

Methodology for inventory risk analysis and management using excel and visual basic modeling

Aurélio Paulo Leandro¹, Simone da Silva², Manoel Henrique Reis Nascimento³

¹Master's student in Process Engineering - Academic, of the Postgraduate Program in Engineering, Process Management, Systems and Environmental (PPEMSE) - Institute of Technology and Education Galileo of the Amazon – ITEGAM.

²Post-doctorate in Biodiversity and Biotechnology by the Federal University of Amazonas – Teacher and Researcher at the Galileo da Amazônia Institute of Technology and Education (ITEGAM).

³Teacher and Researcher at the Galileo da Amazônia Institute of Technology and Education (ITEGAM).

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Abstract — *Visual Basic for Application (VBA) programming, when used in an Excel programming environment, is an important tool in determining inventory classification risks, as well as an excellent option in view of the current situation of scarcity of classification optimization assessment. inventory risks. This work aims to contribute to the development of programming for an application in VBA - Excel, with the ability to classify inventory risks, capable of delivering data and assertive responses, according to the concepts established within the organization. To achieve this objective, a field research was carried out with small and medium-sized companies in the city of Manaus, Amazonas. The research is classified as experimental, allowing the achievement of qualitative type results. The use of the proposed tools will be available to academic circles and the result of the study will be used to improve the quality of information and data speed, whenever necessary, for management decision-making. It is also expected that this research will contribute to foster discussion about the proposed theme and serve as a technical-theoretical framework for practical application for users and programmers in Solver and VBA tools.*

I. INTRODUCTION

Many products lose their functionality or lose market value over time. Examples include fresh products, blood products, packaged foods, pharmaceuticals, technology or fashion products. The rational configuration of inventory risk can reduce the costs of business losses, lessen the risks of taking time-consuming actions and improve the rates of a reduction in expenses or cost (saving), in addition to determining the success of logistics management. In view of the current situation of scarcity of inventory risk classification optimization assessment, an opportunity was identified to analyze possible practices to accelerate and optimize this process.

The theoretical framework of the work was divided into three sessions where inventory management, its importance, needs, types and problems were addressed. Then it was discussed about inventory management, its meaning, theories, categories and main techniques and finally, the application of IT in Supply Chain Management, its role, goals, MRP system and use of Excel/VBA Spreadsheets. After the literature review, the Visual Basic for Application (VBA) programming language was used to develop a tool to determine the various risks of inventory classification, and cluster analysis and the fuzzy evaluation method were applied to establish the model and the inventory optimization evaluation algorithm.

It is believed that the topic, despite being very important for the business, still has many opportunities for the companies' inventory system. Regardless of the type of business, there is a great need for the classification of inventories, which is one of the most complex activities within companies, to be carried out in a faster and more practical way, in order to avoid the risk of inventory loss. The relevance for such activity is to propose a clear and well-defined answer, through related criteria, in order to provide an efficient return for decision-making, according to the strategy that best suits.

The general objective of this research is to contribute to the development of programming for an application in VBA - Excel, with the ability to classify inventory risks, able to deliver data and assertive responses, giving reaction time for taking action within the business. . As specific objectives: identify the parameters for analysis and inventory risk management; model the input data for inventory risk analysis and management; classify inventory risks for assertive answers and develop the application in VBA – Excel for classifying inventory risks.

II. LITERATURE REVISION

2.1 Inventory management and its objectives

The term inventory refers to the goods or materials used by a company for the purposes of production and sale. It also includes items, which are used as supporting materials to facilitate production.

According to Lambert; Stock; Vantine (2010, p. 77) “There are three basic types of inventory: raw materials, work in progress and finished goods. Raw materials “are the items purchased for use in the production of the finished product”. The work-in-progress “consists of all items currently in production.” Finished products “consist of items that have already been produced but not yet sold.”

Inventory is one of the important items of current assets, which allows the proper functioning of the production and sale process of a company. Inventory management is the aspect of current asset management, which is concerned with maintaining the ideal investment in inventory and applying an effective control system in order to minimize the total cost of inventory (LINDER, 2012, p. 81).

An effective inventory management system is the cornerstone of companies. With a strategic plan in place that streamlines the inventory oversight and management process, including real-time data on inventory conditions and levels, companies can realize inventory management benefits.

