouses and the imperative to meet customer demand. The implementation of effective warehouse planning is critical to ensuring optimal utilization of storage capacity, thereby minimizing the incidence of wasted space and enhancing the overall efficiency of the supply chain.

This study aims to optimize warehouse logistics planning considering inventory and total profit using a hybrid planning formalism. The hybrid formalism enables numeric and temporal aspects of the planning domain to be modelled realistically. Our model seeks to simulate and optimize the logistics of managing the stock levels in multiple connected warehouses based on consumer demand.

2. Background

The management of inventory across multiple warehouses is an integral challenge faced by modern large businesses. This problem has been addressed using various methodologies, and functional solutions have already been established. Nevertheless, to the best of our knowledge, the utilization of a hybrid planning formalism that incorporates both temporal and numerical aspects has not been explored in this domain. We aim to introduce a novel solution to warehouse management by implementing a hybrid planning formalism with temporal and numerical considerations.

3. A Planning Model for Warehouse Management

Our model consists of a collection of warehouses, suppliers, vehicles, and items. The goal is to minimize the cost of our stocking operations and to maximize our profits. At the conclusion of each day, items are sold at each warehouse to meet assumed demand. When items are sold, revenue is added, and the warehouses will have vacant stock space to be replenished. We intend to run the model for a limited amount of days, possibly as little as 5-10 days.
As we require the incorporation of both temporal and numerical aspects in our model, we will utilize a hybrid modeling approach. At present, the temporal and numerical aspects of our model are absent. However, we anticipate that as we delve deeper into these topics during our upcoming lectures, the implementation of these aspects will become more apparent.

3.1. Objects

The model will largely consist of the following objects:

1. Item: To be bought and sold at our warehouses. Items can be split into further sub-types such as: non-perishables, perishables, and refrigerated items. Some items may have expiry dates.
2. Supplier: Contains infinite stock of some specific items, purchasing from suppliers incurs a cost.
3. Warehouse: Contains inventory of many items, has a maximum space capacity for each item type.
4. Vehicle: Transports goods across warehouses and suppliers. Has maximum space capacity for each item type.

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3.2. Predicates

The following predicates will do the heavy lifting of our model:

1. Roads: Describes the status of roads between warehouses/suppliers.
2. Stock: Describes the status of stock at a specific warehouse.
3. Item-Status: Multiple predicates could combine to describe the status of specific item (expiry date, cost, revenue of selling item, etc.)
4. Vehicle-Status: Multiple predicates combine to describe the status of the vehicle (vacant space, location, items carried, etc.)

3.3. Functions

We plan on having two functions that capture cost and revenue.

1. Total-cost: Captures the total operational cost of running the warehouses including cost of items, loading, and transporting. Total-cost is already partially implemented. We want to minimize total-cost.
2. Total-revenue: Captures the total amount of revenue made from selling the items. We want to maximize total-revenue.

4. Evaluation

We plan to test our model against a variety of problems, and will evaluate the model based on how well it does compared to our own estimations of how much profit it could possibly make. We will experiment with the following settings to test how the model performs on various problems:

1. Number of warehouses, size of warehouses, and connectivity of warehouses.
2. Number of vehicles and their capacity.
3. Number of items (of each item type) and their revenue margins.
4. Number days the model will run for.
5. The accuracy of item demand forecasts. We expect that more uncertain forecasts may limit the model.

5. Related Work

Our study pertains to prior research conducted in the field of distribution planning within the domain of supply chain management.

In [1] distribution planning is used to optimize the total cost and service level for just-in-time delivery in a supply chain. The distribution network has three levels: suppliers, wholesalers, and retailers. Warehouses are utilized by both wholesalers and retailers for product storage. The time it takes to have goods ready for delivery (lead times) and capacity constraints are considered. A hybrid sorting genetic algorithm is applied to solve the problem with a mixed-integer linear programming model.

The focus of [2] is also distribution planning in a supply chain context. This work first develops a simulation model and a heuristic for a distribution problem. Then it integrates the capacity constrained production environment and two stage transportation distribution.

Our study considers warehouse distribution planning for perishable items in a supply chain. In [3] an approach is outlined for the design and planning of a supply chain for perishable food products. In this work, the delivery time of the supply chain is considered not only as a constraint but also as an objective function, in conjunction with the optimization of cost and environmental impact factors. Additionally, the approach integrates the decision-making processes for transportation, entry point selection, the location of distribution centers, and the determination of the associated flows between the nodes of the supply chain.

6. Summary

We created a hybrid planning model that captures the essence of multi-warehouse stock management. Our models Incorporated warehouses, suppliers, vehicles, inventory items, cost of transport and inventory, and forecast sales. The goal was to maximize the profit of running our warehouses by maximizing revenue and minimizing the cost of management. We tested our model against expected profits and found our... (to be continued once full model has been implemented and tested)

6.1. Future Work

Based on the results in the evaluation section, we will decide what kind of future work is possible. If the results are somewhat promising with certain constraints, we could recommend the use of planners in certain situations. However, it is quite likely that planning is not the way to go to solve warehouse management problems and in that case we will just highlight that.

References

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[3] V. Yakavenka, I. Mallidis, D. Vlachos, E. Iakovou, Z. Eleni, Development of a multi-objective model for the design of sustainable supply chains: The case of perishable food products, Annals of Operations Research 294 (2020) 593–621.