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A Logistics Management study proposal in a Service Sector through the perspective of the Theory of Constraints

André Luiz Marques Serrano[1], Lucas Oliveira Gomes Ferreira[2], Patricia Guarnieri dos Santos[3], Maria Gabriela Mendonça Peixoto[3], Carlos Rosano Peña[3], Clovis Neumann[1], Lucas Soares Caldas[1], Patrícia Helena dos Santos Martins[1], and Sérgio Ronaldo Granemann[1]

[1] Department of Production Engineering, University of Brasília - UnB, Brasília, Brazil
[2] Department of accounting sciences, University of Brasília - UnB, Brasília, Brazil
[3] Department of Management, University of Brasília - UnB, Brasília, Brazil
lucasoliveira@unb.br

Abstract. The purpose of this paper is to present the logistics management applied to the service sector using the Theory of Constraints - TOC. This study is justified due to the ever-increasing complexity of operations carried out in providing such services and the ability of the TOC provides manager to deal with such situations. Thus, it draws on the research gap that the literature appears to analyze the management processes as a function of the production system. However, this theory is a field of applied knowledge in the manufacturing sector, and the application is relatively small and exploited in industry services. Methodologically, this paper brings on the use of TOC, considering that it has full relevance in process management services firms, whether in a public or private nature. Considering the results of this study, based on the key findings identified in TOC, it is possible to state that this theory enables significant improvements in service performance based on assumptions or straightforward steps, which, in turn, recommends and justifies its use in logistics management. The assumptions emerge as an alternative in the processes that make up a production chain, which should be viewed in an integrated manner to understand the system's functioning and connections.

Keywords: Logistics, Services, Firms, Theory of Constraints.

1. Introduction

Managing dynamic processes in competitive markets is an entrepreneurial task and becomes much more difficult when the manager must establish new means to this effect, given the competition's basis for comparison (Sengupa; Sena, 2020; Zilberman; Lu; Reardon, 2021). During this situation, logistics management in service sectors is found, as there are no well-established standards in the market, competition is high, and the number of variables in the process is always high, given the significant number of factors and elements that interact between activities and processes (Mariani; Borghi, 2019). To deal with this type of situation, the objective of the present research is to present an empirical analysis of logistics management applied to the service sector with the aid of TOC.

To accomplish this objective, a defined analysis pattern was used for the execution of the work; that is, the theoretical foundation was obtained from secondary sources employing the literature analysis technique, composed of articles, master's dissertations, and tertiary data sources. More specifically, the analysis procedure was started by studying the company system seen as a flow. Each activity corresponds to a related link, generating energy interchanges among themselves, their functions are interdependent, and the production process of each area influences the whole. As an example of flow, we have the production in each chain link related to a specific resistance and traction. If the flow is subjected to limited traction, it will break at the weakest point, that is, at its restriction. It is this point that defines the maximum resistance capacity of the system. The same reasoning applies to the operation of the system company.

In this context, observing TOC, process management can be improved if the five steps of TOC are observed (Chavez et al., 2020); the first step refers to the identification of the system constraint, which is intended to find in the system, the primary constraint or weakest link of the whole system. In this context, the constraint means 'any element that limits the organization in achieving greater profitability.'Constraints can be external or internal: market, materials, capacity, management, directive, standards, and policies. Whereas external constraints may be unavoidable, the market is a constraint, and process management technology is intended to address internal, capacity, or material-related constraints (Ab Talib, 2021).

The second step to be outlined refers to the exploitation of the system's restriction; the weakest link in the chain defines resistance, that is, the primary restriction of the company, defining its maximum gain. Thus, the company will be unable to perform its function (production, sale) in the process to a greater extent than it is possible to flow through the constraint. This step establishes the maximum production level according to the constraint. There will be a hierarchical synchronization of the resources that work at the rhythm of the constraint and its absorption capacity (Lai et al., 2021). Subordination guarantees activity levels with the minimum possible inventory and reduces investment (fixed capital) and operational expenses. The system company has a hierarchy of processes, regardless of the relationship between the support processes and the capacity of the restrictive channels in the system (Urban; Rogowska, 2020; Mishra et al., 2022).

The penultimate step is raising capacity, where the optimization level of the system operation and the capacity constraints are defined; it is possible to make interventions in the production process to break the constraint (Urban; Rogowska, 2019). For example, purchasing equipment, hiring new human resources, a new work shift, etc. Thus, breaking a constraint generates another weaker link or a new constraint in the system; finally, we return to step 1, in which the orientation occurs when the system constraint is broken. The importance of not letting inertia become a constraint is emphasized. One must return to the starting point, in the process of continuous improvement, without accommodation.