Simply put, according to Novaes (2011, p. 107), “an inventory management system oversees all stock and stock items of a company”.

Through a robust inventory management system, all inventory items can be tracked and managed throughout their lifetime, from delivery to warehouse to customer's shopping bag. Most inventory management systems have some similar elements. First, they have a way to identify each item, usually via a barcode or RFID. After each item (BALLOU, 2011, p. 98).

An inventory management system helps keep businesses more organized. Without tracking and managing inventory, it's hard to know what's needed, when, and in what quantity.

Silva (2015, p. 12) mentions that “With a quality inventory management system, you have detailed records of all company assets”. You can see all the moving parts in one place, easily see the products that are moving and those that are selling slowly. Having all of this information and resources in one place allows you to make informed decisions about your business needs.

The investment in inventory must not be excessive or inadequate. It must be ideal. Maintaining the optimal level of stock is the main objective of stock management. Excessive investments in inventory result in more funding costs, reducing profitability, inventories can be misused, lost, damaged and retaining costs in terms of ample space and others. At the same time, insufficient investment in stock creates problems of lack of stock, interruption in production and sales operation (LINDER, 2012, p. 82).

Therefore, the company may lose customers as they switch to competitors. The finance manager, as he is involved in managing stocks, should always try not to over- or under-invest in stock.

Inventory control refers to the efficient control of goods stored in warehouses. Maintaining an adequate level of stock is very essential for a business flow.

For Moura (2010, p. 53) “The stock acts as a bridge between customer orders and production. They are the reservoir of goods kept in anticipation of sales”. Therefore, it needs to be managed and controlled properly.

Inventory represents a key economic factor in network design that forces inventory consolidation in a small number of locations. Over the years, there has been substantial research on controlling inventory levels for individual product items, but relatively little on estimating inventory levels when there is more than one product item at a time. The practical concerns of network design require that many items be collected across product families and

treated as an aggregated group. What is needed is to be able to estimate stock levels as demand is assigned to facilities (SEVERO, 2012, p. 97).

Proper anticipation of product demand is necessary to maintain the correct level of stock. Properly estimated demand helps companies in terms of inventory cost, providing the customer on time and maintaining the production schedule.

Fleury (2015, p. 74) mentions that the basic objective of inventory management is “to minimize the amount of working capital blocked in inventories; and, at the same time, provide a continuous flow of materials to meet production requirements”; and provide timely supplies of goods to meet customer demands.

Novaes (2011, p. 70) points out that the administration must maintain stocks of:

1. Raw materials and parts
2. Semi-finished goods
3. Finished products

Management must balance the benefits of holding stocks with the costs associated with holding stocks, such as - storage space costs, insurance costs, risk of damage and deterioration in stock holdings, etc.

2.2 Inventory control

Inventory control refers to a planned method of purchasing and storing materials at the lowest possible cost, without affecting the production and distribution schedule. Inventory control, therefore, can be classified as a scientific method, capable of determining what, when and how much to buy to have in stock for a certain period (SCHONSLEBEN, 2000).

According to Schonsleben (2000), inventory control refers to the process by which the investment in material and parts transported in stock is regulated within predetermined limits defined in accordance with the inventory policy established by the management. Thus, inventory control activities include: determination of inventory limits to be carried out, determination of inventory policies, establishment of investment standards and its regulation, according to individual and collective requirements, and monitoring, to examine the work of the policy of inventory and, effecting changes, as and when necessary.

It should be evident from the above analysis that materials control is the operational process, while inventory control is the management process and the latter is the first step to be followed by the former. Inventory control therefore forms the basis of material control, without which the entire operation of inventory

maintenance can be ineffective or aimless to some extent. On the other hand, stock control precedes storage, which predetermines the scope of stocks and investments (SALEEMI, 2007).

Ramanathan (2006) proposed an approach, called weighted linear optimization, to aggregate the performance of an inventory item, in terms of different criteria, to a single synthetic score, using a weighted additive function. He proposed an extended version of such a weighted linear optimization for multi-criteria inventory classification. These quotes directly explore and support the problems observed in the case study.

