Development of operational indicators for logistics functions in a "Dark Store"

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Abstract

The growth of the E-commerce worldwide has been a disruptive factor in the way companies look at the market. The case of the national panorama has not been an exception to this tendency. Increasingly, food retailing has sought to differentiate itself to attract new customers and maintain the existing ones. SONAE MC, as the leader of the national food retail, tried to increase the E-commerce level practiced in Portugal, and in December of 2015 opened the first Dark Store in the country. This infrastructure is fully dedicated to the satisfaction of the orders made by the online customer in the Greater Lisbon. In the follow-up, the opening of this Lisbon Distribution Center has led to a bigger logistical complexity for the organization. The logistics models in the E-commerce area have been triggered from trial-error and represent a great challenge in terms of operational efficiency.

DC Lisboa is organized into three logistics processes: replacement, picking and shippment. Currently, only the picking holds operating indicators capable of triggering process improvements.

The first objective of this dissertation is the construction of operational indicators (base) for the replenishment and dispatch process so that they can serve as a tool to support the operational management of DC Lisboa, triggering further improvements to the processes.

Keywords: E-commerce, E-grocery, Omnichannel, Multichannel; KPI's; warehouses; SONAE; Operational Efficiency

1. Introduction

Nowadays, information and communication technologies are the most important aspects that we should take under consideration for every country. Over the past two decades, the continuous application and diffusion of the Internet and the online commerce, as well as the advance of the information technology, have both changed radically the global economic activity.

In the case of food retailers, they have been transforming the food purchasing to be more convenient and they use less time doing it, by providing satisfaction of online orders, delivering them at the customer's house. All retailers in this industry have a common goal: to give customers the opportunity to purchase food and other products through the Internet and have them be deliverd to their homes. The retailers recognize that the selection of the product and its quality, the customer service, the price and the convenience are the main competitive factors that affect this business (Duval, 2000).

As the food retail leader in Portugal, SONAE MC is constantly innovating, and one of their main concerns has always been the new market trends. Since that, in 2001 the company has launched the Continente Online platform, in order to keep up with the pace of the market developments. This platform was initially intended for customers with high purchasing power, sophistication and more online shopping driven. However, this concept led to complex logistical operations, once they were previously picking the products directly in a Continente store and the layout of the stores was not prepared for the complexity of this operation. Due to the low productivity of pickers, SONAE MC created the first Dark store in Portugal. This infrastructure is fully dedicated to the satisfaction of the orders placed by the e-commerce customers. SONAE MC is now seeking to find new solutions and improvements that will offer the best range of products, with a minimal number of breaks for their customers, by delivering orders on time and offering a range of different track and pick up windows.

In this context, the present paper is an opportunity to develop a detailed analysis of the logistics operations of the e-commerce and a proposal to improve the operations from the Lisbon distribution center (also known as the Dark Store. The challenge is combining concepts such as e-commerce and food retail, which means satisfying the customer with the best service possible.

2. Problem Description

In this section there will be presented the e-commerce of food retail characterization (2.1), Distribution Center Lisboa (2.2) and DC Lisboa Challenges (2.3).

2.1. E-commerce of food retail characterization

The food retail market in Portugal is considered very mature and highly concentrated, in which five large groups share approximately 80% of the total market share. The sector has experienced a disruption over the years, in which two major groups, SONAE and Jerónimo Martins, stand out from the others, with the largest market share, as can be seen in Table 1. The third, fourth and the fifth positions are occupied by the groups "Os Mosqueteiros", "Grupo Auchan" and "Lidl", respectively.

Table 1 - Ranking position of brands

Brands	Margin (M €)	Nº of stores
Jerónimo Martins	4,038	376 (Ano 2016)
SONAE MC	3,461	640 (Ano 2016)
Os Mosqueteiros	2,33	297 (Ano 2017)
Auchan Group	1,87	32 (Ano 2016)
Lidl	1,392	245 (Ano 2017)
DIA	876	634 (Ano 2017)
Leclerc	495(e) €	21 (Ano 2017)

In March 2001, SONAE opened the online store, named Continente Online. The creation of this digital channel was an opportunity to meet the customer's expectations, reinforcing the convenience value proposition, and offering convenience and innovation (HiperSuper, 2017). In turn, El Corte Inglés joined the online market in 2004 through the SuperCor online grocery shopping service. Back in 2007, Intermaché followed this trend and lauched their first online store in the great Lisbon.

