Process Optimization: A Beverage Distributor Using Organizational Tools and Modeling Via Petri Nets

Letícia Verônica Almeida[1], Nataly Marcela de Freitas[2], Vinícius Melo Pereira[3], Renata Duarte Mellim[4], Luiz Melk de Carvalho[5], Rafaela Priscila Cruz Moreira[6], Flávio Henrique Batista de Souza[7]

Centro Universitário de Belo Horizonte - UNIBH

Abstract

In the face of a competitive scenario, quality management assumes an important role by presenting itself as a strategy capable of helping organizations to achieve the expected results. In this context, the present work analyzes the processes of a small beverage distributor, in order to find bottlenecks and propose improvement solutions. The concepts and theories are based on organizational tools and on the stages of the planning phase of the PDCA cycle: problem identification, observation, analysis and, finally, the action plan. The study begins with the identification of the problem through technical visits and interviews with the manager. Then, in the observation phase, organizational tools were applied to improve processes and reduce losses. Finally, the organization and standardization of data contributed to improving inventory management, managing the billing process of the company and drawing up future strategic plans using technologies for data management and scenario simulation. The simulations used Petri Nets, a structure defined in the literature, for their representation and application. This case study is a demonstration of the management optimization potential of a small entrepreneur, in the Brazilian market, where the recovery of control of its processes during the pandemic period is demonstrated.

Keywords: Drink's distributor, ABC curve, Inventory, Management, Pandemic, Simulation.

1. Introduction

In Brazil, the beverage sector represents a large portion of the Brazilian GDP (Gross Domestic Product). According to the statistics carried out by the Brazilian Food Industry Association (ABIA) in 2020, the sector represents 10.5% of the national GDP, with an increase of 13% compared to 2019. On the other hand, the micro-entrepreneur in the beverage sector has suffered a sharp reduction in its earnings caused by the Coronavirus pandemic, which

revealed a 50% decrease in sales in one month, according to the latest study carried out by the Brazilian Service for Support of Micro and Small Enterprises (SEBRAE), in August 2020 (Portal Veja, 2019; Ministry Of Economy, 2021). In contrast to the previous year, due to the resumption of activities during the Coronavirus pandemic, the first four months of 2021 show that there was an increase in the number of new retail beverage stores, representing an increase of 15,6% in relation to the third quarter of 2020. In the period covered, it was found in the business map, made available by the Ministry of Economy (2021), a number of openings four times greater than the number of closings of enterprises in the sector.

According to Leković & Marić (2016), entrepreneurship changes in times of crisis, in order to achieve better economic redistribution. This movement can be seen with the implementation of welfare policies, taking emergency aid as an example, to increase the consumption power of the population, thus creating a more favorable environment for the micro-entrepreneur. Inventory control is one of the main factors responsible for the survival of small businesses, according to Barreto & Antonovz (2017). Recently, both work on inventory management and process optimization work are present in the literature, even more so in the beverage sector. However, for the most part, medium and large companies are approached, or more robust (and not so accessible) technologies are used (Abu Zwaida et al., 2021; Cevallos-Torres et al., 2022).

According to Melo & Monteiro (2020), processes are tasks performed by people or machines, in order to achieve a common result. Management takes place in its optimization, looking for more satisfactory results in shorter times. In that case, the process management and the use of organizational tools become vital for micro and small companies that are commonly managed by few or no employees, concentrating operational and strategic demands on the owner of the enterprise. Such a business model provides an informal environment with low management quality, caused by the lack of information about processes and lack of market knowledge (Cezarino & Campomar, 2010). To glimpse the results, the aim of the present work is to use modeling and simulation through Petri Nets, which are “a mathematical formalism used to model and analyze systems that have parallel, concurrent, asynchronous and non-deterministic activities” (Lisboa et al., 2019; Beatriz et al., 2021).

Therefore, the general objective of this work is to demonstrate a process of optimizing the inventory management of a micro family business in the beverage sales and distribution sector in the face of the critical scenario caused by the pandemic that has extended in the country in the last 2 years. The specific objectives are: to carry out a diagnostic evaluation of the operating process of the company, inventory management and control and possible optimization feasibility; carry out an assessment using organizational tools and the ABC Curve for inventory management and improve profitability; propose an initial modeling and simulation for future process management guidelines in the company; carry out a survey of possible tools and software available on the market that can be used to organize, manage and standardize the company data.

This work is justified since a study carried out by IBGE from 2012 to 2017 showed that 6 out of 10 companies close their activities before completing 5 years of activity. In view of this, the

enormous complexity and series of difficulties faced by micro and small entrepreneurs to be able to remain profitable in a critical scenario that currently exist, which was aggravated by the pandemic scenario (Cervieri Junior, 2017; Do Nascimento et al., 2020). Nowadays, it is already possible to notice the resumption of growth opportunities, mainly in the beverage sector, which has adapted to a new way of consumption, based mainly on delivery. Therefore, the challenge of this work is to seek ways to optimize and improve the processes of the company by making the best use of this prosperous scenario. Many works on inventory management are available in the literature, in several segments, including beverages. However, a question can be asked: how would such knowledge be used, in a small company, in Brazil, in a company that is adapting to the formality processes? The relevance of this research is confirmed by the importance of evaluating the behavior of the application of tools from the literature in a public profile that often does not know the existence of such resources (nor the impacts and procedural optimizations they produce).