The main purpose of an inventory control is:

- Minimize downtime caused by stock shortages and non-availability of stocks as required;
- Keep capital investment in inventories low, avoiding carrying cost losses and obsolescence. Achieving these goals will result in more return on capital, which is materially the main goal of an organization, whether commercial or industrial.

Return on Capital is the relationship between Profit and Capital Investment. Under normal circumstances, the profit margin depends on external factors such as competition over which management has little control. Since the capital turnover rate is maximum when capital investment is minimal, management can exercise control over competitive market trends to some extent (SALEEMI, 2007).

2.3 Types of Costs Involved in Inventory Control

Mclaney (2003) emphasizes that all companies normally seek to balance the costs and risks of keeping inventory levels zero or even low in relation to the parameters established for each organization. Thus, such costs, which until then were aggregated, would be reduced. One of the types of costs involved in inventory control is the order cost. This is the sum of the fixed costs that are incurred each time an item is ordered. These costs are not associated with the quantity ordered, but with each activity required to process the order.

The great challenge of stock management is to reconcile, in an integrated manner, the goals of the departments involved, optimizing this investment, without harming the company's operations. Still, according to Ballou (2006), there are three categories of associated costs. These are acquisition costs, maintenance costs and the costs of out-of-stocks. Acquisition costs generally include the price of the products, the costs of processing orders by the purchasing department, and especially the transportation costs, when these fees are not part of the purchase of the products. Maintenance costs comprise

those deriving from the storage of stocks during a certain period. Among them are the cost of space, which are costs related to the volume occupied by inventories. Capital costs are also included in maintenance costs as they result from the cost of money fixed in stock. There are also the costs of storage services and the costs of storage risks.

2.4 Order point, replenishment time and safety stock

For Pozo (2010), it is the inputs found in the stock that ensure the production process so that continuity problems do not occur, while the arrival of the previously made purchase batch is expected. In order to find the minimum stock needed for the continuous operation of companies and to meet customer demand, it is essential to determine the time taken to replenish stocks.

According to Dias (2010), replacement time is the time spent from verifying that the stock needs to be replaced until the material actually arrives in the company's warehouse. This time can be divided into three parts:

- Order issuance: It is the time it takes from the issuance of the purchase order until the purchase order reaches the supplier;
- Order preparation: It is the time it takes from the supplier to manufacture the products, separate the products, issue billing until they are ready to be transported;
- Transport: It is the time it takes from the supplier's departure until the company receives the ordered materials.

In order for the company to maintain the balance between reducing costs and minimizing uncertainty, it is essential to determine a level of stock called safety stock or minimum stock. According to Dias (2010), the minimum or safety stock may be the minimum amount needed to cover any delays in demand, thus ensuring the continuity of the flow of production processes.

According to Pozo (2010), the main purpose of safety stocks is to try not to harm the production process, much less to cause inconvenience to customers due to lack of supply, which occasionally can lead to delays in the delivery of products to the market. Safety stock is intended to address the impact of uncertainties such as delays and claims in freight transport, unexpected increase in demand, and denial of defective purchase lots.

2.5 Inventory management

Efficient inventory management within companies has the most important objective of determining a more streamlined flow of materials and products, which guarantees good customer service, without any waste and surplus stocks throughout the entire chain. The main

objective and purpose of an Inventory information system is to collect and keep up to date all data from within the company, for decision making covering the operational level.

According to Dias (2010), companies are growing and standing out, especially in the supply chain, offering the possibility of reducing unit costs for moving products between companies. For Antônio (2009), inventory management is of paramount importance for the company to avoid possible deviations and ensure the availability of stocks to serve the end customer. According to Francischini (2004), inventories usually contain a description of the product as well as the existing quantity and location. Accuracy in inventory management is currently important and should be placed as a priority for supervisors, managers and directors of any company that seeks to achieve the desired operational efficiency objective.

Inventory control and maintenance is a vital problem experienced by almost every sector of the economy. This topic is very important, as all organizations deal with inventories on a daily basis. Neglecting the importance of inventory in any organization can lead to the closure of the company, especially if the factors of production are not well managed in order to meet the needs or desires of customers, the company tends to move towards a stop. The stumbling block of inventory is having enough items available when desired by customers. Item inventory must be reasonable, which means it should not be too much or too little, and the company must be in a position to meet customer demand in terms of quantity and quality.