2.2. Distribution Center Lisboa

This distribution center responds to all orders from the geographic areas of Amadora, Loures, Oeiras, Benfica and Telheiras. This center has a maximum daily capacity of 968 orders and operates 24 hours and 7 days a week in three different shifts, 363 days a year (except for Christmas and New Year).

By this time, there are about 6000 articles centralized on CD Lisboa. However, this center is supported by the main store in Telheiras, which has about 15-25% of the items ordered by customers like Charcuterie, Fresh fish, Butchery, Bakery, Bazaar and House (see figure 1).

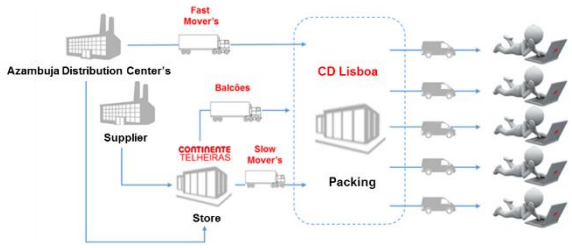


Figure 1 - CD Lisboa logistic model

There are mainly three logistic processes: replenishment, picking and shippment.

Replenishment is the logistic activity that is responsible for filling the shelves. This procedure is dedicated to the replenishment of products in ambient and refrigerated temperature - fruits and vegetables - and non-organic products.

On the other hand, picking starts with a shopping car, which has all the necessary components for the process, namely the tablets, scanners, Chep boxes and bags. First, the picker enters the system through a tablet, logging in with the respective user. The tablet has a main screen where you can choose the circuit to work.

The picker starts the process by "pulling" an order on the tablet and then moves it to the beginning of the circuit to pick the labels corresponding to the pull-order on the tablet, and afterwards, the picker collects all the products regarding to the online order that he is working on and when he finishes, the box is placed in the end of the circuit. The expedition worker will then collect this box.

Shippment is the last procedure of the process. It is divided in consolidation of the boxes in the marshalling area, route preparation (at ambient and refrigerated temperature) and route conference.

In the end, the driver packs the orders, wich are organized by delivery order. In other words, the first one to be delivered is the last one to be packed.

2.3. DC Lisboa Challenges

Currently, the only operational indicators that exist, are for the picking operation. In this case, only 50% of the workers are evaluated, so it is necessary to build up a model that can evaluate the other operations. The main challenge faced is to develop performance indicators for the replenishment and shippment operations.

3. Literature Review

In this section there will be presented multichannel and omnichannel (3.1), Online options (3.2), picking processes operations and (3.3) and key performance indicators (3.4).

3.1. Multichannel and Omnichannel

In the case of specific retail markets, the online channel has become very dominant and has been considered a disruptive development (Christensen et al., 2003). Many retailers have initiated multi-channel strategies. However, the literature has suggested that the retail model is no longer a multichannel to become omnicanal (Rigby, 2011)

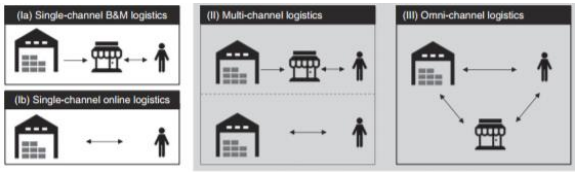


Figure 2 - Multi-channel and Omni-channel logistics (Wollenburg et al., 2016)

3.2. Online Options

Food retailers try to combine different approaches to manage the stock, choosing and packing orders online (in-store or warehouse) with different delivery models: delivery at home, "Click and Collect" (C & C) in a store, and - most recently - "Click and Drive", also called "Drive-in". Through "Click and Drive", the consumer orders from his house, and later he collects the order in a pick-up point (Fernie et al., 2010; Durand & Senkel, 2007). In the C & C option, also known as "Pick-and-Go", the customer goes to the store. The development of "Pick-and-Go" infrastructures presupposes the store concept and can act as a promoter for the "Click and Drive" model. The last one is the "Click and Drive" model, in which the customer drives to

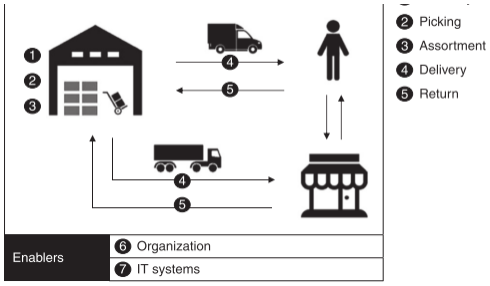
the store, parks and waits for his order to be taken to the vehicle (Lapoule, 2014).

