# Integrated Approaches for Multilevel Distribution Problems

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## Abstract

In this work we deal with multilevel integrated distribution problems and in particular, we analyse the management of inventories of final goods in the distribution system.
We present a survey of methods proposed in the recent literature devoted to the integration of inventory management systems. Starting from the concept of *echelon inventory position* we present an approach for the optimal flow of goods in a three level network.

## Introduction

Today it is important for each company to be *market–oriented* in order to reduce the *time to market*, that is to say quickly, flexibility and limited costs must characterise the logistic system of each company.

In a competitive and aggressive market more and more companies developed a new function, the logistic function, devoted to manage the flows of information and goods in the logistic system in order to improve the customer service level and control the logistic costs.

In this work we will focus on the distribution system that is devoted to the flow of final products from the plants (where they are produced) to the demand points (distributors, wholesalers or retailers, generally called customers).

Distribution activities connected to the customer service level and the logistic costs are for examples the orders management, the inventory and storage management, the material handling, the transportation of goods.

Our aim is to analyse new management policies for the flow of information and goods based on the correlation of distribution activities and on the integration of the company with different actors operating in the supply chain (i.e. suppliers, producers, distributors and customers). As the Efficient Customer Response Study [4] pointed out, the optimisation of the flows in the supply chain can be reached only by using vertical and horizontal integration among companies. In particular, our attention will be devoted to integration in the management of inventories of final goods in the distribution system.

If inventories can be necessary they must be managed in the best way for avoiding an uncontrolled growth of costs and the presence of overstocks in the warehouses. The search for a trade-off between inventory and transportation costs can be done considering new integrated inventory policies (the continuos replenishment like the Vendor Managed Replenishment System, the echelon stock policy based on the concept of the echelon stock position) or new integrated transportation strategies (like multi-drop, multi-pick).

## Related literature

We will present a survey of models and methods that face the problem of vertical and horizontal integration of distribution activities. In particular, starting from the works dealing with tree-like distribution systems and stressing the importance of the customer service level and of the balanced distribution [1], [2], [5], we propose two 0/1 mixed integer programming models and an algorithm for the optimisation of the flow of goods in a multilevel distribution network. In our study we also include transportation costs.

## Problem definition

We consider a distribution network made up of three levels: central depots (CD), regional depots (RD) and customers (big client BC). CD represent the supply points of the network and send goods to RD. BC are served directly by CD because of their large demand. The demand is known and expressed in terms of units of a single representative commodity. The demand of RD is related to the demand of the customers served by them (they do not appear as nodes of the network).

We analyse a simple case in which the assignment of RD and BC to CD is known (since we do not consider a link among CD, we can reduce the problem analysing simple subsystem networks with only one CD); then we consider a second case in which we have also to determine the best assignment of the nodes of the network to CD.

Our goal is to optimise the flow of goods in order to minimise logistic costs like transportation, warehousing and stock-out costs, while granting a certain customer service level expressed in percentage of the demand to satisfy (that represent one important parameter for checking the performances of the distribution system).

## Resolution approach and computational results

First we analyse the distribution problem assuming that an installation stock policy is used for the inventory management. In this case we propose a 0/1 mixed integer programming model based on the concept of *inventory position* (*IP*) defined as follows:

$$IP = I + Q - SO \tag{1}$$

where $I$ represents inventories, $Q$ quantity transferred to the depot (or just ordered by the depot) and $SO$ stock-out at the depot.

In a second analysis we assume that an echelon stock policy is used and the previous model is modified for including the concept that is the *echelon inventory position* $IP^{ech}$ [3] defined as follows:

$$IP^{ech} = I^{ech} + Q - SO \tag{2}$$

where

$I^{ech}$ represents the echelon stock level of the depot that is to say the inventories at the depot plus all inventories existing in the bottom network.

Finally, in a third step of our analysis we also have the aim of obtaining *balanced inventories* in the nodes of the network, where balanced inventories means to maintain a given inventory level says $BI$ that is sufficient for satisfying requirements at each depots in a fixed time period.

In this last case we propose an algorithm for determining the optimal distribution of goods in the network, that is to say a balanced and integrated distribution that minimises the logistic costs.

The main steps of our algorithm can be briefly summarised as follows:

step 1: compute the optimal global stock level
step 2: compute the existing global stock level
step 3: first check (*satisfability condition*)
step 4: if *satisfability condition is satisfied*

for all warehouses, central depots (for direct supply) and products check (*supply or not)*
check "fast or slow item"
compute the "quantity to send for fast items"
compute the "quantity to send for slow items" and the surplus
STOP
else
step 5: compute the minimum global stock level
step 6: second check (*satisfability condition*)
step 7: for all warehouses, central depots (for direct supply) and products check (*supply or not)*
compute the "surplus"
compute the "quantity to send"
STOP

We test our approaches on a case study related to a food manufacturing company operating in the Italian market and we compare the results obtained in the above different scenarios for understanding the real effect of integration in the logistic costs.

# References


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