Políticas de Gestão de Inventário

Estudo do Caso de Vinhos da Quinta da Bacalhôa

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Abstract: The management of the inventory in an organization is a critical subject that can influence greatly its cost structure and consequently, its success, from a long-term perspective.

The presented dissertation is focused on this subject, and how the several inventory systems to manage the stock of products with different characteristics, accordingly with the priorities of the company.

To support this decision, an ABC Classification of the products, as well as the forecast of their demand is also presented, determined by a Classical Decomposition Method, using the random component of that demand to determine the needed Safety stock for the considered product.

Regarding the results, it was possible to confirm that the high level of demand associated with A products implies short cycles for the process of stock management, for a continuous review policy. Comparing with an option with periodic reviews, there is a large amount of space needed to store the considered product. If we take it account the significantly smaller quantity of demand that is verified for the C product in analysis, it is understandable that there are larger review periods associated, even if the quantities in stock are not very large.

Keywords: Inventory Systems; Safety Stock; Continuous Inventory Policy; Periodic Review Policy.

1- Introduction

1.1 – Problem contextualization

When considering the process associated with stock management, there are several stakeholders to take into account, not only the ones directly involved, such as the company employees, but also the suppliers and the customers. For example, if there is no stock available to satisfy the demand of a product, the clients can consider recurring to other producer when the next opportunity comes, or maybe penalize the company, according with the contract between the two. On the other hand, as a consequence of frequent orders, or occasions where production is initiated, there can be a rise in the fixed costs, as well as the ones related with the space taken by those products, as well as other recourses needed to manage them.

For this reason, there is the need to consider the trade-off between:

- Service level;
- Product quality;
- Reduced price;
- Reduced lead time.

The presented work is cantered in evaluating and comparing alternatives to manage the stock of a selection of products that allows the company to have a perspective of the inventory needs to satisfy the customers and achieve the minimum amount of costs.

1.2 - Objectives and Work Scope

The objective of this dissertation is to present different solutions to implement in Quinta da Bacalhôa, to solve the identified problem, as well as to evaluate them accordingly with several indicators, to allow a better process of decision making.

1.3 - Work methodology

After the research needed to put in practice the Case Study at Quinta da Bacalhôa, the following steps were defined:

- Data collecting and treatment, for the history of demand of the products kept by the company;
- ABC analysis to identify a set of products that will be analysed;
- Application of demand forecasting methods to those products, isolating the random component of demand (for the determination of the safety stocks);
- Development of inventory management models to apply to the same product mentioned before, identifying the one that take into consideration the company preferences. Considering the inclination towards the continuous improvement of the service level, the approach followed is focused on that factor, when comparing inventory policies.
- Results analysis, that define the inventory systems that can be adopted in the case study presented, as well as the comparison of those models, using the defined indicators.

2 - Problem definition

This work in centred around a specific organization, as well as the problems faced by the employees when managing its inventory.

The non-existent systematisation of processes to manage the inventory, as identified at Quinta da

Bacalhôa, can cause resources' usage inefficiencies, such as the labour force and space owned by the company.
Currently, the company organizes the production and the stock based on monthly plans that are redefend at the beginning of each week, considering the number of orders received and the resources available. Given this, there are no specific and formal processes defined for the management of the products stored by the organization.
Considering that the company faces problems that are specific for them, determined by the characteristics of its internal and external environment, these must be taken into account when defining how the inventory is managed. In the case presented there are products with different levels of demand and prices, meaning different levels of penalization when their demand is not fulfilled.

3 - Literature review

3.1 - ABC Classification

The product differentiation in a company is considered a crucial phase to better adapt to operations put in practice to those products.
To classify the products, into A, B or C, by a decreasing order of significance, this study must be based in the Pareto rule, being 80% of the revenue justified by the sales of only 20% of the products, and vice versa (Carvalho et al., 2017; Silver et al., 1998).

3.2 – Demand forecasting

3.2.1 Decomposition methods

From the forecasting methods based on numerical data, the ones that use time series are enhanced in this work, for which the variation of seasonality, trend and the random factor of demand are taken into account. More specifically, the Additive decomposition method is base on the assumption that every timeline series is constituted by the mentioned parts that, when summed originate the value observed, in this case, of demand. This is represented by expression 1 (Makridakis et al., 1983; Silver et al., 1998):

$$X_i = I_i + T_i + E_i \quad (1)$$

Being:

$T_i = trend\ component\ at\ intant\ i$

$I_i = seasonality\ component\ at\ intant\ i$

$S_i = radomness\ component\ at\ intant\ i$

The extended process of determining the several components included in the data collected are described with the application to the case study.

