Analysis and Improvement of Transshipment Operations in Jerónimo Martins

Camille Garcia Guimarães Andrade Coyac

Department of Engineering and Management, Instituto Superior Técnico

Abstract
The present study studies the transshipment operations between JM warehouses so as to reduce the associated costs. This operation influences directly both the costs and the Group's service level. Transshipment emerged in response to the increase in volumes and the restructuring of the logistics network, allowing a higher level of flexibility in the chain. However, currently, the increase of transshipment represents high logistics costs and inefficiency in operations. Therefore, it is intended with this work to improve JM's transshipment operations by reducing costs, increasing the service level, as well as the sustainability of the supply chain. To achieve this goal, this paper will tackle the problem, its origins and consequences, through the description of JM’s logistics network in Portugal. Then, it will analyze the reasons and the transshipment flows. Proposals are developed to reduce costs, as well as a model that determines what strategy, transshipment or centralization, is the best suited for each article, in order to minimize costs for the Group. The conclusions of this work offer JM tools that can be implemented in order to improve the transshipment processes.

Keywords: transshipment, logistics network, centralization, optimization, supply, transportation.

1. INTRODUCTION

Increased competitive pressure and globalization of the current market push companies to reduce their operational costs and increase the quality of their services (Thomas & Griffin 1996). To remain competitive and respond to customer needs, retail companies have a responsibility to develop flexible and efficient supply chains.

Jerónimo Martins (JM) is an international company in the food sector. It has a diversified business portfolio that encompasses four sectors in Portugal: distribution, mass consumption goods, services, and the agro-food industry. In Portugal, this group is the leader in food distribution, operating with brands such as Pingo Doce and Recheio. JM’s logistics network has a mission to guarantee different operations to satisfy individual clients' needs at the highest quality and lowest cost through contact with suppliers, storage, and transport.

This paper mainly will focus on the Group’s food distribution in Portugal.

To ensure a high service level, to cope with increasing volume, and to integrate the new Algarve Distribution Center (DC), JM made a decision to implement lateral transshipment between the Group’s warehouses.
Transshipment occurs when goods are transferred between points at the same level of the distribution chain, in this case, between the distribution centers. This operation policy may be used as an efficient alternative to minimize total costs (Paterson et al, 2011). However, it is often the case that it becomes complex to manage given the underlying costs and benefits affecting several departments. An additional difficulty also arises since the cost-benefit breakdown is not clear to every party involved (Lee et al, 2007).

Despite this complexity, good management of transshipment on a distribution chain makes possible to increase the service level and reduce costs in the long term. It is in this scope that the present work emerges, aiming to assess the operations of transshipment at JM and to propose solutions for its improvement.

To achieve these goals, this paper has the following structure: JM’s transshipment problem is described in section 2. Section 3 presents the most relevant literature review. Section 4 analyzes the transshipment in JM. Section 5 presents the operations and decision-making improvements identified for this problem. Section 6 is a short description of the decision-making model and a presentation of its results. Section 7 is the final one, where main conclusions are drawn.

2. PROBLEM DESCRIPTION

JM transportation corresponds to 46% of the logistics costs, which represents approximately 1.5% of the company’s total costs. Since transshipment influences these costs, this paper aims to develop measures that could be implemented as means to reduce the transshipment transportation costs in the distribution chain. Furthermore, considering the recent increase of transshipment costs and the absence of an outlined and common strategy for transshipment, it is imperative to assess and improve these operation.

The three main reasons for implementing transshipment at JM are the following:

- The configuration of the current logistics network (namely the proliferation of warehouses and the opening of the Algarve DC).
- The company’s strategic decisions (e.g. promotional campaigns).
- Small quantities delivered by the suppliers (when suppliers need to deliver small shipments to several warehouses, they may increase the supply costs).