The advantage of the C & C is to support the cost of the last mile, wich reduces the logistic cost in 70%.

3.3. Picking Operational Processes

The layout of the store is designed to deliver products to the final customer, not for developing an efficient picking. In fact, customers can notice the convenience associated with the shopping experience in the store, where they have a clear layout and a sophisticated array of products (Teller et al., 2012). Conventional store structures have to be significantly altered to achieve the efficiency that the online shopping of food products requires. In addition, there is an out-of-stock risk, if a costumer collects the last product available in the store that was also required online. To the in-store order preparation, the picking can be done more efficiently in centers that are specifically designed to serve orders placed online, and easy to scale for larger volumes (see figure 3).
The warehouses allocated for this type of

Figure 3 - Omni-channel logistics (Wollenburg et al., 2016)



operations offer inventory only for the online channel. In this case, it is more easy to inform the costumer about the stock availability.
Delivery time plays a key role in convenience, service and customer satisfaction. The primary goal is to reduce the time that customers wait to receive their order, reducing distribution costs and increasing warranty. The home delivery of the products in the same day that the costumer orders requires greater logistical challenges in terms of cost and complexity of planning (Hays et al., 2005).

3.4. Key performance indicators

Nowadays, the business world is characterized by the online business phenomenon, globalization, competitiveness, the constant evolution of new technologies, a constant change in the customer's needs, and the transformation of economic and political structures. Due to that, companies need to develop strategies that allow them to achieve a competitive advantage (Porter, 2001). Thus, it becomes difficult to manage something that is not being measured, since organizations need structures to measure their knowledge assets. Managers need tools that help companies to define key performance indicators so that knowledge assets support the organization's key strategic capability (Schiuma et al., 2004).
Today, KPIs are extremely important for the control and planning supported by information, creating transparency and functioning as a support for managers' decision (Meier et al., 2013). KPIs should proceed the following requirements: 1) Reduced - the less KPIs are, better they are; 2) Detailed - users can analyze them in detail; 3) Simple - users should clearly understand what KPIs indicate; 4) Actionable - should know how they affect results; 5) Own - KPIs must have an owner (ex: for a CEO,for a COO or a CFO) ; 6) Referenced - users can see origins and context; 7) Correlated - KPIs should lead to desired results; 8) Balanced - KPIs consist of financial and non-financial metrics; 9) Aligned - KPIs do not cancel each other out; 10) Validated - workers can not bypass KPIs; 11) Regulated - KPIs should be measured frequently; 12) Distributed - are measures that assign responsibility to a given team (Badawi et al, 2016).

4. Operational indicators definition

The only indicator used was related to the number of pallets replaced per employee named after

"No. Pallets Multiproduct Replacements Ratio".

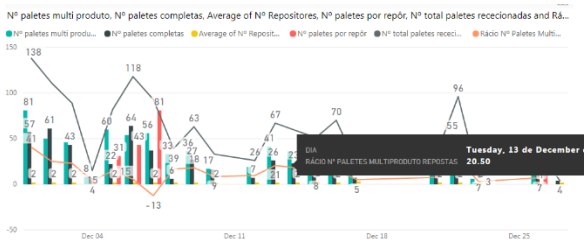
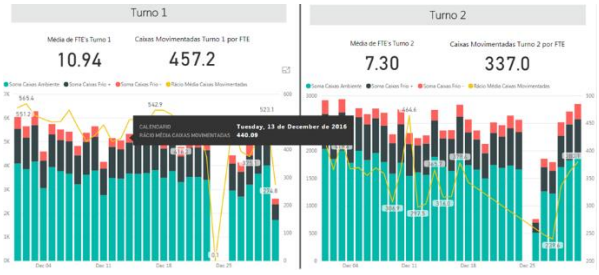


Figure 4 – Nº of pallets received in CD Lisboa

According to figure 4, it can be verified that on December 13, 2016, 41 multi-product pallets were received and 2 collaborators were allocated, resulting in a ratio of 20.5 multi-product pallets answered by the collaborator.