Considering the steps presented above, this paper draws as its starting point, on the research gap that the literature appears to analyze the management processes as a function of the production system. So, it is guided by the following research question: what is the format assumed by logistics management in the service sector from the perspective of the Theory of Constraints – TOC? Thus, it is structured as follows: In section 2, the literature review is set out. Section 3 presents the TOC tools contextualized in models applied to logistics management in services. Section 4 presents the results and discussion, and finally, in section 5, the final considerations.

2. Literature Review

To better understand this article's objective, we initially highlight some significant characteristics that distinguish the product and service industries. While the former tends toward automation and work specialization, reducing human participation, the service sector can only easily do with the human element allied to management technology (Meier et al., 2010; Sabaei, Erkoyuncu, Roy, 2015). Kotler (1998) attributes to the production industry the commoditization phase, in which it becomes increasingly difficult to differentiate products in terms of technology and usability. Still, according to the same author, products are increasingly similar, requiring services that generate value, such as delivery, technical assistance, warranties, insurance, credit, distribution, information, after-sales, etc.

The company's quality of delivering goods and services to its customers constitutes the logistics service level (Beysenbaec; Dus, 2020; Khonglumtan; Srisattayakul, 2023). Ballou (2006) defines it as the quality with which the flow of goods and services is managed, constituting a key element in developing logistics strategies and customer loyalty. In this sense, one notices the performance of logistics involving the activities permeated by the production chain, from supply services to distribution and, after the sale, comprising services related to the return of products (Bowersox; Closs, 2001; Cohen; Roussel, 2004; Beysenbaev; Dus, 2020). Still, observing this perspective, Schemenner (1999) points out that service levels allow for the differentiation (personalization and customization) of processes defined according to performance. This essentially intangible factor does not result from the ownership of something (Goldratt, 2003).

The service level may or may not be linked to a physical good. Thus, services are performed in time and space, which generate value for stakeholders - through a transformation or user experience, which are the specific characteristics and requirements defined according to the service level that is intended to be applied. Some industry characteristics common to service provision, which should be understood under the single conceptual layer analysis of inseparability, variability, intangibility, and perishability proposed by Schemenner (1999), explained below:

- Inseparability: a characteristic that signals that for every service activity, there is a time when production and consumption are simultaneous, allowing the consumer's interference in the production process. An assumption that is not relevant in the product industry, in which production and consumption times are different;
- Variability: services vary according to service providers and customers, allowing for inter-phases of customization, personalization, and product differentiation;
- Intangibility: although the service is not a tangible object, it has tangible and perceptible phases that work as evidence of it. These are the signposts that translate the promise of service production, such as packaging, the service delivery environment, the professionals involved, and others; and
- Perishability: service activities cannot be stocked; this characteristic delimits the provision of services in time and space, directing the search for a balance between supply and demand.

The concept of product in the service sector is obtained from a combination of processes and people that aim to meet the needs of consumers, generating satisfaction and value through performance. The service level at the end of the productive chain is evaluated by what is delivered to end customers. The proposed research will be carried out from the process perspective and applied to service companies in the transportation sector (Parasuraman et al., 1985; Patterson; Cicic, 1995; Kotler, 1998; Cloninger; Oviatt, 2007; Spohrer et al., 2007).

The analysis proposed by Schemenner (1999) has two relevant points in the provision of services:

a) capture and b) distribution. This implies their availability at the time required by the downstream part (demand) of the production chain since services cannot be stocked. For products, this reasoning is equivalent to production and sale, but in the services sector, the reading is more complex since it requires the planning of the entire chain analyzed. In Bowersox's (2001) analysis, logistics and transport services have their measurement characteristics, such as availability, operational performance, and service reliability, which are explained below:

- Availability: characteristic related to the existence of stocks to meet the needs of inputs or products for the processes and customers. This can be measured by stock-out frequency, availability index, and shipping of complete orders, among others;
- Operational performance: characteristic related to the service time from the receipt of the order to the delivery of the cargo, which can be measured by speed, consistency, flexibility, and recovery failures; and
- Service reliability: the relationship between availability and operational performance. Attribute related to the fulfillment of the requirement (specification).

Research such as that of Vivaldini, Souza, and Pires (2008) highlights the importance of logistics service providers and the need for performance indicators to measure the performance of services provided and ensure the level of service. However, achieving a higher level of service is directly related to higher costs; thus, the importance of managing the relationship between cost and service level (trade-off) is inserted. This is one of the most significant logistics challenges, considering that customers increasingly demand better service levels, although they are willing to pay less. Thus, logistics is assigned to add value to the product by utilizing its service (Martins et al., 2005; Navendan; Wicaksono; Valilai, 2022). Souza and Pires (2010) emphasize the dilemma faced by distribution logistics systems, which must meet a double objective: reduce logistics costs while ensuring an adequate level of service, the latter being generally related to the quality of the right product, at the right place and at the right time.