The proposals developed along this paper to improve the transshipment operation focused into the following two categories:

Operational:

The execution method of goods has a significant impact on transshipment costs since it influences the capacity of the truck used. Aiming to make these operations more efficient and reduce costs, this paper assesses the different shipping methods and identifies the most efficient one. Additionally, a platform to create synergies along the supply chain and reduce costs was created.

Decisional:

As per DC, it was noted that each distribution center manages the transshipment of its region independently making it hard to optimize the transshipment operation as a whole some inefficiencies were identified. This work proposes a model that improves the supply decision-making process, aiming to minimize the costs for the company.

In order to sustain the analysis developed, a bibliographic study of the transshipment operation was performed.

3. RESEARCH BACKGROUND

Transshipment is the transfer of goods among locations situated at the same echelon level in the supply chain (Özdemir et al, 2005).

According to Paterson et al (2011), this policy...
generally allows the reduction of inventory quantities and costs while successfully achieving the required service levels.

The most common classifications used in the literature to identify the type of transshipment are reactive and pro-active.

In the first case, reactive transshipment occurs when a warehouse is in stock failure and the goods are moved from a warehouse that has more available stock. Since this transshipment is done when the warehouse is in stock failure, not performing transshipment implies not satisfying the demand, which consequently reduces the service level.

Pro-active transshipment is used to redistribute stock between all points in the same echelon level. In this case, it is necessary to decide the more adequate moment to execute the process. The study of pro-active transshipment began in 1963 with Gross (Gross, 1963) and later was developed by other authors, namely Karmarkar & Patel (1977), Diks & de Kok (1996), and Evers (1996).

Based on the literature review, several elements that influence transshipment were identified such as: the cost structure; the level of service desired by companies; and the policies of inventory used, in addition to other factors. As mentioned by Patersson et al (2011), these elements give rise to different models, which provide policies of transshipment more adequate to each case. According to Minner and Silver (2005), the determination of an optimal policy of transshipment is a complex mathematical problem. So, the problem of transshipment may be tackled using different approaches. However, to obtain a holistic vision and to consider all variables in JM’s case, it was necessary to integrate the vision of a fixed supply cost, inventory, and transportation. According to Khurana & Arora (2011), in real life, the major part of the problem encompasses mixed restrictions, which implies the problems are more than simple transportation problems. According to these authors, there is no systematic method in the literature to find an optimal solution for transshipment problems that include mixed restrictions.

4. TRANSSHIPMENT ANALYSIS IN JM

4.1 - Comparing scenarios with and without transshipment

The main impacts of transshipment in the supply chain are reflected in costs and service level. However, the additional flexibility offered by transshipment implies an additional difficulty on the control and optimization of an inventory system (Paterson et al, 2011). So, to assess the transshipment at JM, the trade-offs between the scenarios with and without transshipment were analysed. For that it is important to evaluate the different trade-offs between transportation costs, fixed supply costs (influenced by the locality of the delivery), storage costs, flexibility of the supply chain, operational costs and service level (Table 1).

<table>
<thead>
<tr>
<th>Factors to consider in transshipment</th>
<th>Scenario with transshipment</th>
<th>Scenario without transshipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportation Cost</td>
<td>Increases</td>
<td>Decreases</td>
</tr>
<tr>
<td>Fixed Supply Costs</td>
<td>Decreases</td>
<td>Increases</td>
</tr>
<tr>
<td>Operational Cost</td>
<td>Increases</td>
<td>Decreases</td>
</tr>
<tr>
<td>Storage costs</td>
<td>Decreases</td>
<td>Increases</td>
</tr>
<tr>
<td>Service Level</td>
<td>Tends to increase</td>
<td>Tends to decrease</td>
</tr>
<tr>
<td>Flexibility</td>
<td>Increases</td>
<td>Decreases</td>
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</tbody>
</table>

The underlying trade-offs of these factors considerably impact the service level, the total costs, and the company results in the medium and long-term.

