Order cycle optimization in Just in Time: The case study of Jerónimo Martins

Beatriz Silva Batista

Department of Engineering and Management, Instituto Superior Técnico

Abstract
Portugal is currently facing social and economical tribulation and as a consequence companies are actively trying to develop and restructure their supply chains so as to reduce cost. In the retail industry this is the case and the Jerónimo Martins (JM) Group is no exception. As such, one of the main problems identified by JM’s logistics regards the order cycle optimization. Presently, their stores (i.e. Pingo Doce stores) are able to place orders to the warehouses at any day of the week, regardless of the quantities, type and product specifications. This situation becomes more complex when products are being managed in a Just in Time flow. In this paper, the order cycle problem is going to be studied and two main phases were considered on this study: the first one contemplates the sample selection of critical items for the warehouse; and the second develops and applies a mathematical model to the case study, in order to reduce the difference in volume of boxes picked and picking times per day in the warehouse, with a subsequent analysis of the results.

Keywords: Order Cycle, Product Flow, Supply Chain Management, Just in Time, Productivity, Critical Items, Optimization.

1. Introduction
In the past three decades operational and strategic aspects for the management and design of supply chains have been emphatically studied (Holweg and Helo, 2013). The aggregation of the concepts “value chain” and “supply chain” allows for a holistic approach, where companies can define adaptive strategies that are more efficient in the face of constant market uncertainty. This is the case of the retail supply chains that will be studied along this paper.

Within the retail industry and in Portugal, Jerónimo Martins Group has a dominant position in the national food distribution sector. Part of the JM’s Group strategy involves the optimization of logistics operations and one of the key points in the logistics network optimization relates to the order cycle planning. Nowadays, stores can place orders to the warehouses seven days a week, regardless of the quantities and lead time of the products, increasing uncertainty and inefficiencies in the warehouses and consequently in the global supply chain.

Having identified the problem the focus of this paper is JM’s Non-Perishable (NP) warehouse that works in Just in Time (JIT), through the study of the orders placed by Pingo Doce stores to the warehouse.

The objective of the study is to improve the NP warehouse operation, and so through the use of optimization approaches determine in which day and quantity an item should be at the warehouse and,
indirectly, define the day and quantity for any given store orders.

To achieve such objective the paper is structured as follows: in Section 2, the case-study is presented. In Section 3, the relevant literature about supply chains focusing in the retail industry and some of their important operational aspects are analysed. In Section 4 the main aspects of the NP warehouse are presented as is the sample selection process. In Section 5, the developed mathematical model is explained and applied to the case-study. Finally, in Section 6 the main conclusions are presented.

2. Case-study

As mentioned the focus of the present study is on the retail supply chain of JM and within this on their Non-Perishables warehouse of Vila Nova da Rainha that works in JIT environment and its layout is organized into four main sections: Promotions layout, Food layout, Non Food layout and Milk deck.

Operations in the warehouse happen between 06:00 and 24:00 - reception and picking occur over this period. Shipping begins at 14:00 and at 17:00 approximately 60% of products are shipped. The remaining activities go on until 24:00. There are two shifts in the warehouse: from 6:00 to 15:00 and from 15:00 to 24:00. Thus, planning is performed continuously.

The provisioning operation starts at the store level. Stores can place orders in JIT to the warehouse seven days a week (Monday to Sunday), with each item having a specific lead time supply as agreed with the supplier. The main method to place the order to the warehouse is through the automatic suggestion of an MRP algorithm. Nonetheless, stores can ask for more or less amounts of what MRP is suggesting (due to demand variability not predicted by the algorithm).

The warehouse operation is summarized in figure 1:

![Figure 1. Warehouse operation in JIT](image)

3. Literature Review

The technological development of the early twentieth century and the advent of mass production gave rise to a new paradigm for industry - modern industries have evolved into systems with multiple products, features and locations around the world.

Chandra et al. (2007) describes the supply chain as a network of suppliers, manufacturers, warehouses, distributors and retailers, where raw materials are converted into final products through coordinative planning and activities. In this process, there is sharing of material and information flows between the different elements in the chain. Thus, the goal of supply chain management is then to incorporate in an optimized form the different activities along the chain, resulting in increased value to the consumer and reduced overall costs.