2. Methods

This article demonstrates a case study, and firstly the approach performed to identify the main issues with the processes of the company is carried out. Three main steps guided this study. In order to carry out the diagnostic evaluation of the operating process of the company, in the first stage, data collection was carried out through three technical visits, semi-structured interviews with the business manager to identify the factors and achieve the objective of the study. Secondly, in possession of this data, the current operating system of the company was described, presenting all the relevant aspects for this work, through the creation of process flowcharts. Through the graphic representation, it was possible to identify the critical points that can be improved.

As a third step, organizational tools based on software available on the market and the ABC Curve method were applied in the analysis of the processes to guarantee the organization and standardization of data, analyze the business management, organize the inventory, and consequently, increase profitability. After completing these steps, an initial modeling and simulation was proposed for future process management guidelines in the company. Numerous mathematical models, including the type of modeling in Linear programming, are available in the literature. However, we chose to use Petri nets, a bipartite graph structure, oriented to events, for reasons such as: modeling of graphic representation and didactic understanding for the proposed user (unlike models like Simplex). The possibility of using accessible software without the need for a license (such as ARENA). In addition to a model that can be updated as samples are collected to refine measurements of time to trigger transitions.

3. Results

3.1 Analysis of the productive environment of the company

The company studied started its activities in January 2021 in the eastern region of Belo Horizonte, Brazil. Its operations are focused on the beverage sector and in terms of its geographic coverage area, it is restricted to the eastern region of Belo Horizonte. The warehouse of approximately 18 m² is in the neighborhood of Boa Vista and its current marketing mix comprises thirty-three products classified in three categories: beers, soft drinks and distillates. Currently, the company has two employees who divide the functions according to the work demand, and a car that is used to carry out deliveries.

During the technical visits, it was not observed any type of standardization and organization of the data of the company and documentation that helps in the management of the business. Currently, the data related to the orders from the customers are recorded on the telephone through conversations on the Whatsapp® application, without the use of any organizational tool or management software. The current process makes management and control of product inputs and outputs difficult, and there is not any visualization of the monthly profit margin, leaving the manager without any useful information to conduct the business. Another problem that it faces is the loss of products due to the expiration date. The owner does not have a record of this data and uses the FIFO (First In First Out) methodology, which basically consists of the first (product) to enter stock must be the first out as well, avoiding reaching the expiry date of the product.

3.2. PDCA Cycle

One of the biggest challenges for family-based, informal or small companies in the Brazilian scenario is the planning and distribution of tasks in an organized and standardized way. Based on this fact, a standardized definition of task planning via PDCA was proposed (which with its simple but robust concept, it was possible to demonstrate its importance to the owner). Having diagnosed the absence of standardized documentation that organizes and enables better management of the business, the first recommendation is the development of a PDCA cycle to optimize and organize the process. Based on that, the following tools and steps were used to obtain the desired results.

- Plan: a process flowchart was proposed, which would make it possible to visualize the entire production chain of the business and possible bottlenecks, delays, and aspects of improvement. After this step, continuing the work, a 5W2H plan was prepared with some of the observed aspects that would allow the elaboration of an intervention proposal. In the third step, the standardization of data was started, supporting the use of electronic data spreadsheet to organize and to standardize the data that was previously stored in messaging applications. This step helps to enable the possibility of elaborating further modeling and simulation processes.

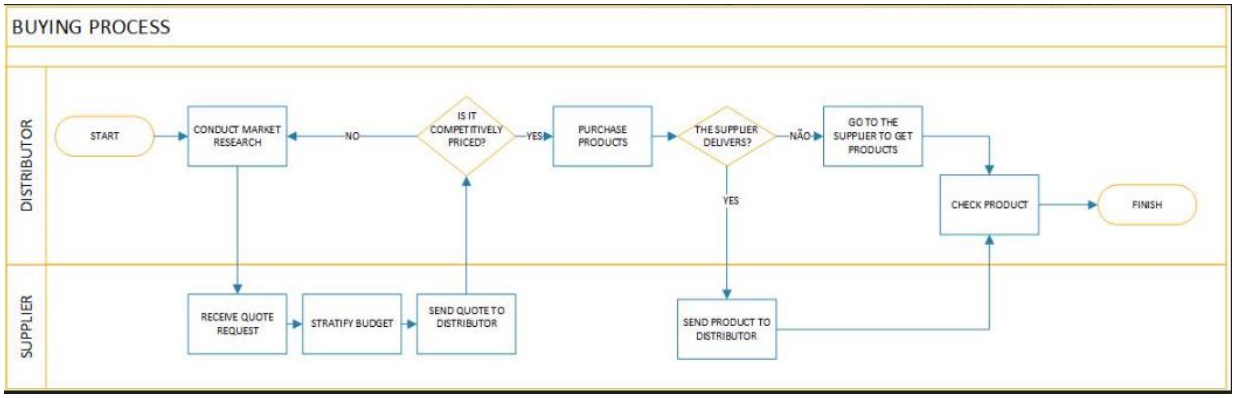
- From: Between May and September 2021, a process of applying the models was carried out, in which a flowchart was prepared according to the business profile of the company studied. A 5W2H assessment of the inventory, purchase and sales management process was carried out, including the evaluation of the possibility of hiring new employees, envisioning an optimistic growth scenario for the company. Third, data consolidation was carried out with the aid of a spreadsheet in a way that allows for compatibility with tools and software available on the market.
- Check: Elaboration of the checklist to monitor, observe, analyze and validate the points that underwent intervention, to verify the achievement of the expected results.
- Action: The entire process was carried out by the researchers of the article and verified with the manager of the analyzed business to validate its relevance and carry out possible readjustments of the process.