With transshipment, transportation costs increase due to the exchange of goods between the company’s distribution centers. Without transshipment, these transportation costs revert to the supplier. Consequently, this
factor has an impact on the fixed costs of supply (i.e. on commercial agreements), since without transshipment, the quantities of goods delivered by the supplier in each warehouse are lower. Thereby, several consequences will emerge, such as the reduction of the minimum volume of products bought, lower weight on the negotiation, higher costs for the supplier and, finally, higher pressure on the sales margin. In a scenario with transshipment, the operational costs will tend to increase due to the double execution (at the origin warehouse and at the destiny warehouse).

Finally, according to Herer & Tzur (2001), these scenarios diverge in terms of flexibility. In a scenario with transshipment, we will have higher flexibility, since it is possible to satisfy emergency requests using the stock available at other warehouses.

Currently, the implementation of a scenario without transshipment at JM is hampered by the following constraints:

- Lack of capacity of the distribution centers;
- Cases where the supplier charges a higher cost if he has to deliver the goods in different DCs, than the transshipment cost;
- Inability to respond to requests that need an emergency transshipment.

According to Burton & Banerjee (2005), although the costs of transportation increase with lateral transshipment, it is recognized that this policy still represents a more acceptable approach than a policy without transshipment. Based on the current restrictions of the Group and on the bibliographic revision performed, a scenario with transshipment is more advantageous for JM.

Since a scenario with transshipment is more desirable in this case study, it is necessary to calculate the transshipment percentage that optimizes the total costs.

### 4.2 - Flows and percentages of transshipment

Before determining the optimal transshipment level, we will analyze the current supply flows as well as the current percentage of transshipment.

Transportation costs account for 46% of the company’s total logistics costs. This percentage is partially due to the transshipment between warehouses, which accounts for 5.1% of the supply. The percentage of transshipment for non-perishable goods represents 6.7% and for perishable goods it accounts for 2.3%.

#### 4.2.1- Flows of Non-Perishable items

The non-perishable transshipment flows correspond to an average of eleven trucks per day, five days per week, between the Centre and the North, and about eleven daily trucks for six days per week between the Centre and the South, (figure 1).

![Figure 1: Average of non-perishable pallets sent daily](image)

In Figure 1 it is possible to observe that the transshipment flows of non-perishable items are mostly from the Centre to the North and from the Centre to the South. Similarly, it is known that almost half of the non-perishable items in the Southern region are supplied by transshipment.
4.2.1 - Flows of Perishable items

With regard to the perishable items, an analysis was performed for three categories: fruits and vegetables, fresh and butcher, and fish.

The transshipment of fish represents the perishable category with the highest transshipment rate: it accounts for 1.8% of the total shipping of these three perishable categories. The fruits and vegetables transshipment represents 0.4%, and the fresh and butcher has a weight of 0.1%.

It is possible to conclude that the reasons for performing transshipment vary according to the type of item.

Therefore, it is necessary to identify specific proposals for each type of merchandise, as a way to optimize the items’ allocation and reduce costs without harming the consumer.

5. OPERATIONS AND DECISION-MAKING IMPROVEMENTS

Related to the transhipment operations decision-making process three solutions are proposed aiming to improve the transhipment in the company: the implementation of an IT collaboration tool; an alteration in the execution method; and the use of a new KIP (Key Performance Indicator) for decision-making.

5.1 – Collaboration tool for suppliers with small quantities to deliver

Regarding items delivered by suppliers in small quantities three different policies can be used: multipack (i.e. collect the goods from several shipping points on a single delivery point), multidrop (i.e. transporting the goods from a start point to several shipping points), and shared management of supply (i.e. the collaboration of the agents of the logistics chains through a warehouse fed by several suppliers, later supplying several distributors). Each of these policies enables a reduction of transportation costs, allow for an increase in the delivery frequency, and can reduce CO2 emissions.

According to Mentzer et al (2001), obtaining an efficient management of the supply chain requires cooperation between the different supply chain members. To that end a prototype tool was developed that aims to mobilize the suppliers, hence the two parties (retailer, supplier) may communicate efficiently and establish synergies among themselves (Figure 2).