2.1. Service Logistics Chain

Logistics is defined as planning, implementing, and controlling the efficient and effective flow of goods, services, and related information, from the point of origin to consumption, to meet customer requirements (Ballou, 2006; Pfohl, 2022). Thus, the logistics process in a conventional supply chain consists of a network of connections of processes, activities, and operations that aim to transform and transfer goods from the point of origin to one or more destinations (Bowersox; Closs, 2001; Ballou, 2006; Marotta et al., 2018). However, the logistics value chain, resulting from all these processes and activities, is more complex since it contemplates several participants and other variables concatenated in support operations to the main processes and specific support for each activity. This necessary integration leads to the concept of supply chain management (SCM), composed of service networks, consolidation, and distribution and return of products, encompassing all the efforts involved from the supplier's supplier to the customer's customer (Cohen; Roussel, 2004).

Logistics service operators aim to serve customers, strengthening the services performed and adding value to the production chain (Vivaldini, Souza; Pires, 2008). Although transport and storage are still considered the most relevant logistics services, many others have been incorporated into corporate processes, which logistics operators can conduct. These configurations are generally added to a digital network as an integral part of the logistics process. Based on this context, Figure 1 represents a scheme of interaction and composition of these networks.

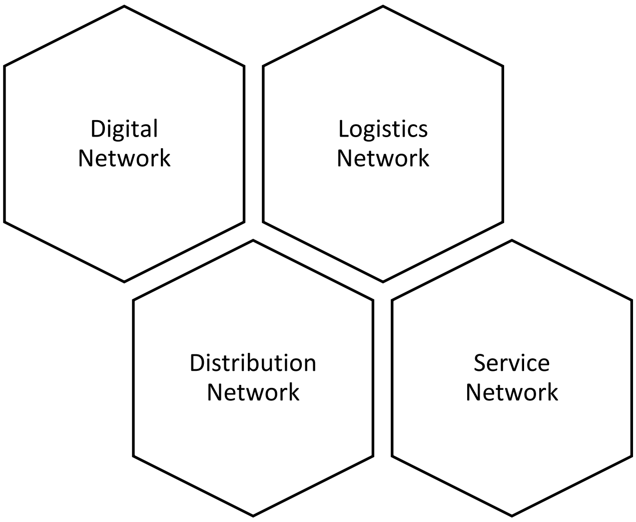

Fig. 1: Outline of service, logistics, distribution, and digital networks.

As observed in Figure 1, the value chain can be represented by the macro processes: Capturing (Attendance Network and Digital), Handling, Shipping, Transportation (Logistics Network and Digital), and Distribution (Distribution Network and Digital). The Fulfillment process refers to receiving the demand and capturing the objects to be transformed and transported. The next step, also known as a treatment, consists of treating, if necessary, the cargo demanded by the previous process, adding some values, such as handling, repackaging, clearance, etc. In this sense, Figure 2 shows the general model of a logistics system.