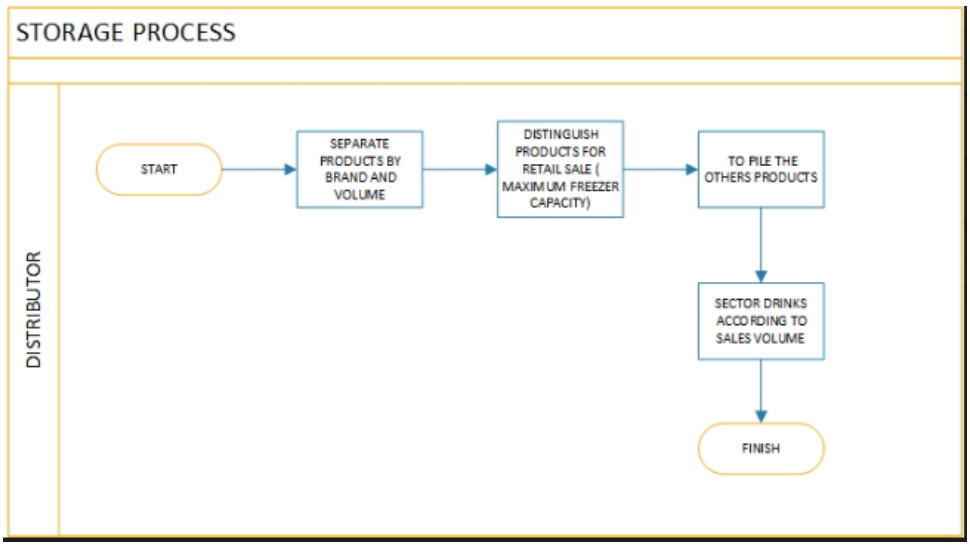
3.3 Optimization Process

3.3.1 Standardized Description of Processes

As a first optimization step, a standardized description of the purchase, storage and sales processes is presented. The operational process of the company is described in Figure 1. In Figure 1, the manager (owner) makes quotations with based on the catalog of the suppliers and makes the purchase that presents the best proposal. After this activity, the purchased products are received and stored. Then, customer orders are processed and taken to the delivery car for distribution. Currently the distributor has 2 sales models. In the retail modality (Figure 2), the customer goes to the physical store and, arriving there, places the order. The attendant checks if he has stock and if it is at the ideal temperature for sale to process it. The customer selects the best payment method, and after payment approval the purchase is delivered by hand to the customer. The wholesale (Figure 3), is when a fixed customer gets in touch via telephone asking for a quote for the products they want, and if the value is attractive, they place the order. The owner checks if he has stock to fulfill the order, performs the separation of the items from that sale and finally supplies the car with the goods to make the delivery.

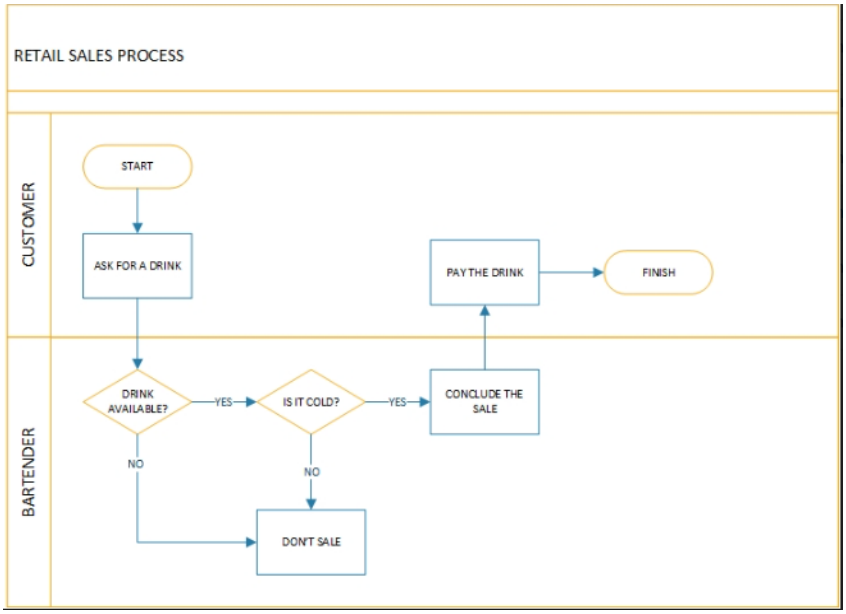
Figure 1: Flowchart of the Company's Purchase and Storage Process