![Figure 2: Prototype - Suppliers Map](image)

With this tool, the suppliers may group their goods and deliver them at the different DCs, reducing the transportation costs for both the suppliers and JM. It is important to highlight that sharing the load contributes to a higher utilization rate of vehicles, and also promotes the reduction of harmful impacts on the environment.

These proposal generates a more sustainable supply chain with increased collaboration and reduced costs and should be pursued by JM.

5.2 – Change in the execution method

According to Bravo & Vidal (2013), the fact that the transportation costs are typically high in comparison with the total logistics costs, in any industry, makes transportation of goods one of the most studied logistics problems in scientific literature.

Therefore, to make operations more efficient and reduce costs, the best methods to execute goods through transshipment operations will be presented as well as solutions to optimize the amount of space used in vehicles.
There are two ways to execute goods by transshipment:

- Execution per store: separation of goods at the origin warehouse and consideration of the individual requests of each store.
- Execution in bulk: separation of goods by store at the destiny warehouse. At the origin warehouse, this method groups the requests of different stores within the same region as if they were a single store.

To compare these two execution methods, the analysis focused on the transshipment flows from the warehouses of the Central region to the South, given the higher inefficiencies. So, the two scenarios considered are the following (Figure 3):

- **Scenario A**: Execution per store from the JIT (Just in Time) warehouse in the Centre to the South;
- **Scenario B**: Execution in bulk from the stock warehouse in the Centre to the South.

![Figure 3: Scenarios analysed](image)

**Comparative approach of the scenarios:**

To evaluate the type of execution and transportation that best promotes minimization of costs, a comparison of costs per PUM (Purchasing Unit of Measure) was performed on the goods shipped from the Center to the South (Figure 4).

- **Scenario A**: JIT flow: Execution by store with “common” vehicle = cost of execution by store + cost of transportation + cost of cross-docking execution = 0.031 + 0.230 + 0.006 = 0.267 euros/PUM.
- **Scenario B**: Stock flow: Execution in bulk with “common” vehicle and double deck = cost of execution in bulk + cost of transportation + cost of execution per store = 0.019 + 0.158 + 0.056 = 0.233 euros/PUM.

![Figure 4: Comparative approach of the scenarios](image)

Scenario B presents a lower total cost. Therefore, it is recommended to separate the goods per store in the warehouse of destiny instead of the warehouse of origin. As a result, executing the goods in bulk would represent a cost reduction in the order of 74,000 euros per year.

**5.3 – Use of a new KPI for decision-making**

To understand the decision-making process, the different departments’ drivers and influences were analyzed. The conclusion showed the decision-making process of transshipment is not centralized and each department has its own KPIs, sometimes conflict during the decision making process.

For the purpose of obtaining a more integrated vision of each item, the use of the DPP (Direct Product Profitability) index would allow accounting for the item’s costs throughout the supply chain. Therefore, DPP is a solid tool to analyze the impact of a specific decision on costs, to identify opportunities for improvement and to make the chain more competitive.
To bring the decision making process regarding transshipment closer to the optimum level, a model was developed that attempts to identify the adequate decision of supply for each item (i.e. centralization or transshipment), optimizing the costs of the Group.

6. **Decision Support Model**

In this chapter, a decision-making model will be presented. This model enables the choice between transshipment or centralization that minimizes costs for the Group.

The implementation of this model is crucial since, currently, the decisions being made are not optimal. For example, there are suppliers that deliver goods with high turnover only in the DC of the Center region, and are willing to deliver these goods in other regions with no additional cost. In this case, centralization method should be used. On the other hand, there are suppliers that deliver goods with very low turnover in several warehouses, when transshipment would be cheaper for the company.

To solve these problems, the presented model calculates the cost of centralization as well as the cost of transshipment for each item, allowing the choice of the most favorable alternative.