According to Dobbler (1996), the main objective of inventory management and control is to provide services to customers at a minimum cost. Managing inventory has become a special issue when selling globally. Inventory management is of great importance especially for managers who must decide how much (if any) they have to insure and how to manage the rest of the logistics system more creatively in order to ensure that customer service does not suffer as a result of lower stock levels. This is why inventory management requires special attention or support from all levels of management in the company in order to meet customer satisfaction.

III. MATERIALS AND METHODS

This chapter's main objective is to present the research method that will be used in this work, the reasons that make clear the implementation of the inventory risk classification system. More specifically, with food products, where the motivations and difficulties that were encountered during the entire process of implementing the

system will be identified, in addition to raising the main benefits achieved with the use of this tool.

For such an investigation, which can be considered as contemporary, premised on the answer to the research questions: “What are the potential benefits for the inventory with the implementation of the risk classification system?”.

In order to answer this question, the case study methodology will be used in this project. This method will allow us a deeper analysis of the problem, which allows us a better understanding of the inventory classification process (MIGUEL, 2007).

The problem to be solved in the present study is the lack of speed in the classification of inventory risks, in relation to stock management of perishable products, when the demand is sensitive to the product's expiration date.

Due to several factors that can contribute to the formation of these inventories, such as demand and sales, a schedule will be created to contribute and support the user, in a clear and objective manner.

For the development of the research, a methodology was developed using VBA Excel as the main tool, this application was chosen because it is a tool that can be used in Microsoft Excel, where it has access to most users, this way, the user has more options for controlling and editing spreadsheets. Basically, VBA acts as a programming language at the service of the user, allowing the creation of macros and the automation of various processes within spreadsheets and tables developed in Excel.

During the field research visits were carried out at the sites, for observation and dialogue with the people involved in the process, this visit had a foundation and direction in order to obtain non-formal information, the foundation was guided according to a composed research script for ten questions to be observed by the researcher, nine of which are multiple choice and one is a dissertation. The target population determined for this research was approximately 48 small and medium-sized businesses, located in the neighborhood of Tarumã, West Zone of the City of Manaus, AM. The selected sample consisted of 12 businesses, representing 25% of the target population surveyed.

IV. RESULTS AND DISCUSSION

4.1 Field research

According to the population and sample defined for this research, the answers to the questions were acquired through the application of a research questionnaire and

tabulated and presented, with the use of graphs and tables, in order to better elucidate the issues observed.

This analysis also contemplated the results of the development processes of a programming for inventory risk classification, using Visual Basic Applications (VBA). This schedule consisted of three steps:

- Elaboration;
- Modeling;
- Compilation.

To analyze the issues related to the size of the stock of the companies evaluated and the use of inventory control tools, the observations reported in questions 01 and 02 were grouped, as shown in Table 01.

• Question 01: What is the approximate size of the stock?

• Question 02: Does the establishment use any tool for inventory control?

Table 1 - Size of stocks and stock control tool is used.

Reference	Use tool	Don't use tools	Total	%
Up to 1,000 items	2	5	7	58,3 %
Between 1,000 and 5,000 items	5	-	5	41,7 %
	7	5	12	

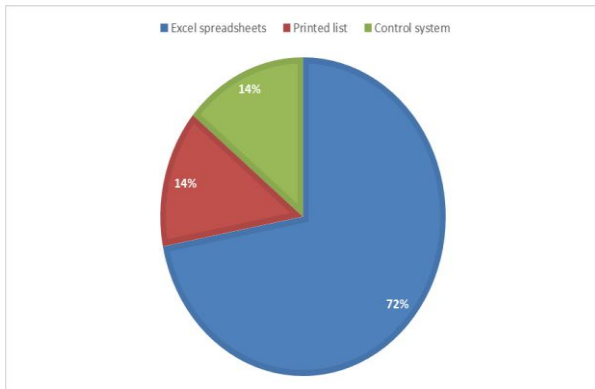
Source: Authors, (2021).