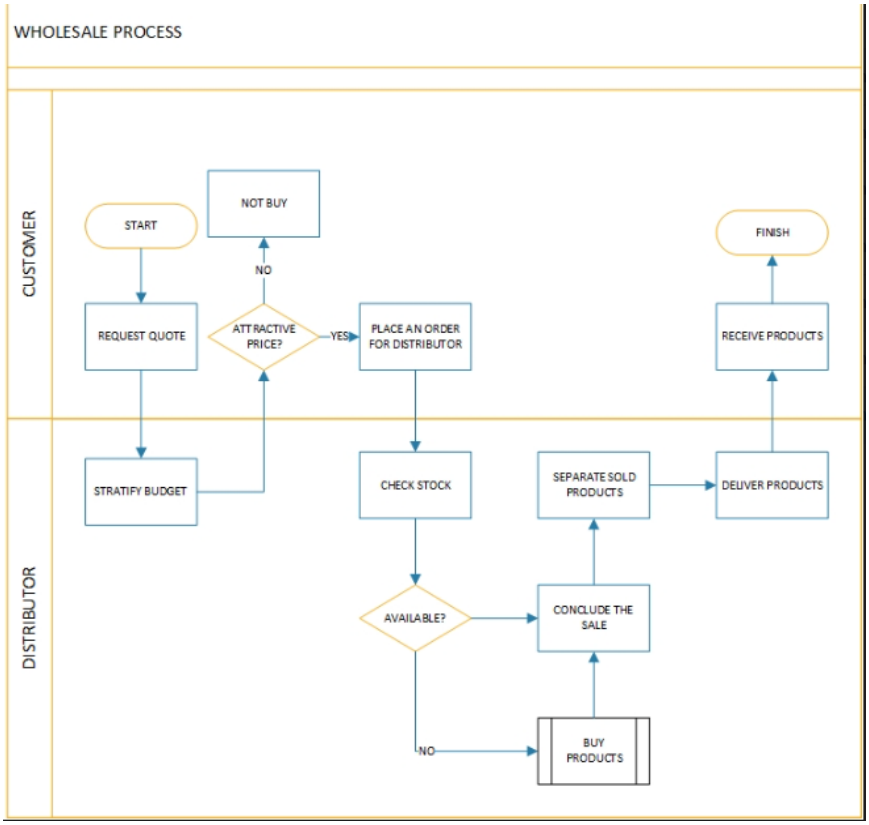
Source: (Authors,2022)

Figure 2: Retail Sales Process



Source: (Authors,2022)

Figure 3: Wholesale Sales Process



Source: (Authors,2022)

There are several action plans models for implementing activities arising from strategic planning. In this article, the model known as 5W2H was chosen, as it is more relevant to what was observed in the company. Figure 4 demonstrates the definitions with the proposed methodology.

Figure 4: Planning via 5W2H

Nº	REASON	WHAT	WHY	HOW	WHERE	WHO	WHEN	HOW MUCH
1º	NON-STANDARDIZED DATA	DEVELOP ELECTRONIC SPREADSHEET	LOSE INFORMATION	TRANSFER DATA TO ELECTRONIC SPREADSHEET	ELECTRONIC SPREADSHEET	AUTHORS	SEPTEMBER 2021	-------
3º	INVENTORY MANAGEMENT		LACK OF PRODUCTS, EXPIRATION DATE AND IMPROVE LAYOUT	APPLY THE FIFO METHODOLOGY			OCTOBER 2021	-------
2º	LACK OF ATTENTION	TRAINING	LACK OF ATTENTION TO BUDGETING	BUDGET THROUGH THE ELECTRONIC SPREADSHEET	MANAGEMENT	OWNER		-------
4º	INCREASE SERVICE AGILITY	INCREASE THE NUMBER OF COLLABORATORS	INCREASE REVENUE AND COMPETITIVENESS	HIRE AN AGILE EMPLOYEE			2022	R$ 1500,00

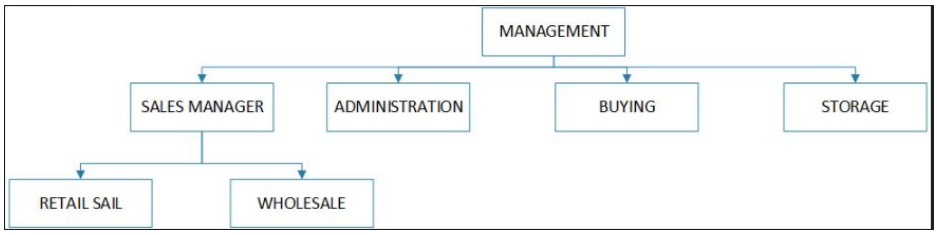
Source: (Authors,2022)

The importance of its use is justified by the retraction of evidence and justification of each task to be performed, as well as the resource of each such activity. It was a simple, but robust and well-founded way to demonstrate to the owner the distribution of tasks and the elements that compose them.