Supply chains need to be flexible, thus must have the ability to efficiently adapt to the surrounding environment. In this context the retail industry is facing a high pressure to become flexible as their supply chains contact directly with the final market (Levy et al. 2012). The role of the retailer is to create added value for the customer, through the efficient performance of activities that the manufacturer can not accomplish, such as the provision of a high assortment of products, the ability to hold inventory and the performance of services (eg transportation and customer support).

In Portugal, the food retail industry has evolved over the years. Consumers have abandoned traditional commerce sites for structures that house many types of products, not just food. The growing consumer demand led to a changing role in the retail supply chain. As such, supply
systems and logistics also had to evolve in order to provide "the right product at the right place at the right amount. To achieve this goal different operation strategies have been explored at the different supply chain levels amongst which warehouses are a key entity. Considering the problem in study is important to understand the just in time operation of such systems and additionally the way products should be managed. These aspects are going to be next discussed.

3.1. Just in time

The main premise of JIT philosophy is to maintain adequate inventory levels, both in terms of raw materials or finished products, in order to meet demand. As a consequence, the application of JIT philosophy allows maintaining a high level of service with the customer and simultaneously reducing capital investments in inventory and costs related to waste and obsolescence (UPS Supply Chain Solutions, 2005).

Several benefits of implementing a JIT strategy are mentioned in the literature, among which are the elimination of waste in the manufacturing phase, improving the internal (within the organization) and external (between the organization, partners and customers) communication, potential for reducing procurement costs, reducing the time of supply, increase product quality and service, integration of different functional areas of the organization among others (Yasin et.al., 1997).

Furthermore, JIT is a business strategy that requires the commitment of the organization. An important factor for the successful implementation of JIT in organizations is the realization of demand forecasts, in order to match the demand and supply effectively (Bowman, 1991). Additionally, suppliers must have access to real-time information of the company's operation and should share critical information and planning with the same, avoiding problems related to product delivery, including timings, quantities and quality (Yasin et.al. 1997).

Demand from customers is not the same for all products - in the warehouse are products with higher turnover (fast movers) as lower turnover (slow-movers). The management of products with different levels of demand becomes more challenging in JIT environment, since their stay in storage is the same (due to the JIT concept), but the frequency and quantities that arrived to the warehouse are different.

3.2. Managing products with different order demands

Due to different product characteristics and different levels of demand, it is necessary to classify items in a warehouse. This classification will allow the establishment of appropriate techniques and the management of logistics and inventory activities, according to their degree of importance in the company.

The classification of inventory through ABC analysis is the technique most widely used in organizations. ABC analysis is based on the Pareto principle, i.e. 80-20 rule (rule dictates that, for example, 80% of SKUs in inventory are responsible for 20% of sales generated). Normally, products are rated based on their value of annual use, however this is not the only criterion for ABC classification. Other important criteria referred to in the literature relate to inventory costs, supply time, levels of obsolescence, demand distribution, among others (Ramanathan, 2004).

With ABC classification products are classified into three classes: Class A comprises a relatively small number of products that constitute the majority of the annual use; Class C is composed of a large number of products whose annual use is residual (Ramanathan, 2004); and the products between the classes described above constitute class B. Class A products are typically fast-movers and Class C slow-movers. The classification of the products A, B, or C is very broad and varies from organization to organization (ie, a slow-moving item in an organization can be a fast-moving elsewhere).

The management of products in a warehouse should be made depending on the type of product. Normally, fast-movers exhibit stable levels of demand, so this demand can be modeled by a gamma distribution (Nenes, et.al. 2010). Slow-movers have intermittent searches and can be modeled using a Poisson distribution (Nenes, et.al. 2010).

Although no specific article on the subject under study has been found, the topics presented in this section, including the specifications of the JIT flow and the forms of classification of inventory in a warehouse, allow the contextualization of the present in study and the definition of an approach to the problem, developed in the following sections 4 and 5.
4. Data analysis

As mentioned above the main goal of the present study is to improve the operational activities of the NP warehouse, through the improvement of order cycle management that will result in an increase of warehouse productivity levels. A first step to achieve such goal is through the identification of a representative sample of warehouse items that reflected the difficulties of warehouse activity (essentially picking) and therefore could be studied and optimized in order to increase current levels of productivity in the warehouse.