According to Table 1, seven (58.3%) of the companies visited have up to 1,000 (one thousand) items in their stocks. Of this total, only two use some control tool and most (five companies) do not use this tool. With regard to companies that have an average of between 1,000 (one thousand) and 5,000 (five thousand) items, all use some control tool.

• Question 03: If YES in the previous question (If you use a control tool). Which one?

As seen previously in Table 1, only seven companies visited use some inventory control tool. In this sense, Graph 1 shows that of these seven companies, 72% use Excel spreadsheets to control their stocks, 14% use printed lists and only 14% (1 company) use a control system.

Graph 1 - Inventory control tools used by respondents.

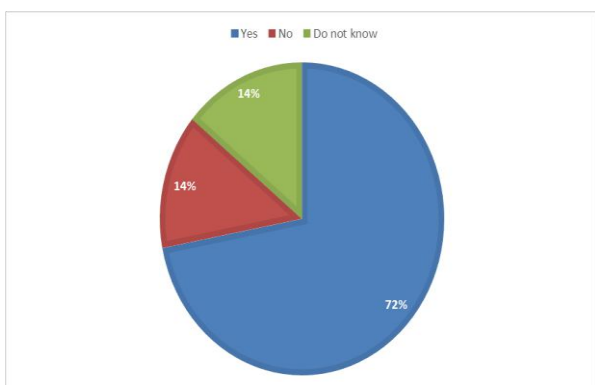


Source: Authors, (2021).

Question 04: Does the control tool used today meet all stock needs?

As for the efficiency of the tools used, the reports of those responsible for the establishments who reported using some tool (seven establishments) were considered. Graph 02 shows that for 72% of companies the tools used meet their needs. 14% reported “No” and 14% did not know or did not report.

Graph 2 - If the tools used by respondents meet their needs.



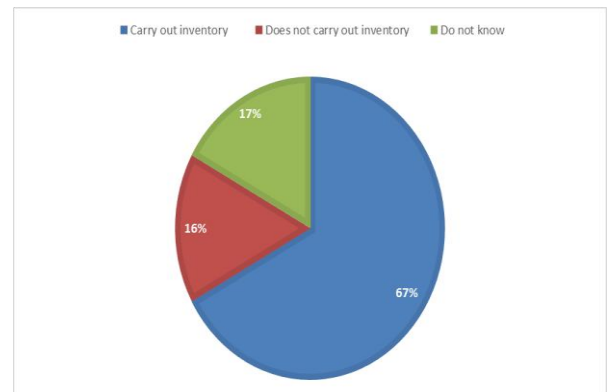
Source: Authors, (2021).

Question 05: Carrying out inventories (item counts) in stock:

As shown in Graph 3, 67% of establishments carry out inventories in their stocks. A minority (16%) do not carry out inventories and 17% did not present any relative data. It is noteworthy that in this question only the realization or

not of the inventories was addressed, as to their frequency, accuracy or effectiveness, it was dealt with in questions 06 and 07 below.

Graph 3 - Companies that carry out inventories in their stocks.

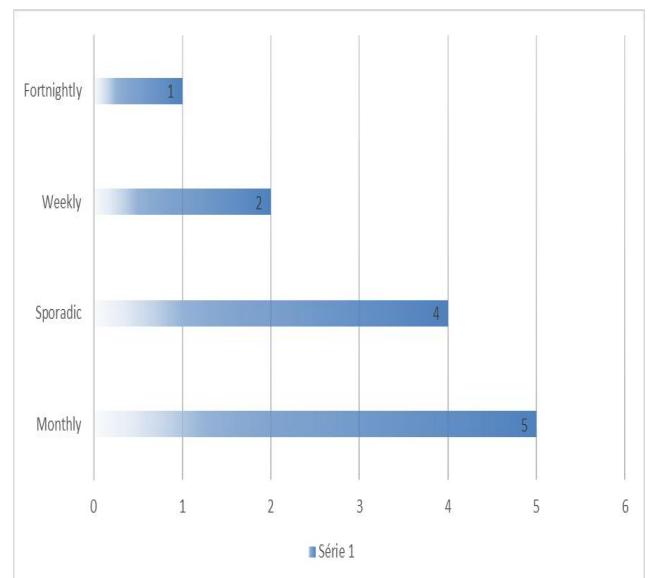


Source: Authors, (2021).