3.3.3 Alignment of responsibilities via Organization Chart

The organizational chart is one of the stages of the organizational structure. By using this tool a company can graphically represent its administrative organization. The main objective of an organizational chart is to facilitate the understanding of the hierarchical relationships in the company and the integration between areas and positions. The company under study is a family micro-enterprise with two employees who divide their functions according to work demand (as shown in Figure 5).

Figure 5: Organizational chart of the company



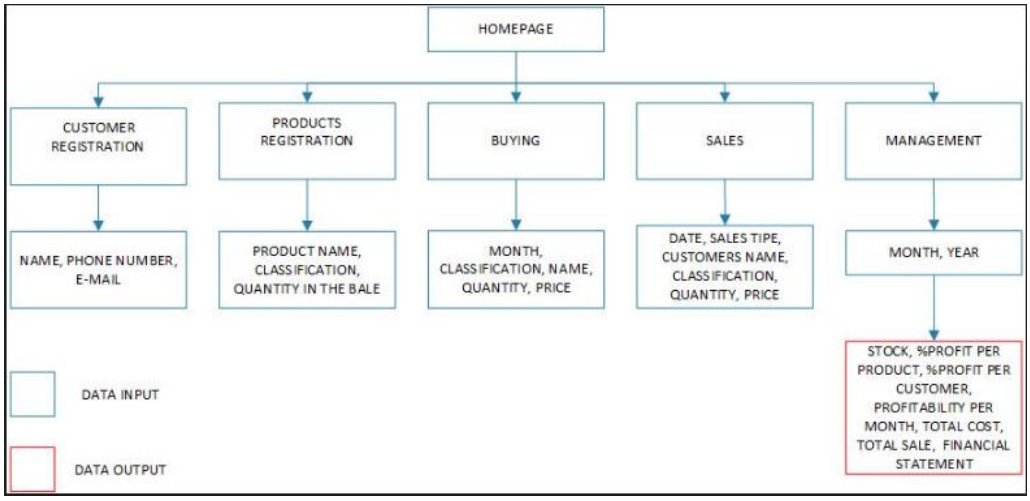
Source: (Authors,2022)

In this way, the organization chart was formulated together with the manager, in order to establish the appropriate hierarchy according to all the processes of the organization.

3.4 Data Optimization and Standardization

Aiming at data standardization and greater organization of the amount of stock, an electronic management spreadsheet was created. Microsoft Excel software, previously acquired by the manager, was used, not causing impacts on the costs. Figure 6 demonstrates the complete structure.

Figure 6: Diagram of the electronic spreadsheet built.



Source: (Authors,2022)

The document has a graphical interface, through buttons for navigation between pages, which are:

- **Home Page:** Presentation of the worksheet containing legend for each navigation button.
- **Customer Registration:** In this tab, there is the registration of the descriptive variables of each customer, being the type of customer (Wholesale or Retail), name, telephone and email.
- **Product Registration:** Tab intended for data entry of descriptive variables of the product category between alcoholic, non-alcoholic and variable cost nomenclatures, such as water, electricity, internet, names of each product, in addition to the quantitative variables of the units present in every bale.
- **Purchases:** The year and month of purchase data are entered for stock, product category, product name, quantity of purchased bales and purchase price. In this tab, the payment amount for the purchase is automatically returned. A field of percentage of intended profit was inserted in the Purchases tab, where the manager enters the desired profit, and a sale value is automatically suggested to obtain such profit.
- **Sales:** Data entry of date of sale, type of customer (wholesale or retail), customer name, product category, between alcoholic and non-alcoholic, quantity of sale and unit price of sale. On this screen, the quantity in units of beverages sold is returned, which, in the case of wholesale sales, all quantities per bale are discounted, and for retail sales, the product is discounted one by one, which will make the future calculation of stock. On this same page, the total sales value of each item is returned.
- **Managerial:** A screen was created for inventory management and financial control by the project manager. On this screen, the input data is the month and year that the manager wants to analyze. The data return the delivers from the inventory of each product in units and bales, in addition to the amount spent on purchases and sales revenue by product. To facilitate the analysis of the manager, there is a column that gives the percentage of profit per product. On the same screen, it is possible to get the total cost amount for the month, as well as all earnings and balance. A quick consultation area was created, where it is possible to enter the type of product data (alcoholic or non-alcoholic), choose which product to analyze, and obtain the return of the stock of the specific product, speeding up the consultation process. Also on the management screen, the monthly amount sold per wholesale customer is available, and in retail as a single customer, in order to provide a strategic business visualization for the enterprise. On this screen, there are graphs of sales by customer, pareto costs, pareto sales, and an inventory graph by product.