3.3 – Inventory Management

For the determination of the stock quantity and the reviewing periods that describe an inventory system associated with a set of products, there are some key concepts to consider:

- Economic Order Quantity (EOQ): stock quantity that considers the stockout costs, as well as the holding costs and fixed costs, determined by expression 2 (Silver et al., 1998):

$$EOQ = \sqrt{\frac{2A\hat{x}_t}{vr}} \quad (2)$$

Being:

$v =$ cost per unit;

$r =$ holding cost;

$A =$ fixed cost;

$\hat{x}_t =$ average demand during t.

- Safety stock (SS): the amount of product kept in inventory that is meant to fulfil the part of demand that exceeds the level forecasted. This can be determined when there is a common factor to consider, such as k, in expression 3 (Silver et al., 1998, Tavares et al., 1997):

$$SS = k \times \sigma_L \quad (3)$$

Being:

$\sigma_L =$ standard deviation in the errors of the demand forecasting during period t;
$k =$ safety factor.

- Order point, order quantity policy: based on the continuous review of the inventory, being placed an order of Q when the quantity s is reached (Silver et al., 1998).
- Periodic review, order-point policy: based also on the placement of orders at level s, but the reviews in this case are performed in intervals with R duration (Silver et al., 1998).
- (R,s,S) policy: resulting of the application of cyclical reviews, with R time between them, placing an order each time s (determined by expression 4) is reached, but in this case until quantity level S (Silver et al., 1998).

$$s = \hat{x}_L + SS \quad (4)$$

Being:
$\hat{x}_L$= average demand during lead time;
SS = safety stock

3.4 Key Performance Indicators

Considering the consequences of stockout occasions, such as the possible lost of clients that rely on supplying souces that they trust, there is the need to identify which option of inventory policy has the best performance when serving those customers. Some of these indicators are the following, being described its concrete determination when applying to the case study:

- Average demand quantity (Q);
- Average cycle duration (t);
- Average orders per year;
- Stockout probability;
- Average stock level;

- Average coverage of demand
- Average stockout demand per cycle.

4 - Application to the case study

4.1 - ABC Classification

Considering the data about the demand of the company's products, since 2008, the ABC analysis preformed is presented in the graph in Figure 1.

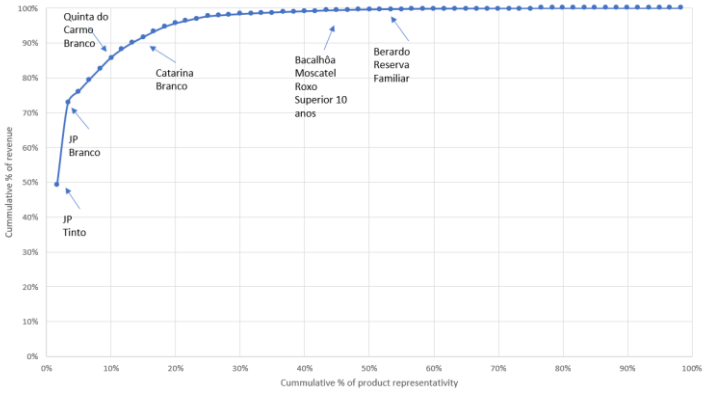

Figure 1 - ABC Classification of the products of Quinta da Bacalhôa

From the graph, the identified products to represent each class are:

- A: JP Tinto (75 mL) and JP Branco (75 mL);
- B: Quinta do Carmo Branco (75 mL) and Catarina Branco (75 mL);
- C: Bacalhôa Moscatel Roxo Superior de 10 anos (75 mL) and Berardo Reserva Familiar Branco (75 mL).

4.2 Demand forecasting

The same data of the quantities sold of the products of Quinta da Bacalhôa, from January of 2008 to December of 2019, were used to determine the components that constitute the demand of those products.

The trend component was identified by considering a CMA of 12 months and determining the linear equation that suits that variation the best.