However, these records did not allow the design information that was related to the replenishment process, which is only a data record, and there is no term of comparison. Despite the existence of these data, they did not have the information and complexity required to measure the productivity of the replenishment process, and therefore, became obsolete. The process was divided in three types of pallets: Environment, and G and H circuit

The counting of the boxes was elaborated according to the corresponding shift. The " Moved Boxes average ratio" per employee was calculated according to each shift, and based on the quotient of the total sum of moving boxes - Environment, Refrigerated and Frozen - and the number of employees assigned to the activity of that day



For example, considering 457.2 boxes have been moved on shift 1, it is not clear what was actually the environment or frozen boxes, which itself is enoght to adulterate the data. Therefore, it is vague to consider this value, and it is not related to any sub-process of the operation. And again, there was no standard time value that would suit as a comparison term. So shippment was divided into two four sub-processes 1) Packing of the boxes in marshalling; 2) Route's preparation at environment temperature 3) Route conference and 4) Route's preparation at refrigerated temperature. The present and future influence factors are presented in table 2.

Table 2 - Present and future influence factors of operational indicators

ACTIVITY	PRESENT INFLUENCE FACTORS OF OPERATIONAL INDICATORS	FUTURE INFLUENCE FACTORS OF OPERATIONAL INDICATORS
REPLENISHMENT	• Number of multiproduct pallets received;	**Environment**
	• Average number of repositors;	· Number of boxes
		· Sku's number of dairy products
		· Sku's number of salt grocery
		· Sku's number of sweet grocery
		· Sku's number of cleaning products and Pet Care
		· Number of circuits
		· Type of different products
		· Number of employees
		· Food/ non food
		· Circuit G
		· Number of boxes
		· Sku's number of fruit
		· Sku's number of vegetables
		· Number of employees
		· Type of different products
		· Circuit H
		· Number of boxes
		Sku's number of charcuterie
		· Sku's number of yogurts
		· Type of different products
		· Number of employees
SHIPPING	•Environment boxes sum;	· **Marshalling;**
	• Cold boxes sum;	· Workers number
	• Average number of mizu;	· Boxes number
		· Route's preparation in environment
		· Skates number
		· Orders number
		· Boxes number
		· Zone number
		· Route number
		· Route conference

	· Route number
	· Orders Number
	· Orders in conformity number
	· Ordens in non conformity number
	· Route preparation in cold
	· Workers number;
	· Boxes number;
	· Skates number;
	· Zone number;

5. Standard times definition

In this section, there will be presented multiple linear regression models (5.1), replenishment validation model (5.2) and shipping validation model (5.3).

5.1. Multiple linear regression models

So, there were no studies on the reference values of replacement and dispatch times. So then, faced with a global average such as the " Number of pallets restored ratio" or "Mean ratio of bins moved", it was impossible to gauge the productivity of each process, since there was no default value in which it was possible to compare. Taking this into consideration, in addition to the definition of operational indicators, it is necessary to define standard values for these indicators, which allow us to understand which productivity values may be "below" or "above" this standard.

It can also be so variable, given the deviations of the values of each factor.

In the case of the reset, the multiple linear regression model that best explains the environment reset in the G circuit and the H circuit, wich is given by the following equations:

1) Replacement Time at Ambient = 33,249-2,957 [Sweet Grocery] -3,308 [No. of Circuits] +10,430 [Non-Food] -2,165 [Bakery and Salted Grocery] -2,601 [DPH and Pet Care] +3,205 [Product Type] - 2,709 [Beverages and Dairy Products] -7,437 [Number of Contributors]

2) Replacement time in the circuit H = 45.098 + 0.657 [Yoghurts] +0.211 [Type of products] -0,125 [Number of boxes] -13,892 [Number of employees] +0.434 [Charcuterie]

On the other hand, the multiple linear regression model that suits the most the consolidation of marshalling, the preparation of routes in environment, the conference of routes and the preparation of cold routes is given by equation 3,4,5 and 6 respectively:

Consolidation time in Marshalling = 0.0247-0.0112 [Number of employees] + 0.0039 [Number of boxes]

Transport of routes in environment = 0,01123-0,00186 [Route Number] -0.0126 [Zone] -0,0089 [Number of Orders] + 0,0041 [Number of Boxes]

Routes Conference = -0.0714 + 0.0018 [Route Number] +0.0178 [Conforming Orders] +0.0906 [Reason] + 0.1096 [Non-conforming orders]

Preparation of routes in cold = 0,0202-0,0362 [Number of people] +0,0116 [Number of Orders] +0,0008 [Route Number] +0.0054 [Number of Boxes] -0.01483 [Number of Roller Skates]

5.2. Replenishment validation model

For the validation of the model eleven, new observations were made in the environment reset.