The model formulation uses the following indexes, parameters and variables.

### 6.1 – Indexes and parameters

To characterize each flow, the model uses the following indexes:

- **i** = item, represented by the item code;
- **j** = region of origin;
- **k** = region of destiny.

It should be noted that if the index j is null, the item is only referent to the origin warehouse and if index k is null, the article is only referent to the destiny warehouse.

However, if both indexes are positive, they refer to the item’s flow from area j to area k.

### 6.2 – Main Variables

When sending an item by transshipment or when centralizing it in a warehouse, the following variables should to be considered.

- **$X_{i,j,k}$**: Number of pallets consumed of item i during the month in analysis, in the different regions j and k.
- **$CT_{i,j,k}$**: Transportation cost of item i from the warehouse of region j to the destiny k.
- **$CA_{i,j,k}$**: Cost of supply, i.e., the purchase price of item i from the supplier for the different regions j and k.
- **$Dif(CA_{i,j,k})$**: Difference of the cost of supply, i.e., the difference of the price of purchase, if the supplier delivers the item in the warehouse of the region j, or in both warehouses (of regions j and k).
- **$CP_{i,j,k}$**: Monthly cost of stalled stock of item i, at the different regions j and k.
- **$Dif(CP_{i,j,k})$**: Difference of the monthly costs of the stalled stock between the scenarios with and without transshipment.
- **$CE_{i,j,k}$**: Extra cost of execution for item i due to transshipment from the warehouse of area j to the warehouse of area k.

### 6.3 – Restrictions

The restrictions considered in this model are the availability to order, the status, and the promotions.

- **$P_{i,j,k}$**: Availability to order

  It shows if the stores that are supplied by the warehouse of region k can order the item in a continuous manner. If the stores do not have this option, then the item should not be centralized in that region.
The status represents the continuity of the good. If the item will be discontinued, a change in the supply method shouldn’t be proposed.

Since consumption of the goods generally changes significantly when the item is being promoted, the model takes that into account.

### 6.4 – Objective Function

When negotiating the location of delivery with suppliers, the cost of carrying out transshipment should be calculated and compared with the cost of centralizing the product in each region. Thus, the decision to implement transshipment should be based on the model developed, which would allow for the reduction of the costs incurred by the company. Therefore, the logistics cost of each item would be considered in the decision making.

\[
\text{Transshipment Cost} = \left( CT_{i,j,k} + CE_{i,j,k} \right) \times x_{i,j,k}
\]

\[
\text{Centralization Cost} = \text{dif}(CA_{i,j,k}) \times x_{i,j,k} + \text{dif}(CP_{i,j,k})
\]

\[
F(x_{i,j,k}) = \text{Transshipment Cost} \quad [\text{dif}]
\]

\[
F(x_{i,j,k}) = CT_{i,j,k} \times x_{i,j,k} + CE_{i,j,k} \times x_{i,j,k}
\]

\[
- \text{dif}(CA_{i,j,k}) \times x_{i,j,k} \times \text{dif}(CP_{i,j,k})
\]

The model calculates the difference in the purchase price for each article, indicating when it is economically advantageous to switch the supply method. Thus, the model supports JM’s decision making, helping to identify the most adequate scenario for each product, in an effort to minimize costs.

### 6.5 – Calculation of the Variables

The model considered four variables, which are the transportation cost, the cost of stalled stock, the difference in the cost of supply and the execution cost.