Due to the lack of information prior to May 2021 and the form of control previously adopted by the manager, where the quantity of product sold and its purchase price were recorded on the cell phone, the standardized data returned zero stock. To solve this situation, the manager was

instructed to carry out an inventory to know the real stock, and enter data such as purchases in the amount of R$0.00 (zero Brazilian Reais), in a month before May 2021, ensuring the data of the stock collected in the spreadsheets, without compromising the financial information already established. An advantage of data standardization is the possibility of the user being able to analyze the management of the cash flow, viewing more easily the inputs and outputs of the business, with graphical analysis support compatible with Power BI analysis tools, which are relevant in a scenario of business expansion.

To ensure the correct handling of the electronic spreadsheets made available to the company, training was carried out lasting three hours, where each tab was studied, showing the correct way to register customers, products, entry of purchases and sales made. On the Management screen, an explanation was also made about viable business strategies with the output data, as well as the correct reading of the financial and stock graphs and tables presented on the screen. Currently, the business moves an average of R$50,000 BRL per month and suffers from fluctuations in demand due to municipal decrees that restrict the operation of sporting events, bars and restaurants that constantly change depending on the growth or reduction statistics of Covid-19. It was reported by the manager that sporting events, carnival, concerts and parties in the city represented its highest sales volume. The perspective is that the business will grow, since the commerce and the service sector tend to normalize and with the opening of the physical store that started to work from the month of September.

3.5 Modeling via Petri Nets

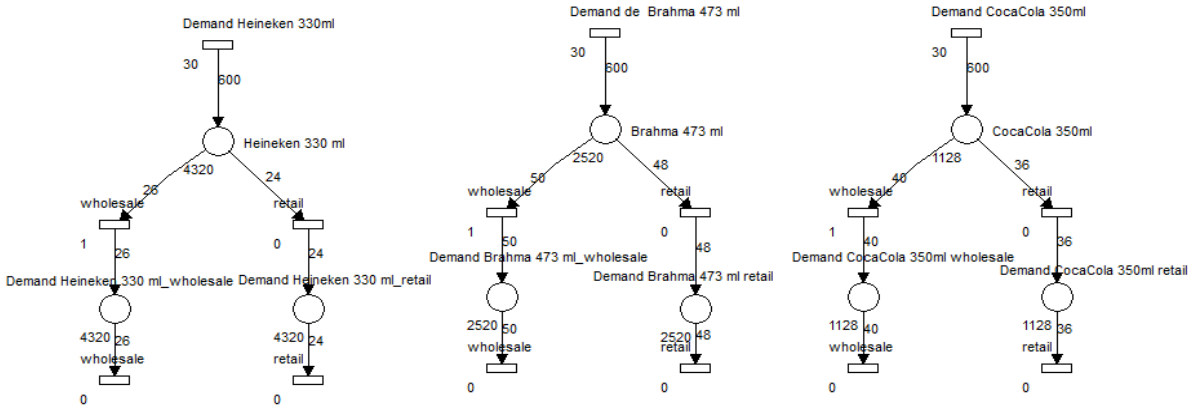
The modeling and simulation processes start from the following prerogative: How would it be possible, through a modeling and simulation structure (accessible, well-founded in the literature and without a proprietary tool) to guide in a didactic way an analysis of the product sales analysis process retail and wholesale? So, the organization of data and standardization of inputs and outputs of information creates for the enterprise the ability to carry out deeper analysis of the business, with the next step being the creation of predictive models through Petri Nets. It was proposed to study the behavior of higher demand sales, using the HPSIM Software, available free of charge.

The proposal of modeling via Petri nets consists of an entry transition (representing the demand event of a product – e.g.: Coca-Cola 350ml) through an average waiting time of 30 days of operation. With the occurrence of the demand event, 600 units of the product are purchased to stock. Each product has a reserve of storage space, in this case Coca-Cola has space for 1128 units. Thus, for a sales simulation of these 30 days, the averages of daily wholesale and retail sales were calculated (Coca-Cola 350 ml has 40 and 36) respectively. The Simulation graphs shown represent the replenishment and consumption process in the month.

For the selection of the 3 firsts simulation, the ABC curve was used, with the A curve having the following beverages: Heineken 330ml, Brahma 473ml and Coca Cola 350ml. It is worth noting that the solution in electronic spreadsheets already provides the ABC curve (characterizing another contribution from the research). The assembly of the cells (as shown in

Figure 7) was based on events, symbolized by the rectangles. In the simulation, when the rectangles (transitions) are black, the event is triggered, and when they are white, a time unit is expected, which in the study, the time unit is counted in days.