Question 06: If YES in the previous question. What frequency?

Regarding the periodicity of carrying out inventories, most establishments carried out monthly. Second, sporadic practice, followed by weekly and finally fortnightly.

Graph 4 - Frequency of inventory realization by establishments.



Source: Authors, (2021).

The modeling, for data observation, was done through the VBA Excel programming environment, where the interface was performed between the provided environments, containing data on stock balance, entry date

and expiration date of the products correlated with the variables analysis of the schedule, resulting in response to the health of the analyzed stock.

Data compilation was carried out using the programming designed to obtain the inventory classification, which is presented by a computer application using Excel resources in the VBA programming environment, where it was intended, in fact, to show the versatility of using this program in making a decision about the scenario of how the stock is at the time of analysis.

The observation and classification of inventories are carried out in such a way as to meet the health of the business' stock, taking into account the variables that we will deal with in this case study.

For the case study, the inventory was classified into three main classifications:

- No Risk – Where it was shown that for inventory, there was no risk of inventory loss, when input and output variables were analyzed, according to demand and consumption, in view of the expiration date of the products.

- Medium Risk - Where it was shown that for stock, there was a risk of inventory loss of up to fifty percent, when the input and output variables were analyzed, according to demand and consumption, due to the expiration date of the products.

- High Risk - Where it was shown that for the stock, there was a risk of inventory loss in one hundred percent, when the input and output variables were analyzed, according to demand and consumption, due to the expiration date of the products.

authors such as: Owler (1985); Pozo (2010); Ballou (2006); Saleemi (2007), Brent and Travis (2008); McLaney (2003), among others, confirm the importance of Control for an effective balance between costs and risks.

According to Dobbler (1996), the main objective of inventory management and control is to provide services to customers at a minimum cost. The financial objective is the ability of funds to make management demands of how much is needed to invest in inventory so that the money has not been put into inventory, leaving other areas without working capital.

Under the objective of asset protection, inventory represents money. Therefore, this objective gives the stock controller the obligation to ensure that stocks are protected against all possible dangers, including theft, waste and misappropriation of inventory, therefore, there must be adequate inventory and stock control.

In this sense, the other questions in the questionnaire sought to address the Inventory Control used by respondents, with regard to the tools used and the practice of inventory. The questions from 02 to 04 were aimed at investigating the interviewees' inventory management, regarding the use of control tools:

Question 02: Use of any tool to control inventory?

Question 03: If YES in the previous question. Which one?

Question 04: Does the control tool used today meet all stock needs?

Simchi-Levi et al. (2004) informs us that the use of technology in inventory control is a crucial enabler that ensures efficiency in the process. Therefore, the evolution of Information Technology (IT) has been and will continue to act as the main driving force for the development of SCM. In this sense, it appears that there are today on the market several tools for stock control, suitable for different types of companies and with a wide range of costs and profiles.

The main importance of an inventory management system is to collect and keep up to date all data from within the company, for decision making, covering the operational level. It is up to the entrepreneur to make an investment plan, according to the particular needs of the company. The lack of standards, on the other hand, contributes to software being soon developed to mediate between different systems and different standards and, eventually, the concept of supply chain standards can be established in the basic systems that make up the infrastructure (SIMCHI-LEVI et al., 2004).

It is also noteworthy that the acquisition of an inventory control tool is part of a mix of investments

Tipo	Lote	Código	Descrição	Data de entrada	Vencimento	Valor	Quantidade
Produto de Limpe	19469	15270	Sabão em pó	01/01/2021	15/09/2021	6	246
Produto de Limpe	18355	11804	esponja	01/01/2021	15/09/2021	5	24
Produto de Limpe	19469	15270	Sabão em pó	01/01/2021	15/09/2021	6	246
Produto de Limpe	18896	22703	Água sanitária	01/01/2021	04/11/2021	4	181
Produto de Limpe	6481	11306	Espuma de aço	02/09/2021	05/11/2021	5	94
Produto de Limpe	1793	30240	Buchinha de pia	07/02/2021	10/11/2021	4	75

Fig.1: Inventory Health Summary.

Source: Authors, (2021).