In this sequence, the data concerning the independent variables of these observations are introduced to the regression model through equation 3 for comparison with the real time.

The first observation collected included 35 Sku's of Cleaning products and Pet Care, the number of circuits was equal to 1, to which 2 employees were allocated and being a non-food pallet. The actual replacement value of this pallet was 56 minutes.

3) Replacement time in the environment = 33,249-2,957 [Sweet Grocery] -3,308 [No. of Circuits] +10,430 [Non-Food] -2,165 [Bakery and Salt Grocery] -2,601 [DPH and Pet Care] +3,205 [Type of products] [0] -2,601 [0] -2,601 [35] +3,205 [35] -2,709 [0] -3,308 [1] +10,430 [1] -2,165 [0] -2,601 [35] -7,437 [2] = 62 minutes

On the other hand, the average time value obtained (equation 4) is calculated from the mean time per product type, and by employees, which in this case is equal to 1.88 minutes per product type and per employee.

4) Mean Time = [Product Type] * 1.88 ⇔35 * 1.88 = 66 minutes

For the validation of the regression model of the replacement in the circuit G nine observations were made. The first observation had 14 types of different products, 29 boxes and in which one employee was affected, being the replacement value of this pallet was 23 minutes. Thus, the data of the independent variables of this observation are introduced in the model through equation 5 for comparison with the real value.

5) Replacement time in circuit G = 42,378 + 0,406 [Number of Boxes] -0.832 [Type of products] +1,054 [Vegetables] -16,458 [Number of Contributors] ⇔ 42,378 + 0,406 [29] -0,832 [14] +1,054 [0]] -16.458 [1] = 26 minutes

The value of the average time per product type and employee in the reset in G is equal to 2.34 minutes. With that average time, considering 14 types of products is calculated the equation 6:

6) Mean Time = [Product Type] * 2.33⇔14 * 2.34 = 33 minutes

Still in the reset, nine observations of reset times in the H circuit. The first observation is a pallet with 140 boxes, 7 Sku's of yogurts, 32 Sku's of charcuterie, 39 types of products and 1 collaborator regarding the replacement of the pallet, which corresponded to a real-time value equivalent to 46 minutes. Equation 7 extracts the value of the reset time in circuit H per the defined model.

7) Replacement time in the circuit H = 45,098 + 0,657 [Yoghurts] +0.211 [Type of products] -0,125 [Number of boxes] -13,892 [Number of employees] +0.434 [Charcuterie] ⇔45,098 + 0,657 [7] +0,211 [39] -0.125 [140] -13.892 [1] +0.434 [32] = 40 minutes

In turn, the mean time is equivalent to 1.16 minutes per product type and per employee in the replacement in H. Equation 8 represents the calculation for the average time when considered 39 different product types.

8) Mean Time = [Product Type] * 1.16⇔39 * 1.16 = 45 minutes

5.3. Shipping validation model

In the case of the first observation for each activity, the mean values of time and the mean time of marshalling and preparation of routes in the environment can be obtained by equations 9,10 and 11,12 respectively. The mean values of time and the mean time of route conference and routes preparation in cold can be obtained by equations 13,14 and 15,16 respectively. It should be noted that in this case, for the estimation of the average time, the denominator "box" was considered for the three activities of the expedition, except for the route conference.

9) Consolidation time in Marshalling = 0.0247-0.0112 [Number of employees] + 0.0039 [Number of boxes] ⇔0.0247-0.0112 [2] + 0.0039 [22] = 2 minutes and 6 seconds

10) Mean time in Marshalling = [Number of boxes] * 4 seconds⇔22 * 4 = 1 minute and 28 seconds

11) Route preparation in environment = 0.01123-0.00186 [Route Number] -0.0126 [Zone] -0.0089 [Number of Orders] + 0.0041 [Number of Boxes] ⇔0.01123-0, 00186 [10] -0.0126 [1] -0.0089 [7] + 0.0041 [53] = 5 minutes and 33 seconds

12) Average time in route preparation in environment= [Number of boxes] * 5 seconds⇔53 * 5 = 4 minutes and 42 seconds

