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State Of Review Relating To the Problem of Transshipment

Elleuch Fadoi

PHD in logistic and production

Abstract
Effective supply chain management (SCM) is currently identified as a primary source of competitiveness for a supply chain, as the execution of supply chain management has a significant impact on the total cost and level customer service.
In this article we mainly focus in the first part, on the presentation of transshipment approaches, then in the second part we represent the different transshipment policies, as well as in the last part we show the types of transshipment (Corrective-transshipment and Preventive- transshipment).
Keywords: *Transshipment, discrete event simulation (DES), Vendor-managed inventory, , partial-pooling threshold, complete-pooling, partial-pooling, Simulation, Vendor-managed inventory, Supply Chain Management.*

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I. Introduction

SCM aims to control all the flows of a logistics chain (physical flow, information flow and financial flow). To date, many quantitative models have been proposed to provide decision support for the management of supply chain materials. The overall improvement of the distribution network, assessed in economic terms or in terms of customer service, can be significantly improved if retailers work together when demand is unexpectedly high.

This collaboration usually takes the form of "Transshipment-Lateral", also simply called "Transshipment" (Figure 1), which allows stocks to be pooled to alleviate the uncertainties relating to requests arriving at sites of the same level, and, thus to obtain effects analogous to those of a consolidation of stocks. Transshipment can also generate flexibility of service.

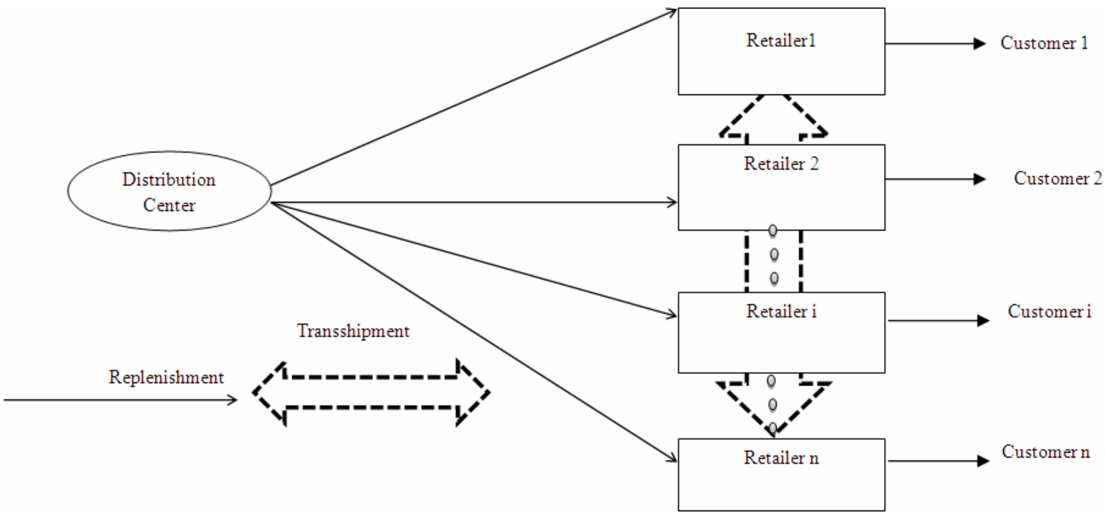

Figure 1. Representation of Transshipment in a logistics chain

II. Transshipment approaches

We distinguish two approaches to transshipment. The first is that of emergency transshipment (reactive transshipment); it corresponds to the Transsipment made following an actual out of stock at a retailer resulting from the arrival of a request. In the literature, several research works aim to study this approach.

Paterson et al., (2012)) studied the problem of a multi-level stock system made up of N retailers, in the event of an actual out of stock at a retailer due to an arrival of random customer demand. They came up with a reactive approach to solve this problem.

Reyes et al., (2013)) studied the same problem as (Paterson et al., 2012) by focusing their research work on the impact of emergency transshipment on the management of stocks in this system in the event of out of stock, and they concluded that responsive transshipment can reduce costs and improve service rates by minimizing the amount of lost customer orders.