The two warehouse streams that have lower productivity levels will be considered: flow A (food flow) and flow NA (non food flow).

Data collection and selection was performed through the following steps:

- Picking activity characterization: Using the available literature and conducting an employees survey;
- Gather information about picked items: in the field (physical characteristics) and through WPMS software and SAP software (picking times and volumes);
- Construction of two tools to classify the items found in the previous step – a picking constraint table with five criteria (weigh, volume, fragility, shape and number of references in a pallet) classified from 1 to 5; and a double matrix that compares scores from the previous table;
- Calculation of the minimum sample size: for the two samples (for each flow in study), N which represents the population size is know, E0 which is the tolerable error of the sample is assumed to be 0.1, and n is the minimum size of the sample:

\[ n = \frac{N \cdot E_0^2}{n + \frac{E_0^2}{N}} \]

Through the application of equation [1] presented by Oliveira & Grácio (2005), the minimum sample size for each flow is as follows:

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Flow A</th>
<th>Flow NA</th>
</tr>
</thead>
<tbody>
<tr>
<td>E_0</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>n</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>N</td>
<td>4.776</td>
<td>10.957</td>
</tr>
<tr>
<td>n</td>
<td>98</td>
<td>99</td>
</tr>
</tbody>
</table>

- Results filtration: performed based on the critical criteria in the picking activity identified as the number of references in a pallet (obtained from the survey), and by the ABC analysis on items turnover and on picking times;

As it is not feasible to study all Pingo Doce stores, a set of them considered as representative was chosen. It was found that the smaller stores represent the majority of Pingo Doce sales and simultaneously are more critical with regards to order volumes, since their storage space is reduced. Therefore, 12 stores with the characteristics presented before were chosen.

With a study basis of 107 items in flow A, 113 items in flow NA and 12 stores in each flow, the next step in the order cycle analysis is to understand in which day are the items arriving to the warehouse and in which quantity. Thus, it was found, for the sample universe considered that the vast majority of items (on both streams) were ordered in small amounts but often throughout the week.
The main differences observed in both figures are related to some important aspects:

- Data in figures 2 a) and 3 a) corresponds to a period of 3 months and gathers all products and stores in each flow, while graphics 2 b) and 3 b) only consider data from 1 month, 12 stores and 107 items in flow A and 113 items in flow NA.
- Promotions have become increasingly important for JM - this flow has priority over the others, therefore this have to run first, leading to delays in other flows; this means that from time to time, items that should be picked and shipped in day n are going to be picked and shipped in day n+1, adding variability into management activities.
- Although there are many aspects that restrict the picking activity, it is possible to point out days that are constantly more critical than others in the warehouse: for flow A these days are Monday, Wednesday and Friday; for flow NA it is Monday and Thursday.
- In the warehouse, with the help of the warehouse manager it was possible to comprehend that, due to the fact that data is only available for a maximum of three months, some days in the week were overvalued/undervalued in terms of volume (for example, Monday is a critical day in flow A).

In order to minimize the existence of the confirmed peaks, a mathematical model is developed. The aim of the model is to smooth the activity peaks, so that the difference between the sum of daily volumes of items boxes picked and the average volume of items boxes picked in a week is as minimal as possible. Due to its critical factor, the picking time for each item in the sample will also be considered in the model.

5. Mathematical model
5.1. Model Description

The objective of the model is to find out in which days the items under study have to be picked in the warehouse, so that the picking activity is as constant as possible over the weekdays. Since the order cycle problem is not widely studied in the literature, concepts from other models and studies were used in order to develop a feasible solution for the problem under study. The concepts behind VRP are used in the construction of the optimization model, but since the scope of the study is different – instead of the flow between the distribution center and the stores (represented by the vehicles), the aim of the study is the “informatic flow” between the stores ans the distribution center – some adaptations and simplifications will be made.