From grouping the data for each month, it was possible to identify the seasonal component at each instant also (represented by S_i expression 4), allowing to apply the formula on which the additive method for classical decomposition is based (5):

$$S'_i = S_i - (\sum S_i)\frac{|S_i|}{\sum|S_i|} \qquad 4$$

$$Y_i = S_i + T_i + E_i \Leftrightarrow E_i = Y_i - T_i - S_i \qquad 5$$

This way, the determination of the random component allowed to calculate its standard deviation, applied to each product.

4.3 Inventory Management

4.3.1 Continuous Management – (Q,s) Policy

Considering the studied concept and calculation method of the safety stock, it is presented in pictures 2, 3, 4, 5 and 6, along with the stockout quantity determined with the help of the normal distribution table, as a function of the stockout probability.

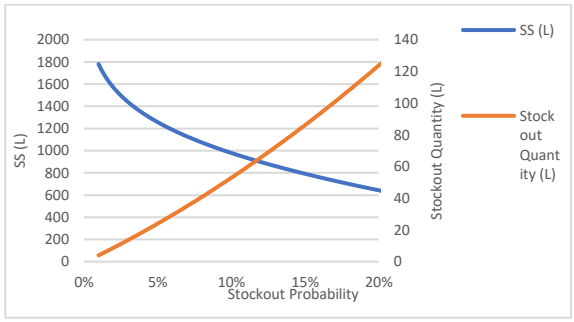

Figure 2 – SS and Stockout quantity for JP Tinto under a (Q,s) policy

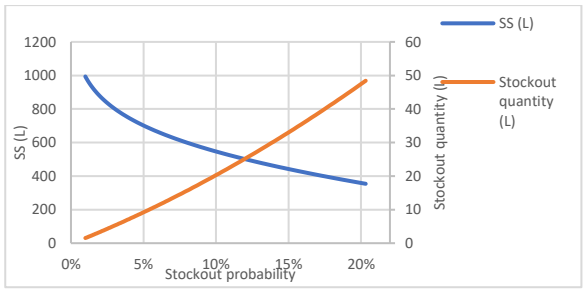

Figure 3 - SS and Stockout quantity for JP Branco under a (Q,s) policy

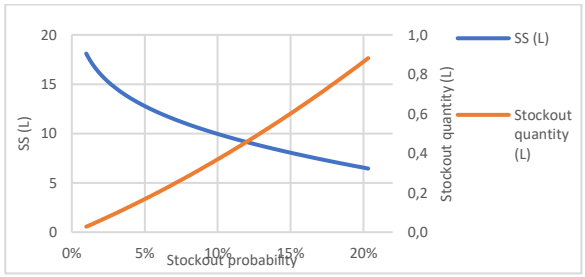

Figure 4 - SS and Stockout quantity for Catarina Branco under a (Q,s) policy

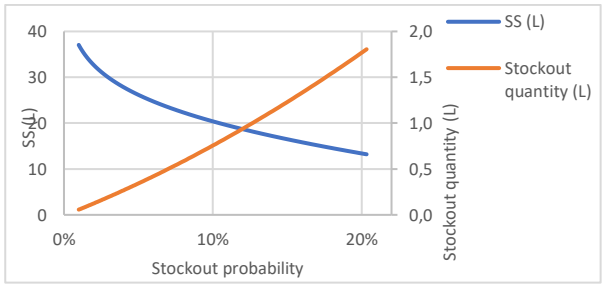

Figure 5 - SS and Stockout quantity for Quinta do Carmo Branco under a (Q,s) policy

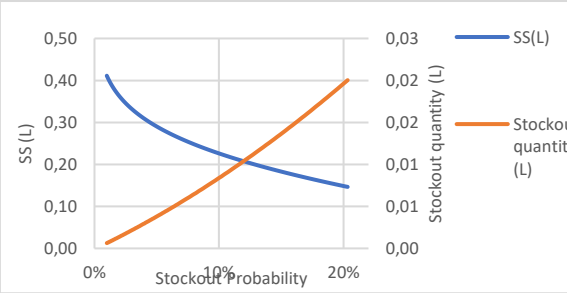

Figure 6 -

Considering some of the previous mentioned indicators, this policy to manage the inventory was evaluated, for several ratios of fixed and variable inventory costs (A/vr):

Table 1 – Average order quantity, cycle duration and orders per year for JP Tinto under a (Q,s) policy

A/vr	2	5	10	15	20
Q (L)	566	895	1266	1551	1790
t (days)	3	4	6	7	8
Orders per year	142	90	63	52	45