The second approach is that of preventive transshipment (also known as proactive), which corresponds to a redistribution of stocks at the start or end of each supply cycle but before customer demand is fulfilled. There is a vast literature that is interested in this type of transshipment approach. The research on preventive transshipment is dominated by periodic review, because at the beginning and at the end of each period it is necessary to make a periodic control on the stored quantities in order to allocate a redistribution of these quantities. In this regard, Agrawal et al (2004) envisioned a two-tier inventory system in which they aimed to rebalance the quantity stored at a predetermined time before the demand was made and they presented a formulation dynamic programming to determine the best decisions. Van et al. (2009) investigated the problem of a two-tiered inventory system. They applied the Markov process to solve it by applying preventive transshipment on a specific date. Paterson et al., (2010) analyzed a multi-warehouse inventory system that follows the inventory policy (S-1, S) combined with the proactive transshipment policy. They assumed that the cost of transshipment is fixed, and they aimed to fix the optimal timing of stock redistribution to minimize disruption, resulting in minimization of the total cost.

To significantly improve a purely reactive transshipment policy, it would be possible to combine it with another proactive policy; this will be called “hybrid transshipment policy” (see, Archibald et al. (2014)). In this area of research, there is a vast literature that emphasizes the policy of hybrid transshipment (reactive and proactive), for example, (Paterson et al, (2011)) who have studied the same problem as (Paterson et al. (2010)) but which combined the two types of transshipment (corrective and preventive), to improve the customer service rate and Glazebrook et al. (2015) who studied the same problem as Reyes et al. (2013), with a proposal to use a hybrid transshipment policy (reactive and preventive) exploiting economies of scale by reducing the total cost by improving the cost of transport and that of stock.

III. Transshipment Policies

The policies of Transshipment are:

- Complete - Pooling: The retailer agrees to transfer all of its available stock if necessary; that is, to pool all its stock with another site, without any restriction (Tagaras (1999).
- Partial - Pooling: The transshipment is carried out while preserving a targeted level of stock.

We find, then, the following variants:

● A retailer accepts transshipment up to the amount of surplus stock at a transshipment threshold equal to the estimated demand for the following period, (Archibald et al., (2009)),

● The decision to integrate a transshipment at the retail level depends on the current stock level and the time remaining before the subsequent supply.

● A retailer accepts transshipment up to the amount of excess stock of a threshold equal to its order point, (Van et al., (2009);

● The retailer applies the transshipment up to the excess stock of a threshold equal to its safety stock.

IV. Classification of research work

There is a vast literature aimed at studying stock management policies in combination with transshipment. For this, we propose to group the research works according to the type of problem they deal with and the way in which the problem is modeled.

One way of structuring the comparison of these works is already to situate them in relation to the following dimensions:

● Single-step / multi-step;

● Number of sites (retailers);

● Type of stock policy used at each storage site: (s, Q) / (s, S) / (R, S) / (R, s, S), (Periodic or continuous);

● Type of transshipment approach: (preventive (proactive) or corrective (reactive));

● The demand is: constant deterministic / dynamic deterministic / stochastic known law (Paterson et al., (2012)) / stochastic unknown law;

● The lead time is: zero / constant / random;

● Breakage is: modeled by a constant breakage cost per item / modeled by a complex cost / expressed through a service rate (Zheng et al., (2016); Louie et al., (2017));
● The cost of transshipment is: linear (depending on the number of units transferred) / fixed per transshipment / constant per transshipment request / complex (composed of a fixed cost and a variable cost);
● The resolution method is: analytical / heuristic / by simulation, etc;
● The different costs: identical / different.

Besides, there is another way of comparing research work by applying the transshipment and fixing the direction of the lateral transfer.

In fact, for centralized systems, most of the publications have focused on transshipment - two-way in supply chains.

This work assumes that transshipment is mutually beneficial for all retailers and aims to maximize the total profit of the system and no longer of such a retailer.

Rudi et al., (2001) analyzed a two-tier and two-retailer storage system, they applied two-way transshipment and they targeted to show the effect of coordination of transshipment prices on the quantity of Optimal inventory control throughout the storage system, in a centralized supply chain.

Hu et al., (2007) analyzed a two-retailer inventory model by applying two-way transshipment, similar to that of (Rudi et al., 2001) and showed that coordinated transshipment prices do not always exist . They have set sufficient and necessary conditions for the existence of coordinated transshipment prices such as, for example, symmetrical retailers.

Zou et al., (2010) considered a two-location inventory model with two-way transshipment in a competitive environment. The intensity of rivalry is assessed using a customer's switching rate by studying its impact on the benefits of transshipment efficiency. Li et al., (2013) discussed the problem of coordinating preventive - bidirectional transshipment between two independent storage sites and proposed a bidirectional revenue sharing contract to coordinate the whole system.

Zhao et al., (2016) studied coordinated transshipment prices in a new e-commerce model, an online-to-offline marketplace comprising a revenue share between online and offline retailers.