Figure 4 shows the simplified version of the JIT flow considered in the model. This is adapted from the real JIT used in the NP warehouse. It is assumed that, when an order arrives at the warehouse, the item is available, which is not always true due to the suppliers leadtime. However, given its importance in the operation of the warehouse and the activities in stores, leadtimes will be resumed at the stage of analysis of the results obtained.

Figure 4. Simplified warehouse operation considered in the model

The supplier entity will be considered indirectly through the inclusion of a parameter “leadtime” described in the model formulation, in order to ensure that an item is found in the warehouse on the
days when the supplier actually makes deliveries to the warehouse.

Also, it is assumed that the items under study are identical in terms of weight, volume, fragility and shape, since these difficult picking criteria have been considered when choosing the sample. Moreover, the focus criteria on the development of the study is the number of references per pallet, a criterion that is expected to alleviate the model output. Another concern that leads to the use of this assumption relates to the goal of creating a generic model that can be used in other warehouses, so the characteristics of the items in analysis should be considered in the selection of the sample and not in the model.

Previously it was mentioned that stores can place orders every day of the week. However, the warehouse is officially closed on Sundays. From the order cycle data analyzed, it appears that this fact provides greater variability in the number of items boxes that arrive daily at the warehouse and influence the number of requests on Monday (these resulting in very high or very low numbers of boxes ordered). Thus, the model will not consider the possibility for stores to place orders on Sunday, having the remaining six days of the week to do so.

Moreover, to standardize the daily volume of boxes in the warehouse, a parameter called capacity \( \text{cap}_d \) and \( \text{cap}_2d \) was created, with the function of representing the number of boxes available to pick daily. In reality, the capacity of the warehouse does not come as a restriction to the sample, given its size. However, in order to understand which days are of increased activity and for testing purposes, the parameter was set to limit the number of boxes available each day, so that in the days of increased picking, it is not possible for a store to place an order, postponing it for one day of lower activity. The capacity factor arises as a restriction for the picking activity. This restriction exists however in reality, not in the form of a maximum number of boxes in the warehouse, but in terms of the number of operators available daily at the warehouse.

In short, the problem can be summarized by:

Given:
- Set of stores and items that make up a representative sample of critical elements in JM Group.
- Days of the week available for stores to place orders.

5.3. Model Formulation

In this subsection the formulation for the model previously described is presented.

Indices
For the definition of the sets there will be used in the model three indices:
- \( l \), stores
- \( a \), items
- \( d \), days of the week

Sets
For modeling the problem there will be considered three sets, from which the objective function and respective restrictions are created:
- \( l \in L \), set of stores
- \( a \in A \), set of items
- \( d \in D \), set of days of the week

Parameters
- \( \text{cap}_d \), capacity available in the warehouse, in every day \( d \) in number of boxes

- Typical order days for every item in study
- Picking times for every item in the study.
- Store demand in number of boxes, for the total number of items in the study.
- Quantities in number of boxes, sought from each item.
- Quantities in number of boxes, sought by every store, for every item.
- Stock (space available) in number of boxes, available in each store.
- Capacity in number of boxes, for every day of the week.
- Delivery days by suppliers of each item, for every day of week.
• proc, demand from store \( l \), in number of boxes
• stock\(_l\), minimum stock (space) available in store \( l \), in number of boxes
• quantidades\(_{a,l}\), quantities (in number of boxes) ordered by store \( l \), of item \( a \)
• leadtime\(_{a,l}\), occurrence of deliveries made by the supplier of item \( a \) on the day of the week \( d \) (if the item is delivered in day \( d \), leadtime\(_{a,l}\) has value 1, otherwise 0)
• cap2\(_d\), capacity available in the warehouse, in every day \( d \) in number of minutes
• temp\(_a\), pickin time for one item \( a \)
• stemp\(_a\), sum of picking times for all items \( a \)
• medP\(_d\), average number of picked boxes, in every day \( d \)
• medT\(_d\), average number of picking minutes, in every day \( d \)
• mval, value set for the application of the Big M method
• \( n \), maximum allowable number of order days for item \( a \), placed by store \( l \) in every day \( d \)

**Variables**

Taking into account the problem’s characteristics and using the above sets, parameters and variables, the model is formulated below:

\[
\text{min } zq = vmaisq + vmenosq \\
\text{min } zt = vmaist + vmenost
\]