When we approach the topic of Stocks, it is essential to pay attention to the Control factor. In this aspect, several

necessary for its good maintenance. In this aspect, Dias (2010) states that investments in stock are necessary as they work as a lubricant for production and sales service. Insufficient stock compromises the pace of production and limits sales.

The questions from 05 to 08 were aimed at evaluating the practice of inventory (counting items) of stocks:

Question 05: Carrying out inventories (item counts) in stock?

Question 06: If YES in the previous question. What frequency?

Question 07: Do the results of inventories usually diverge from the actual stock?

Question 08: If YES in the previous question. At what percentage?

Render (2003) teaches us that an inventory is any stored resources that are used to satisfy a current or future need. The inventories, therefore, usually contain the description of the product as well as the existing quantity and the place where it is found. Accuracy in inventory management is important today and should be placed as a priority for supervisors, managers and directors of any company that seeks to achieve the desired operational efficiency objective.

Inventory management is of paramount importance for the company, to avoid possible deviations and ensure the availability of stocks to serve the final customer (ANTÔNIO, 2009). Saleemi (2007) alerts us to the fact that inventory control is a planned method of purchasing and storing materials, at the lowest possible cost, without affecting the production and distribution schedule and that they incur costs for the care of the stored material. and are subject to damage and obsolescence.

In this way, stocks of raw materials provide a stable source of inputs needed for production. Large inventory requires less replenishment and can reduce ordering costs due to economies of scale. In-process stocks reduce the impacts of variability in production rates in a plant and protect against process failures.

Questions 9 to 10 sought to address the use of the Excel Solver tool with respondents, as well as possible improvements in terms of inventory control:

Question 09: Knowledge or have you ever heard of Excel Solver?

Question 10: What could be improved in inventory control?

For Simchi-Levi et al. (2004), the supply chain management is complex and distinct in each company and they may be concerned with the magnitude of the return on

investment, or very detailed information that does not make sense to the customer, or a certain investment in IT is too much great.

Thus, the large number of resources in computational areas, which are available today in the market to be a support point for decision making, demonstrate the need to apply resources in micro and small businesses. For Cezarino et al. (2008) this is mainly applied in relation to the cost item. To serve this purpose, there are several tools available on the market, for example, in solving problems related to clean production, which can be treated with Solver, which is a tool that is available in Excel and whose main objective is to find an optimal answer to the problems that are encountered.

In this aspect, Solver proves to be quite efficient, as it is composed of a set of programs (tool for hypothetical analysis) and allows the change of values in cells, in which it finds a value through a formula in a system within the spreadsheet, characterized also as a target cell.

V. CONCLUSION

This research aimed to contribute to the development of a methodology for inventory risk analysis, a programming for an application in VBA - Excel, with the ability to classify inventory risks and, for this, it was elaborated from a survey bibliographic and case study, carried out with small and medium businesses in the city of Manaus-AM.

The data presented in the research, in terms of technical-theoretical framework and field research results, allowed an analysis of the scenario experienced by some companies (field research sample) regarding the control and management of their stocks and inventory practices . In this aspect, in relation to the pre-defined specific objectives, it is possible to highlight:

A methodology for inventory risk classification was developed, according to the variables established within the inventory concepts, which met the theorization proposed by the authors and contemplated the variables established within the inventory process, which included the following parameters: Average consumption monthly; Minimum stock; Replenishment Time or Order Point (issuance, preparation and transport).

Then, the parameters for analysis and management of these risks were identified, a modeling was carried out to observe the data, using the VBA Excel programming environment, whose interface is performed using the provided environments, and which included data on: balance in inventory; date of entry and expiration of the products. These data were correlated with the

programming analysis variables, which guarantees results in terms of response to the health of the stock.

Finally, it is concluded that, although it has great economic and operational importance, inventory management is a minimized subject in most of the interviewed companies and that investments in terms of control tools are reduced, causing problems with stock accuracy and control, which can have negative consequences for the company in many situations.

This work is suggested, given its technical-theoretical importance, but of great practical application, to educational and research institutions, in order to contribute to the theoretical framework promoted and to researchers and technicians who use the Solver and VBA tool, from way they can use this reference, as a guide and study material in their projects involving the technical applications of these tools in inventory management.

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