13) Routes Conference = -0.0714 + 0.0018 [Route Number] +0.0178 [Conforming orders] +0.0906 [Reason] + 0.1096 [Non-conforming orders] ⇔ -0.0714 + 0.0018 [34] +0.0178 [4] +0.0906 [1] + 0.1096 [3] = 11 minutes and 24 seconds

14) Average time in route conference = [Number of orders] * 43 seconds⇔7 * 43 = 5 minutes and 2 seconds

15) Preparation of routes in cold = 0,0202-0,0362 [Number of people] +0,0116 [Number of Orders] +0,0008 [Route Number] +0.0054 [Number of Boxes] -0.01483 [Number of Skates] ⇔ 0.0202-0.0362 [1] +0.0116 [6] +0,0008 [11] +0.0054 [14] -0.01483 [2] = 2 minutes and 36 seconds

16) Average route preparation time in cold = [Number of boxes] * 7 seconds⇔7 * 14 = 2 minutes and 59 seconds

6. DC Lisboa operational management

In this section there will be presented replenishment plan allocation (6.1) and shipping plan allocation (6.2).

6.1. Replenishment plan allocation

The allocation of resources to the replacement activity of DC Lisboa is based on several assumptions. In the replenishment case it was considered the monthly mean values of the number of SKU's for the types of pallets and the number of monthly pallets received in each circuit.

Figure 5 represents the number of hours required for the monthly replenishment activity. The direct proportionality between pallets volume and number of hours can be observed through three main "peaks of the operation" that can be accepted - November, March and May. Replacement is less active in November (2016) and in April (2017), months in which the company should choose to reduce the number of temporary workers.

When analyzing by pallet typology, it is observed that the pallets of circuits B, C and D are those that require more spare time to be replaced. Contrary to the H-track pallets, due to the low monthly volume (multi-product), it requires less time spent. Accord to the previous data, it can be verified that the number of employees to allocate daily (considering a month equal to 30 days) can vary between 2.60 and 3.31, which corresponds to 3-4 employees to allocate to the replacement of multi-product pallets on DC Lisboa.

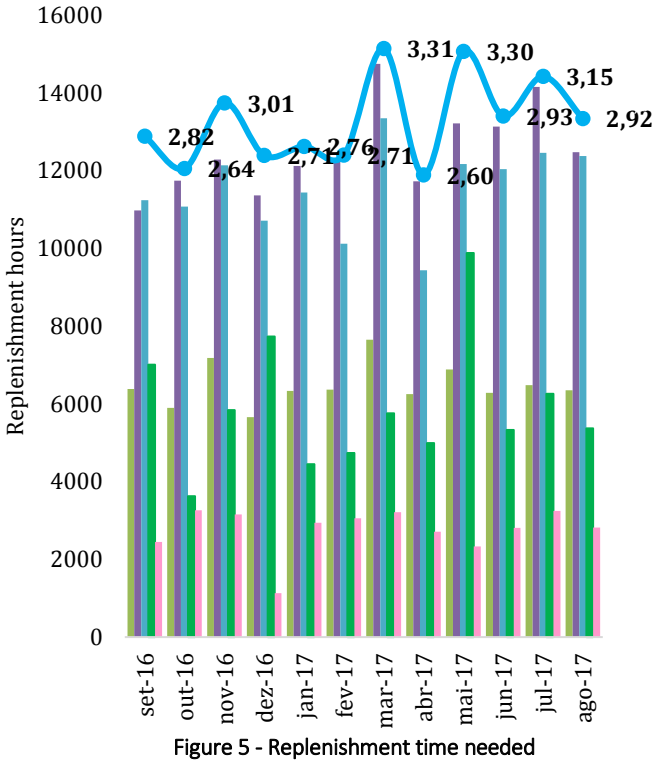


Figure 5 - Replenishment time needed

6.2. Shipping plan allocation

The shipping process refers to assumptions quite different from the replenishment activity. It should be noticed that the company requested to not consider the packing and checking of cold routes.

The period considered for this analysis varies between October 2016 and August 2017, and there were no data records before this period. The common nominators of this activity are the number of orders as well as the number of boxes (environment and cold), so the average number of cartons (ambient and cold) and the average number of monthly orders were calculated accord to each shift (morning, afternoon and evening). For this analysis were considered the daily number of boxes and orders per month.