Figure 7: Petri Net Cells



a) Heineken 330ml *b) Brahma 473ml* *c) Coca Cola 350ml*

Source: (Authors,2022)

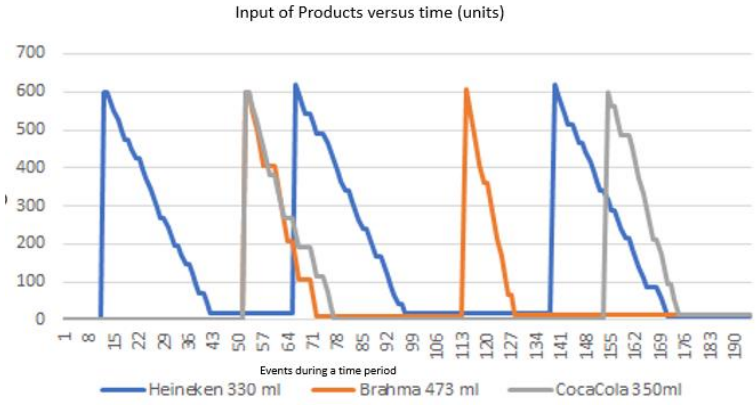
The exponential distribution was used because the values are considered in events with a mean of 30 days. The values of capacities and demands were collected from the data recorded by the electronic spreadsheet created by the authors, using the highest value recorded at the time. For the output weights, represented by the bifurcation of the arrows (called arcs in the literature), they respect the uncertainty of sales between retail and wholesale, where empirical values were used for the purposes of analysis and proof of the effectiveness of Petri Nets, these valuesbeing in units per day. The opportunity to use real values with the proper use of the created electronic spreadsheet is highlighted, bringing an increasing degree of reality with the data population over time.

Different cells were created for each product, but with the same structure, as the demands are not the same, and the suppliers may vary between drinks. For a better understanding of the model, Figure 7-a shows the Heineken 330ml demand cell, which has an input of 600 units, with a capacity of 4,320, with empirical values of daily consumption of 30 and 24 units, for wholesale and retail, respectively. Figures 7-b and 7-c demonstrate the other two products listed by the ABC curve. Through the simulations, deliveries from suppliers were observed as a result, with three entries of Heineken 330ml for two regular entries of the other products studied in the proposed time, as shown in Figure 8. Another finding that is tangible to the study is the analysis of sales by product, both wholesale and retail over time. Based on these results, the enterprise is equipped with data for marketing strategies and plans for sales progression, consequently increasing its monthly revenue (as shown in Figure 9 with simultaneous evaluation of the 3 products).

In Figure 8, it is possible to verify that the monthly demands of each product (the 3 of reference) have their individuality, with a peak of replenishment, reaching 600 units, as described by the y axis of the graph. However, during the sequence of events, it is possible to verify a behavior

of resource consumption. An example is that Heineken has a lower process (consumption of its resources) that is less pronounced than the others (that is, it stays in stock longer than the others and the time between replenishments (the peaks of the graph) still needs to be an improvement strategy, as there is a time without the product in stock (example between events 43 and 64 of the graph) Brahma and Coca-Cola have a more accentuated problem, because with faster consumption, the impact on replenishment time is greater (example of event 71 to 113 is without Brahma).

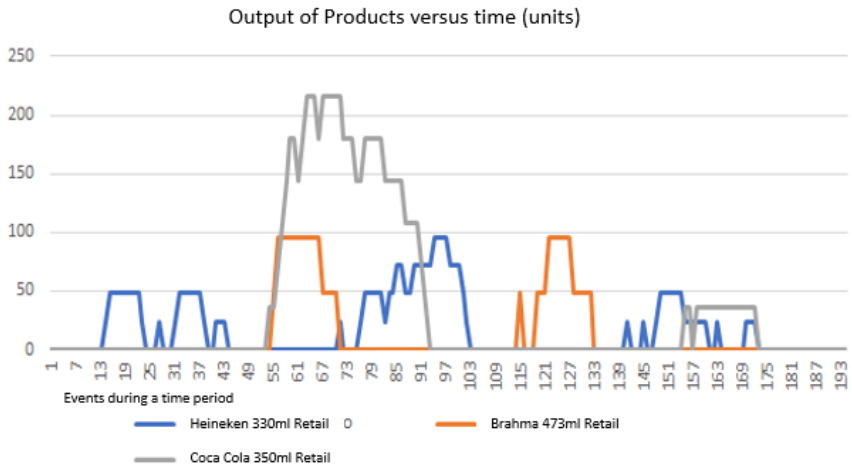
Figure 8: Graph of supplier delivery over time



Source: (Authors,2022)

The proposal of the work compares wholesale and retail methods. In Figure 9 it is possible to see a specific analysis of the retail method. It is noted that Coca-Cola has a more pronounced output than the others, which causes the largest number of absences (breaking point) of the three products (from event 91 to 151) considered a problem to be evaluated in a management strategy of stock.