Li and Li, (2017) discussed the impact of bargaining power in a two-tier supply chain consisting of a manufacturer and two symmetrical retailers with two-way transshipment between them.

The literature on transshipment - unidirectional for a supply chain is however scarce.

Seifert and Thonemann, (2006) studied transshipment - unidirectional integrating direct and indirect sales channels through a traditional retail store and a virtual store under decentralized decision-making. They analyze how the supply chain of a single manufacturer and multiple identical retail stores can be coordinated considering a combination of wholesale pricing, inventory subsidies, and transfer payments.

Dong et al., (2012) analyzed a storage system composed of two rungs, considering a manufacturer and two non-identical inventory locations so that the transshipment is carried out in a unidirectional way only to analyze the asymmetry of information. in the system. Toyasaki et al., (2017) considered two-way and one-way transshipment of relief products in a supply chain under correlated demands. However, given that they consider a supply chain network in a non-business context, their model shows significant differences from the business context in terms of costs and price parameters. For example, in their network, transshipment between channels is based on a system of borrowing and lending without a transshipment price. In addition, they consider reserve prices for emergency orders from an additional rung in the system that can coordinate the supply chain.

V. Types Of Problems

● Storage structure: We distinguish between single-tier storage structure, in which the supplier supplies the retailers directly, and two-tier storage structures, where there is an intermediary between the supplier and the retailers. The structures that are the subject of significant research in inventory management are those at two levels. In the one-tier structure, the supplier is assumed to have infinite capacity and only retailers use inventory policies. In the two-tier structure, the distribution center also adopts an inventory management policy which may be the same or different from that adopted by retailers.
● Nature of the product: The nature of the products has an influence on the choice of the stock policy because, for example, of their lifespan, also at the retailers and the distribution center and on the modeling of the random demand of the product. customer.

We distinguish, then, between perishable or non-perishable products, and also repairable or non-repairable items.

The case of repairable products is considered mainly in the context of the storage at several warehouses of repairable spare "parts", when the type of parts is exceptionally expensive, with a rather large uptime average, but whose failure can have very costly consequences. To cover the needs of a given region, storage centers are planned at various points. These centers ensure, according to a strategy specific to each, the storage of spare parts and agree to support each other, through transshipment, to cover the immediate need in the event of an actual out of stock.

VI. Methods Of Resolution And Difficulties Encountered

We find, then, in the research works, those which propose an exact resolution leading to an optimal solution of the problem under restrictive assumptions of the input parameters.
Other works present heuristic research or approximate analytical modeling with relaxation of certain assumptions. We also find works which seek satisfactory solutions by simulation for large problems and under more general hypotheses. The complexity depends mainly on the following parameters:

- Network size;
- Distribution of demand;
- Deferred or lost requests.
- Distribution of lead time;
- Nil or non-zero transshipment time;
- Same or different management costs.

VII. Emergency Transshipment Models

7.1. Transshipment models with politics (R, S)

At the end of each elementary period, the stock is assessed, possible emergency transshipments are then carried out simultaneously and a supply order is placed if it is a review period. This work generally adopts the hypothesis of deferred requests. Recall that the (R, S) policy is particularly appropriate under the assumption of negligible order / setup costs.

We cite as examples of works emphasizing the importance of politics (R, S), Banerjee et al., (2003) and Burton and Banerjee, (2005) who were interested in evaluation, by the cost bias and for configurations of number of sites with 2, 4 and 8 retailers, the advantages of transshipment based on the availability of the policy (Complete -Pooling) and those of preventive transshipment.

Lee et al. (2007) analyzed a comparison with the study of (Banerjee et al. 2003), and they show the effectiveness of a new approach "service level adjustment" which reduces the risk by anticipating the rupture in advance and responds to an effective rupture, while coupling the quantities of transshipment in preventive and emergency are determined according to fixed service thresholds. Research by Herer et al. (2004)) focuses on the study of an inventory system made up of multi-retailers who are not identical in terms of costs, without transport capacity constraints to achieve reactive transshipment. The random requests arriving at the warehouses are assumed to be correlated (the requests are independent, identically distributed (i.i.d)).

The work of (Özdemir et al. (2006)) focused on the research of (Herer et al., 2004)) by considering transport capacity constraints according to which the quantities of transshipment between depots located at the same level are limited by the capacity of the means of transport. These researchers developed an efficient approximate stochastic approach using Monte Carlo simulation. Numerical results show that transmission capacity constraints increase the total cost as well as alter the distribution of inventory throughout the network.