Subjected to:

\[\sum_a \sum_d (q_{aid} \cdot \text{leadtime}_{ad}) \leq \text{cap}_d \quad \forall d\]  
\[\sum_d (q_{aid} \cdot \text{leadtime}_{ad}) = \text{quantidades}_{a,l} \quad \forall a \land \forall l\]  
\[\sum_a (q_{aid} \cdot \text{leadtime}_{ad}) \leq \text{stock}_{l,d} \quad \forall l \land \forall d\]  
\[p_{aid} = p_{aid}^+ \land \forall a \land \forall d \land \forall l\]  
\[vmaisq \geq \sum_a \sum_d (q_{aid} \cdot \text{leadtime}_{ad}) - \text{medP}_d \quad \forall d\]  
\[vmenosq \geq \text{medP}_d - \sum_a \sum_d (q_{aid} \cdot \text{leadtime}_{ad}) \quad \forall d\]  
\[t_{aid} = q_{aid} \cdot \text{leadtime}_{ad} \cdot \text{temp}_a \quad \forall a \land \forall l \land \forall d\]  
\[\sum_a \sum_d (t_{aid}) \leq \text{cap2}_d \quad \forall d\]  
\[\sum_d \sum_a (t_{aid}) = \text{stemp}_a \quad \forall a\]  
\[vmaist \geq \sum_a \sum_d (t_{aid}) - \text{medT}_d \quad \forall d\]  
\[vmenost \geq \text{medT}_d - \sum_a \sum_d (t_{aid}) \quad \forall d\]  
\[q_{aid} \cdot \text{leadtime}_{ad} - \text{mval} \land p_{aid} \leq 0 \quad \forall a \land \forall l \land \forall d\]  
\[p_{aid} \leq q_{aid} \cdot \text{leadtime}_{ad} \quad \forall a \land \forall l \land \forall d\]  
\[\sum_d p_{aid} \leq n \quad \forall a \land \forall l\]
The objective of the presente model is to minimize the deviations between the number of boxes in the picking activity every day and the average boxes in the picking activity during the week. On the other hand it is also important to minimize the difference between the daily picking time (in minutes) and the average picking time in a week. – The first objective function $z_q$ [2], is obtained through the sum of vmaisq (upper deviation from the mean) and vmenosq (lower deviation from the mean) allows the calculation of the deviation in quantities (number of boxes). The second objective function $z_t$ [3], is obtained by summing vmaisq (upper deviation from the mean) and vmenosq (lower deviation from the mean) allows the calculation of the deviation from the minutes of picking. Due to specifications of the study, these functions are performed sequentially: first $z_q$ is minimized, and with its minimum value, $z_t$ is then minimized.

Equation [4] requires that the sum of the quantities ordered by stores for all the items can not exceed the capacity of the warehouse in each day of the week.

Equation [5] ensures that the sum of the amounts requested by the stores of each item is equal to the demand of the stores for each item.

Equation [6] imposes that the amount requested by the stores of each item may not exceed the space available in store (in number of boxes) for their storage.

Equation [7] ensures that each item will always be ordered in the same day of the week for any store.

The inequality [8] allows the vmaisq variable to save the difference between the sum of the amounts ordered by the stores for any item and for each day of the week, and the average number of boxes picked in one week, resulting in the deviation above average. Similarly, the inequality [9] allows the variable vmenosq to save the difference between the average number of boxes picked in one week and the sum of the amounts ordered by the stores for any item and for each day of the week, resulting in deviation below the average.

Equation [10] allows to relate variable $t$ with the variable $q$, such that $t$ presents the overall picking time for any item, request by a store in any day of the week.

Equation [11], similarly to equation [4] requires that the sum of picking times of the items can not exceed the capacity of the warehouse (in minutes) on each day of the week.

Equation [12] ensures that the sum of picking times for an item, ordered by a store on the any day of the week is equal to the sum of picking times for each item.

The inequality [13] allows vmaisq to save the difference between the sum of picking minutes for the items ordered by the stores on each day of the week, and the average number of picking minutes in one week, resulting in the deviation above the average. Similarly, the inequality [14] allows the variable vmenosq to save the difference of the average number of picking minutes in one week and the difference between the sums of picking minutes for the items ordered by the stores on each day of the week resulting in deviation below the average.