Table 2 - Average order quantity, cycle duration and orders per year for JP Branco under a (Q,s) policy

A/vr	2	5	10	15	20
Q (L)	280	443	627	768	887
t (days)	5	8	12	14	16
Orders per year	70	44	31	26	22

Table 3 - Average order quantity, cycle duration and orders per year for Quinta do Carmo Branco under a (Q,s) policy

A/vr	2	5	10	15	20
Q (L)	588	930	1315	1610	1859
t (days)	2	4	6	7	8
Orders per year	147	93	66	54	46

Table 4 - Average order quantity, cycle duration and orders per year for Catarina Branco under a (Q,s) policy

A/vr	2	5	10	15	20
Q (L)	75	118	167	205	236
t (days)	20	31	44	53	62
Orders per year	19	12	8	7	6

Table 5 - Average order quantity, cycle duration and orders per year for Bacalhôa Moscatel Roxo under a (Q,s) policy

A/vr	2	5	10	15	20
Q (L)	5	8	11	14	16
t (days)	286	643	640	784	906
Orders per year	1,3	0,8	0,6	0,5	0,4

4.3.2 Periodic Management – (R,s) Policy

Regarding the periodic review policy, some intervals for the reviews were considered for the calculation of the safety stock and stockout quantity, being also dependent on the stockout probability.

Once more, the values obtained for the performance indicators applied to this system are presented:

Table 6 - Average order quantity, review period (R) and orders per year for JP Tinto under a (R,s) policy

A/vr	5	15
R (days)	4	7
Orders per year	91	52
Q (L)	878	1537

Table 7 - Average order quantity, review period (R) and orders per year for JP Branco under a (R,s) policy

A/vr	5	15
R (days)	7	14
Orders per year	49	26
Q (L)	404	764

Table 8 - Average order quantity, review period (R) and orders per year for Catarina Branco under a (R,s) policy

A/vr	2	5
R (days)	21	28
Orders per year	17	13
Q (L)	80	107

Table 9 - Average order quantity, review period (R) and orders per year for Quinta do Carmo Branco under a (R,s) policy

A/vr	2	15
R (days)	2	7
Orders per year	183	52
Q (L)	480	1680

Table 10 - Average order quantity, review period (R) and orders per year for Bacalhôa Moscatel Roxo Superior de 10 anos under a (R,s) policy

A/vr	5	15
R (months)	15	26
Orders per year	0,8	0,5
Q (L)	8	14

4.3.3 Variants of (Q,s) and (R,s) policies

For the application of the (Q,Q) policy to the C product studied, the EOQ was considered as both the quantity that determine when to place a new order and the quantity that is ordered. For this reason, the value of Q, as well as the safety stock and the stockout quantity, are the

same as the ones presented for the normal continuous review policy.

Regarding the intermediate policy applied to the class A products, the results of the quantity S are presented in tables 11 and 12, as function of the review period, the holding stocks (vr) and stockout costs (u).

Table 11 – S quantity in L, for several values of holding stocks (vr), stockout costs (u) and review periods (R) for JP Branco

u	vr	$P(D_{L+R+1}S)$	S (R = 5 dias)	S (R = 10 dias)	S (R = 21 dias)
0,5	1,1	0,3125	548,8	875,1	1621,6
0,6	1,1	0,3529	619,3	960,1	1732,1
0,5	1,2	0,2941	515,5	834,9	1569,5

Table 12 - S quantity in L, for several values of holding stocks (vr), stockout costs (u) and review periods (R) for JP Tinto

u	vr	$P(D_{L+R+1}>S)$	S (R = 5 dias)	S (R = 10 dias)	S (R = 21 dias)
0,5	1,1	0,3125	2835,9	4289,6	7548,9
0,6	1,1	0,3529	2986,9	4471,6	7785,3
0,5	1,2	0,2941	2764,6	4203,6	7437,2

5 Conclusions

When the several inventory systems are considered, there are some factors to consider, depending on the preferences of the decision maker. In this case, the one identified as a priority was the service level, to prevent losing clients.

If the products classified as A are considered, there is a great need of storage space for short cycles of inventory management, during which there is a better inventory control.

For the products included in the lower level of demand of the company, there is the possibility of keeping in stock quantities that allow to fulfil demand for longer periods, simultaneously to not taking up too much space and time for reviews.

References

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