The same problem studied by (Özdemir et al. (2006)) has also been treated by (Ekren and Sunderesh, (2008)) by applying the simulation-optimization-based resolution method. The optimization procedure is carried out by OptQuest of the ARENA ® software.

Hu et al. (2007) studied a storage system made up of two retailers and they targeted to emphasize the non-coordination of transshipment prices.

Archibald et al. (2009), for their part, studied a model made up of multi-retailers that are not identical in terms of costs, without transport capacity constraints to carry out a transshipment. The requests arriving at the sites follow the fish law (the requests are independent, identically distributed (.i.i.d)). To solve this problem they use the Markovian resolution methodology.

Pazhani et al., (2015) have focused in their research work on reducing the total cost of the storage system by minimizing the cost of disruption (by minimizing the service rate) and that of transport and on the improving supply chain efficiency by making the best decision by selecting the optimal supplier under a stochastic demand constraint.

Emel and Lena, (2017) focused their research on the same work of (Hu et al. (2007) but they aim to study “Risk pooling via unidirectional lateral transshipment” between two retailers in local decision-making under the following constraints :

- One-way transshipment can only be applicable when cost structures and / or storage capacities are different from one warehouse to another,
- And, the transhipment donor storage site must have a very large quantity so that it becomes a secondary central warehouse to meet its customer demand and that of the warehouse that receives the transshipment.

Nevertheless, the work closest to our study is that of (Emel and Lena, 2017).

The two works have the following similarities:
● Elimination of the transshipment capacity constraint,
● The distribution relates to a single type of product,
● The transshipments are unidirectional;
● The logistics chain management decision is decentralized,
● Orders placed during the supply cycle are not subject to any constraints,
● The time horizon is over (periodic check).
These two works also present the following differences:
● Transshipment policies applied: Complete-Pooling and Partial-Pooling,
● Number of retailers exceeds two,
● The transshipment applied is bidirectional,
● The logistics chain management decision is centralized,
● Setting of the threshold beyond which the retailer accepts the transshipment in competition with the available stock (in the case of the "Partial-Pooling" transshipment policy),
● Requests arriving at the sites follow the Normal (the requests are independent, identically distributed (i.i.d)).

7.2. Transshipment models with politics (s, Q)

For jobs that have adopted the continuous review policy, the (s, Q) system is most commonly used because it is relatively simple. Investigations were carried out under the two hypotheses of lost demand systems and deferred demand systems.

Evers (2001), developed two heuristics to determine the conditions under which transshipments generate benefits for the stock system.

The first heuristic seeks to solve the problem of transshipment of a single unit (site) and the second addresses the transshipment of multiple units (multiple sites). The all or nothing transshipment policy is adopted in the model of Evers (2001) with a linear transshipment cost, depending only on the quantity transferred.

Research work (Minner et al., (2003)) focuses on a relaxation of the hypotheses of (Evers, (2001)) by accepting transshipments by quantities lower than those requested and by adding a fixed cost per request satisfied. They also completed the model by taking into account supply costs as well as any disruption costs resulting from the decision to transshipment.

Satyendra and Venkata, (2005) studied a storage system (s, Q) composed by two-retailers by supposing that the demand is random and follows the Normal law N (, for this they applied the method of resolution by Simulation for seek the best solution in terms of total cost and rate of service. Olssen (2009, 2010) was interested in solving the problem of "lateral unidirectional transshipment" in stock systems of type (s, Q) or (S - 1, S) with deferred or lost requests.

Olssen (2015) studied a storage system (s, Q) composed of a distribution center and two-retailers, he applied the analytical resolution method to seek the optimal solution by applying the policy of transshipment (Partial Pooling).

7.3. Transshipment models with politics (S-1, S)

The study by (Wong et al., (2005)), is one of the few to have assumed that the time of non-negligible transshipment and a deferred transshipment (ie in the event of a break in a warehouse, if no depot has of available stock then the transshipment is deferred (put on hold) until the stock becomes positive in one of the storage sites).

Liu and Lee (2007) focused their research on a single-tier, multi-product, and multi-retailer inventory system. They emphasized the influence of partial transshipment on the reduction of the total cost by applying the Markovian method of resolution.

Paterson, et al. (2012) analyzed a single-tier, single-product, and two-retail inventory system. They demonstrated the importance of making a decision to transshipment only if the stock position is above a set threshold. To solve this problem, it applies the analytical method of resolution.