Equation [15] and equations [16] result from the application of the Big M method (via mval) with the goal of transforming variable $q_{ald}$ in the binary variable $p_{ald}$.

Equation [17] limits the days available for stores to place orders, for any given item.

5.4. Results

- **Baseline**

Before the implementation of the model, and with the sample data gathered, the distribution of boxes per week day and picking minutes per week day is presented in figures 2 b) and 3 b) above. Also, the number of FTE’s (operators in the warehouse) needed in each flow is presented in table 2.

<table>
<thead>
<tr>
<th>Table 2. Number of FTE’s needed in each flow per weekday</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow A</td>
</tr>
<tr>
<td>Flow NA</td>
</tr>
</tbody>
</table>

In this situation, the average number of order days is 5 for flow A and flow NA, which means that, on average, every item in the sample is ordered in each day of the week.

- **Base scenario**

The base scenário results from the application of the model without restriction [17]. Figures 5 and 6 show that the number of boxes and minutes in every weekday is now evenly distributed.
Figure 5. Distribution of boxes and minutes per weekday in flow A for base scenario

Figure 6. Distribution of boxes and minutes per weekday in flow NA for base scenario

Also, it is possible to reduce the maximum number of FTE’s needed to 7 in flow A and 3 in flow NA (a difference of 2 in both). And finally, the average number of order days for flow A is now 1.27 and 1.04 for flow NA.

- Scenario Resume

From figures 2 b) and 3 b) it is understood that there are activity peaks throughout the week. To understand how the application of the model could suit these differences, three scenarios were studied.

- **Scenario 1**, which restricts the capacity factor described earlier, in order to allocate items on specific days of the week (manipulated by the user of the model) which are the ones with less activity, namely Tuesday, Thursday and Saturday in flow A and Wednesday and Saturday in flow NA;

- **Scenario 2**, which studies the effects of restricting order days available to a maximum of one day or three days;

- **Scenario 3**, which combines constraints of scenario 1 and 2:

  Scenarios 1 and 3 result in higher values for $\zeta_q$ and $\zeta_t$ because the model is being constrained in order to allocate more boxes and minutes to specific days of the week, not smoothing the distribution of boxes and minutes per week. In spite of that it is possible to reduce the number of FTE’s and the maximum number of orders per week. Scenario 2 allows for reduced values in $\zeta_q$ and $\zeta_t$ – restricting the maximum number of days for stores to place orders to 1 is not feasible in reality (although it is in the model) due to the variable nature of the elements portrayed in the model (such as available space in stores, increased demand for a certain item etc.)

Scenarios where the capacity parameter is restricted (scenarios 1 and 3) were developed as short term solutions that the warehouse could implement specifically to these items (which are critical to the picking activity) and, even though these scenarios do not give the best solution possible, they still allow for an improvement in the three aspects considered: number of boxes and minutes per day; number of FTEs needed per day and average number of orders per item per week. Scenarios were the capacity parameter is not considered (base scenarios and scenario 2) are solutions for the long term, where a study of all items in the warehouse could be performed in order to smooth out the entire picking activity, so that the number of boxes received, picked and shipped per day would be more or less the same throughout the week.

Therefore, and since the goal of the present study is to minimize the deviations between the number of boxes and minutes in the picking activity every day and the average boxes and minutes in the picking activity during the week, the best scenarios are the base scenarios and scenario 2 for both flows. Table 4 resumes the results found with the application of the model.