About the route check, which is characterized by its non-linearity, it is considered that 90% of orders on a given route are in conformity and

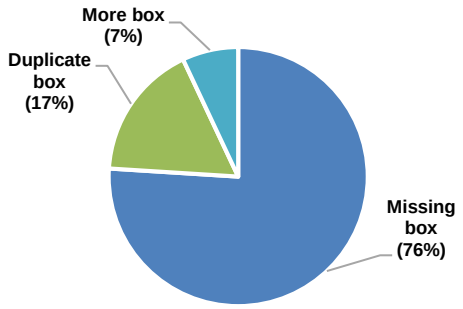


Figure 6 - Divergences reasons in routes conference

10% of orders are in non-conformity. On the other hand, when the orders are in non-conformity, the calculation of the hours required for the route conference assigns a weight to the conference time accord to the reasons shown in figure 6.

Following the assumptions for the calculation of the amount of hours required for the shippment

activity, the graph that represents the allocation of resources accord to the volumes and the time of the year (figure 51) is shown.

The shipping allocation of resources is more stable when compared to the replenishment allocation, the only approximately straight line is the shipping one.

It is important to realize that the analysis of resources against the day of the week would

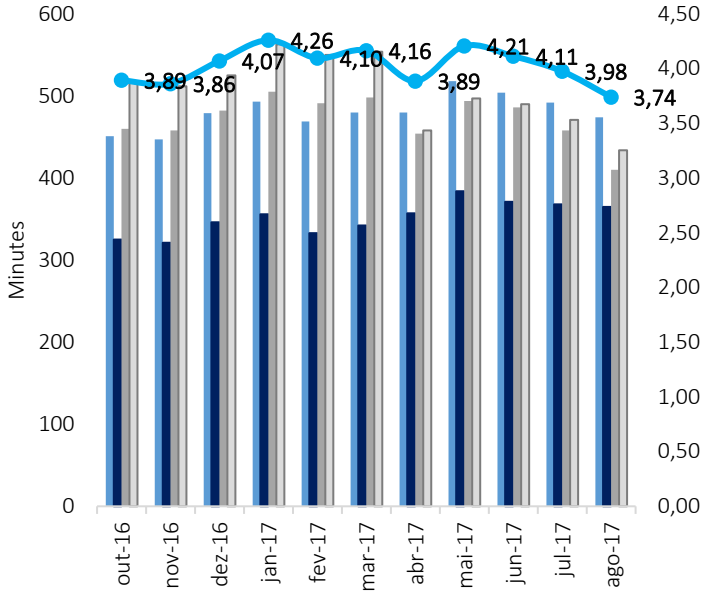


Figura 7 - Shipping time needed

reflect even more the complexity of each operation, and could further "fine-tune" the number of resources to be allocated. However, this analysis was not possible due to the scarcity of detail of each operation.

7. Conclusions

The e-commerce business in the food retail sector, although it has more supporters nowadays, it does not have yet a turnover in the national situation justifying certain investments in automation or infrastructures. Efficiency levels of logistics operations for the online channel are not yet at the level desired by the company. The logistics operation for e-commerce are a relatively recent concept for most retailers, especially in the food business.

The study of this dissertation had the goal of defining actionable performance indicators for the operational activities of replenishment and shippment. The operational indicators mentioned are also the first approach to a future operational plan for the company.

Thus is eminent the development of a monthly resource allocation plan - operational plan - based on forecasts that can begin to be provided by the Business Intelligence team, as it is done in the company's other warehouses.

In comparison to the previous volumes, the number of employees in the replenishment can vary between 3 and 4, and in the expedition (for the activities) considered the number of employees can vary between 4 and 5 people.

The increase in productivity with the increase of employees in circuit A, B and G must be another lesson to take. This factor should be explored when managing the day-to-day operations and resource planning.

It can be concluded that according to a pallet typology and several Sku's, from the increase of employees to a given pallet, productivity increases up to 83%.

The present work allowed us to draw quite interesting conclusions about factors that can have a significant impact on the productivity of the operations under analysis.

For example, in the case of environmental replacement, the sweet grocery has a substantial weight, this can be explained by the design layout. Thus, a layout that optimizes the number of movements when replacing these products could be studied.

The lack of automation in DC Lisboa is related to the number of orders met in the months following the opening; the number of orders doesn’t justify the investment. However, this value has increased more than 30% compared to the historical, and therefore, there is an increasing need of measuring people and then processes, to improve operational productivity.

National turnover still does not justify such an investment, since only the "giants" - Amazon, Tesco - satisfy a substantial number of orders that allows them to justify full automation of the operation.

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