Seidscher and Minner, (2013) examined the policy (S-1, S) in an inventory system composed of a distribution center and N-Retailers, to determine an optimal transshipment policy they applied, first instead, the policy is reactive to minimize the rate of out-of-stock, but they deduce that the quantity of unsatisfied order is high. For this, they have combined this policy of transshipment with another proactive one, resulting in an effective improvement of optimal results in terms of cost and service rate.

Patriarca et al. (2016) studied a two-tier inventory system, the first comprising a distribution center and a maintenance department for repairable parts. The second tier contains a large number of retailers. First, they applied Complete-Pooling when using transshipment, then they set a threshold beyond which they would make the decision to apply such transshipment.

7.4. Transshipment models with (s, S) and (R, s, S) policies

The study of transshipment for (s, S) or (R, s, S) stock systems has attracted relatively less work, arguably because of its more complex nature.

Hu et al. (2005) examined (R, s, S) policy in an inventory system consisting of a distribution center and multiple - retailers with centralized inventory management at the distribution center level to improve the overall performance of the system. whole. The assumptions considered in their model are very restrictive: zero supply and transshipment times, identical demand parameters, identical costs and an infinite time horizon. Within this framework, the authors proposed an approach based on dynamic programming in order to find the approximate optimal policy (s, S) of the entire system at the distribution center level.

Tlili et al. (2010) examined the policy (R, s, S) in an inventory system composed of two-tier, the first containing a distribution center with infinite storage capacity and the second composed of multi-retailers. Their research aimed to reason the advantages of complete-pooling and those of partial-pooling on cost reduction. To solve this problem, they applied the "Simulation-Optimization" method of resolution and they showed that "partial - pooling" is more efficient than "complete-pooling", because with a partial transshipment, there remains such a quantity in warehouse in overstock position, which can reduce the quantity of lost orders; this will improve the optimal result in terms of total cost and rate of service by reducing the unmet amount of customer demand.

VIII. The Preventive Transshipment Models

In the literature, a few models deal with two-tier, multi-site inventory systems where transshipments are used as a preventative measure to balance inventory levels at retailers before demand is met.

Tiacci and Saetta, (2011) studied an inventory system with multiple retailers identical in costs and zero lead time, with the aim of minimizing the costs of disruption and redistribution. Ching, (2014) adopted the same assumptions as (Tiacci and Saetta, (2011)) but limiting itself to a two-site stock system and allowing transshipments in the middle of each supply cycle.

Following the same structure of the system of (Ching (2014)) but considering that the lead time is positive, Hochmuth and Köchel (2012) extended the problem to a stock system with multi-retailers not identical in terms of cost. . They looked at a centralized supply system with an emphasis on full inventory redistribution during the last period of a supply cycle to balance inventory levels at all retailers. They have shown that a considerable reduction in safety stock is possible using this redistribution, just as service improvement is achieved.

In the case of identical retailers, the authors confirmed the results obtained by (Li et al. (2013).

Furthermore, for the case of non-identical retailers, the simulation showed that high values of supply cycle length, number of retailers and cost of ownership, coupled with low values of transshipment costs and lead time supplier, promote the redistribution policy. We can give as an example, Dan et al. (2016) who studied a stock system with two non-identical retailers in terms of costs, they examined the level of stock through a preventive transshipment policy to meet a random demand. Then, they increased the number of retailers to the surplus by two, for this and because of the complexity of the model, they applied the simulation to solve this problem and found a good result close to optimality.

IX. Conclusion

In this paper, we have presented the general characteristics of stock systems with transshipment. We have reviewed various works carried out by classifying them by transshipment policy and by stock management policy. In the literature, the different transshipment approaches can be summarily distinguished into two families: emergency transshipment and preventive transshipment. The policies (R, S), (s, Q), (s, S), (R, s, S) and (S-1, S) were used in this work. This thus closes the first part devoted to the synthesis of the state of the art. On the basis of this synthesis, the positioning of our research problem, its similarities and its specificities appear clearly: We are interested in the study of stock systems of the type (R, S) at two levels and two / multi retailers. We place ourselves in the hypotheses where the customer requests follow a normal distribution, the unit cost of the transshipment will be linear according to the transferred quantity. As transshipment policies, we are experimenting with “Complete-Pooling” and “Partial-Pooling” by modifying the transshipment threshold.

The objective is to:

• Determine, for each retailer, the transshipment policy that improves economic profitability by increasing the Average Global Profit and reducing the Average Global Service Rate.

• Identify the different factors that influence the performance of a stock system with transshipment and analyze its behavior under various constraints,

• Identify in general, the conditions under which the application of transshipment is beneficial.

The presentation of our contributions on this subject is the subject of the second part which follows.

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