Moreover, the output of the model allows to understand in which day a store should place an order. Since operations start at 14:00 in the warehouse, orders should be placed until this time, otherwise stores have to order the following day. So, for example, a box of item a2 is picked in Friday as it is shown in table 3, then the item should be ordered, at maximum, until 12:00 of the previous day, so as to guarantee that the order information is processed correctly.

| Table 3. Number of boxes picked per weekday for Base Scenario in flow A |
|-----------------|--------|--------|--------|--------|--------|
| Item           | M  | T  | W  | T  | F  | S  | Total |
| a1             | 37 | -  | -  | -  | -  | -  | 37    |
| a2             | -  | -  | -  | -  | -  | 18 | 18    |

Table 4 resumes the results found with the application of the model.
Table 4. Results from all scenarios applied to each flow

<table>
<thead>
<tr>
<th>Flows</th>
<th>Scenarios</th>
<th>zq</th>
<th>zt</th>
<th>Avg number of orders per item in a week</th>
<th>% Reduction compared to baseline</th>
<th>Maximum number of FTE’s</th>
<th>% Reduction compared to baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow A</td>
<td>Baseline</td>
<td>-</td>
<td>-</td>
<td>4,67</td>
<td>-</td>
<td>9</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Base Scenario</td>
<td>0</td>
<td>0,02</td>
<td>1,27</td>
<td>73%</td>
<td>7</td>
<td>22%</td>
</tr>
<tr>
<td></td>
<td>Scenario 1</td>
<td>144</td>
<td>53,81</td>
<td>1,25</td>
<td>73%</td>
<td>8</td>
<td>11%</td>
</tr>
<tr>
<td></td>
<td>Scenario 2 - ps1</td>
<td>0</td>
<td>9,66</td>
<td>1</td>
<td>79%</td>
<td>7</td>
<td>22%</td>
</tr>
<tr>
<td></td>
<td>Scenario 2 - ps3</td>
<td>0</td>
<td>0,02</td>
<td>1,27</td>
<td>73%</td>
<td>7</td>
<td>22%</td>
</tr>
<tr>
<td></td>
<td>Scenario 3 - ps1</td>
<td>144</td>
<td>53,48</td>
<td>1,24</td>
<td>73%</td>
<td>8</td>
<td>11%</td>
</tr>
<tr>
<td>Flow NA</td>
<td>Baseline</td>
<td>-</td>
<td>-</td>
<td>3,12</td>
<td>-</td>
<td>5</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Base Scenario</td>
<td>1</td>
<td>0,02</td>
<td>1,04</td>
<td>67%</td>
<td>3</td>
<td>40%</td>
</tr>
<tr>
<td></td>
<td>Scenario 1</td>
<td>2</td>
<td>28,01</td>
<td>1,01</td>
<td>68%</td>
<td>4</td>
<td>20%</td>
</tr>
<tr>
<td></td>
<td>Scenario 2 - ps1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>68%</td>
<td>3</td>
<td>40%</td>
</tr>
<tr>
<td></td>
<td>Scenario 2 - ps3</td>
<td>1</td>
<td>0,01</td>
<td>1,04</td>
<td>67%</td>
<td>3</td>
<td>40%</td>
</tr>
<tr>
<td></td>
<td>Scenario 3 - ps1</td>
<td>2</td>
<td>28,16</td>
<td>1</td>
<td>68%</td>
<td>4</td>
<td>20%</td>
</tr>
<tr>
<td></td>
<td>Scenario 3 - ps3</td>
<td>2</td>
<td>28,13</td>
<td>1,03</td>
<td>67%</td>
<td>4</td>
<td>20%</td>
</tr>
</tbody>
</table>

6. Conclusions

The JM Group, one of the biggest retailers in Portugal, has identified a logistics problem that affects the activity of his warehouses: order cycle planning. In this paper, the problem is analysed considering the Non-Perishable warehouse of JM supply chain that works in JIT, assuming a sample of representative critical items and a set of representative Pingo Doce stores.

Based on this data an optimization model was developed in order to smooth the picking activity in the warehouse, and contribute to other operational gains. The results obtained indicate that the implementation of the model, in any scenario, allows the improvement of the picking activity in the warehouse, through the cease of daily peaks in volume of boxes and picking minutes, a reduction in needed FTE’s in the picking activity and the reduction of the number of days needed for stores to place orders.

For future work, aspects considering the implementation of Cross Docking to more items in the warehouse, the study of packagings, and the study of new layouts for the stores warehouses should be explored.

7. References


UPS (2005). A Just-In-Time Supply Chain? – Achieving Just-In-Time operational objectives requires the coordination of Production Planning, Sourcing and Logistics. UPS Supply Chain Solutions White paper