Figure 9: Graph of sales by product over time



Source: (Authors,2022)

The great advantage of the simulator via Petri nets is that the owners, who do not have knowledge of simulation tools or other techniques, were able to understand and assimilate the knowledge that the simulation structure proposed.

4. Conclusion

At the end of this work, it is considered that the planning and proper use of management tools are very effective for micro-entrepreneurs, who commonly do not know or use them. The correct use of these tools that are available in the literature can leverage a small enterprise without great costs, since in the present work free software or previously acquired by the manager was used.

Using the PDCA, the beverage distributor will be able to adapt relatively quickly to the changes required by its market. Knowledge of the entire process that permeates the enterprise as well as its actors is of paramount importance for the determination of bottlenecks and proposals for improvements. The standardization and organization of data contributes to the management of the stock, as well as the knowledge of how much is sold and bought in a given period of time, in addition to a better management of the billing process of the company. Through modeling and simulation using Petri Nets, the manager will be able to know the behavior of sales curves by product, having in hand the forecast of items sold according to the sales category (wholesale or retail), making his increasingly data driven business, being able to rely on data for marketing strategies and smarter profit generation.

References

Abu Zwaida, T., Pham, C. and Beauregard, Y. (2021). Optimization of inventory management to prevent drug shortages in the hospital supply chain. Applied Sciences, v. 11, n. 6, p. 2726, 2021.

Barreto, A. and Antonovz, T. (2017). A influência da falta de gestão adequada de custos no encerramento das empresas no Brasil [The influence of the lack of adequate cost management on the closure of companies in Brazil] Revista Científica Hermes. vol. 18, pp. 213-232.

Beatriz, J. H. A.; Honorato, J. C.; Cunha, E. M.; Souza, F. R. S.; Vila, G. G. S. B.; Pereira, I. O.; Oliveira, I. R.; Anjos, M. A.; Gomes, N. C. F. C.; Reis, M. V.; Souza, F. H. B. and Carvalho, L. M. (2021). Modelling and Simulation Applied to Gluten-Free Craft Beer: Case Study of a Manufacturing Process. Proceedings of the 3rd International Conference on Research in Science, Engineering and Technology, pp. 70-84.

Brasil, Ministério Da Economia [Brazil, Ministry of Economy0 (2021). Mapa de Empresas – 1º Quadrimestre/2021 [Map of Companies - 1st Quarter/2021] Available: https://www.gov.br/governodigital/pt-br/mapa-de-empresas.

Cevallos-Torres, L., Tobar, M. B., Cadena, A. D. and León-Granizo, O. (2022). Decision making in inventory control by using artificial neural networks. Sustain. Eng. Innov, v. 4, n. 1, p. 66-75.

Cezarino, L. O. and Campomar, M. C. (2006). Micro e pequenas empresas: características estruturais e gerenciais [Micro and small companies: structural and managerial characteristics] Hispeci Lema Online, São Paulo. Available: https://www.unifafibe.com.br/revistasonline/arquivos/hispecielemaonline/sumario/10/19042010081633.pdf.

Do Nascimento, A. C.; Do Prado, N. B. and Da Cunha, C. F. (2020). COVID-19 e modelos de gestão nas micro e pequenas empresas: qual a melhor saída? [COVID-19 and management models in micro and small companies: what is the best way out?] Revista Expectativa, vol. 20, issue 1, pp. 50-72.

Junior, O. C. (2017). Panoramas Setoriais 2030: Bebidas. Banco de Desenvolvimento Nacional [Sector Outlook 2030: Beverages. National Development Bank] Available: https://web.bndes.gov.br/bib/jspui/bitstream/1408/14256/2/Panoramas%20Setoriais%202030%20-%20Bebidas_P.pdf

Leković, B; Marić, S. (2016). Economic Crisis and the Nature of Entrepreneurial and Management Activities. Economic Themes, vol. 54, issue 1, pp. 21-44.

Lisboa, A. C., Souza, F. H. B., Ribeiro, C. M., Maia, C. A., Saldanha, R. R., Castro, F. L. and Vieira, D. A. (2019) On Modelling and Simulating Open Pit Mine Through Stochastic Timed Petri Nets. IEEE Access, v. 7, p. 112821-112835.

Melo, L; Monteiro, D. (2020). Gestão de processos na administração pública: o caso da Diretoria de Cálculos e Perícias do município de Belo Horizonte [Process management in public administration: the case of the Directorate of Calculations and Expertise in the city of Belo Horizonte]. Revista de Gestão e Projetos, vol. 11. issue 3. pp. 136-154.

VEJA. (2019). SEIS em cada dez empresas fecham em 5 anos de atividade, aponta IBGE.[SIX out of ten companies close in 5 years of activity, points out IBGE]. Available: https://veja.abril.com.br/economia/seis-em-cada-dez-empresas-fecham-em-cinco-anos-de-atividade-aponta-ibge.