#### Transportation Cost

This is the cost the company expends to transport the good from one warehouse to another. This cost depends on the warehouse origin and destiny, since it influences the cost of travel and the number of pallets per vehicle.

\[
\text{Transportation cost per PUM (euros/PUM)} = \frac{\text{cost of travel for each vehicle}}{\text{number of PUM per vehicle}} \quad [5]
\]

#### Cost of stalled stock

When the supplier has minimums of purchase (i.e., he only delivers a minimum quantity), delivering this quantity in one or two warehouses can influence the frequency of delivery. Therefore, it can have an impact on the cost of stalled stock. Thus, the model calculates this cost for each item based on the average stalled stock, the purchase minimum and the consumption in the different regions. To obtain the cost of stalled stock, in euros, the average of stalled stock in units must be multiplied by the unit cost of the item and by the WACC (weighted average cost of capital) rate, as follows:

\[
\text{Cost of Stalled Stock} = A \times \text{Unit Cost of the Item} \times \text{Units of Item per UMC} \times \left( \frac{\text{WACC}}{12} \right) \quad [6]
\]

#### Difference of the supply cost

This variable corresponds to the difference in the purchase price when the supplier delivers the goods in several warehouses. This cost then depends on the negotiations with suppliers. Taking into account the absence of a recording of this value, the model allows for the calculation of this variable.
Execution cost

When sending the goods by transshipment, the goods must be executed in the warehouse of origin and destiny. Consequently, this method of supply incurs the following extra execution cost:

\[
\text{Execution cost per month per collaborator} = \frac{\text{Execution cost in bulk per PUM for transshipment}}{\text{Productivity of transshipment operation at warehouse 5401}} = \frac{8.33}{437.65} = 0.019 \text{ euros/PUM}
\]

6.5 – Results

The results presented in this session were based upon the flows from the Center to the North and from the Center to the South since they account for 98.6% of the transshipment of non-perishable goods. There were 16,306 articles tested for the month of January 2015. To perform this test several pieces of information regarding each article were needed, such as the purchase price, the consumption in the different regions, the promotions, the continuity of the article, the minimum quantity delivered, and the number of units in a pallet, among other factors.

Assuming that there is no difference in the extra cost of supply, the model suggests the following modifications:

For the North, 7,897 articles should maintain their current supply method, 1,404 items currently send by transshipment should be centralized, and 49 articles currently centralized should be sent by transhipment, (figure 5).

For the South, 5,358 articles should maintain their current supply method, 1,576 items currently send by transshipment should be centralized, and 22 currently centralized should be sent by transhipment, (figure 6).

Figure 5: Results for the North region in the month of January 2015

Figure 6: Results for the South region in the month of January 2015

Considering the criteria used, these modifications generate savings of 40,777 euros for the month of January. Taking into account the premises mentioned above, these supply modifications could reduce costs up to half a million euros annually. However, when negotiating with the suppliers the delivery locations, the difference in the supply costs of many items is not always null. This difference varies with the quantities delivered and with the supplier purchasing power. For these situations, the model calculates the purchasing price for which a change in the supply method (i.e., centralization or transshipment) is more beneficial.

In brief, the model indicates has shown that the current centralization of JM items is not optimal. Modification of the supply method of 19% of the items should be performed to minimize the total costs.

Conclusion

During the study of the current supply chain process and logistic set-up of JM, a specific analysis of transshipment operations has been performed. From this analysis, four possible initiatives have been identified, which implementation would contribute to the reduction of the total costs. The initiatives are as follows:
• The creation of a collaborative prototype platform to promote sharing and cargo pooling between suppliers, which in turn should help reduce costs.

• A change in the execution method. The comparison between the execution methods (i.e., execution by store or in bulk) resulted in the identification of the bulk execution method being the most effective for transshipment operations.

• The use of a new KPI. Given that the decision making is not centralized and several known inefficiencies exist, the use of a common index for each item throughout the supply chain is proposed so as to improve the decision-making process.

• The implementation of a developed decision-making model is proposed, which determines the best scenario (i.e., centralization vs. transshipment) for minimizing total costs for each item. In the current decision-making, the transshipment costs are not taken into account, leading to inefficiencies.

The study and analysis of transshipment operations in JM, confirm the bibliographic review where transshipment was identified as a difficult operation to optimize. However, the initiatives proposed can contribute to the competitiveness of the supply chain process while reducing costs in the transshipment operations of JM.

REFERENCES