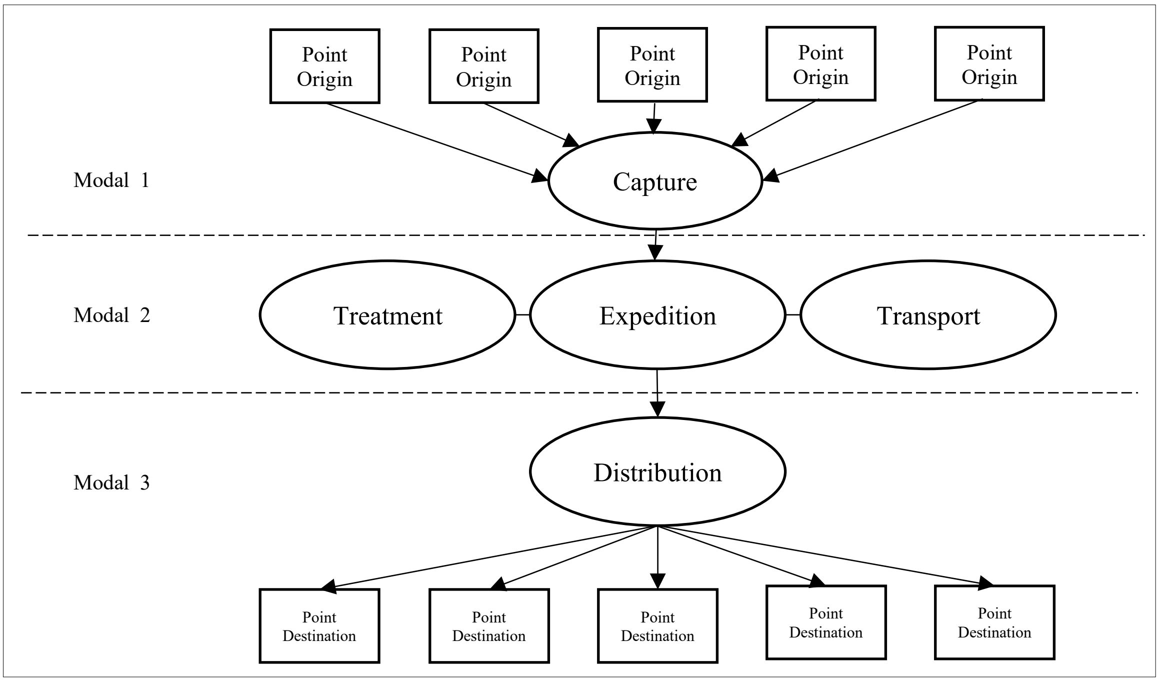

Fig. 2: General model of a logistic system.

Based on Figure 2, Expedition or Forwarding consists of cargo dispatch in the specified compliance with the respective models. The Transportation stage is the operation itself, which must provide security conditions appropriate to each type of cargo and tracking information for the stakeholders of the process until the distribution centers of the network. In the general model presented, the last stage would be distribution, which consists of the delivery of the object to the destination point, usually performed by another transportation modal different from the one used in the transportation to the centers. Depending on the complexity of the process and the value you wish to add, new steps can be inserted into the context, such as another Treatment process before the Distribution step, according to the value you wish to add.

2.2. Theory of Constraints

In the service industries, for quite some time, apparent neglect concerning the productivity of their processes was observed. However, the concept of productivity is questioned by Goldratt and Cox (1992) as a genuine goal when this concept is translated as the "action of leading a company closer to its goal" because, according to these authors, the goal of every company is to generate profit, and the quality of the product, the service rendered, and the process technology are the means to conceive this goal. Hence, the concept of productivity can be seen as the set of actions that lead companies toward their goal of making profits; if they do not have this effect, they will be unproductive (Cooper, 2006).

Pi-Fang and Miao-Hsueh (2005) indicate that in organizations of products or services, traditional management cost accounting systems present errors of vision; instead of focusing on activities that might increase profits, they focus their efforts on the analysis of the reduction of the unit cost of production. For Goldratt (2003), TOC subsidizes the creation of an innovative method of production management and administration because traditional systems do not meet the new operational models, in which the provision of a service is seen as a succession of operations without any connotation of value addition at each stage of the production process. This new form of analysis incorporated into other process management models is also corroborated by the analysis made by Gonçalves (1998) when he states that organizations cannot prevent the world from changing and that the best they can do is adapt. However, Souza (2005) emphasizes that TOC is much more than a scheduling software based on finite resource capacity; it encompasses: i) Logistics, ii) Reasoning Processes as a problem-solving method, and iii) Performance System.

TOC is composed of two strands: reasoning processes and specific applications (such as production logistics), whose focus is on identifying and addressing constraints in the few points of a system that determine its performance, in which the constraint means anything that prevents the system from achieving a better performance about the common goal. TOC notes the importance of the production function as both process and operation (Jesus Pacheco; Júnior; Matos, 2021; Battesini; ten Caten; Jesus Pacheco, 2021). The process corresponds to the flow of the object, information, or material through all stages to its final destination. The operation corresponds to the work done by people or machines to handle the product, information, and material. The improvements must be hierarchically prioritized and associated with the process function, and when associated with the operation function, they must be subordinated to the process improvements. Goldratt (2003) is against process improvements focused on the local optimum, claiming that there is no guarantee of gains in the overall result of the system, causing local decisions to prioritize the allocation of sectorized resources, whose sum does not result in better organizational performance.

In the context of logistics management, Simatupang et al. (2004) add that any improvement initiative in the production chain must be based on knowledge of restrictions, with views to removing them to attain goals. The authors suggest two initiatives to reduce constraints: i) Collaborative replenishment, which reduces and eliminates the bullwhip effect and requires greater information exchange and; ii) Collaborative performance measures, required to ensure that each link in the supply chain is fulfilling its responsibility and, creating more excellent value in the chain.

Pi-Fang and Miao-Hsueh (2005) state that when the system's restrictions are disregarded, one begins to rely exclusively on traditional cost calculation standards, which shows the high risk of transferring to the productive system and the product's attributes, incorrect variables derived from bad decisions. For TOC, the management of constraints allows systemic gains and not only sectorial improvements (Boyd; Gupta, 2004; Zhao; Hou, 2014). Applying the theory of constraints, the following are identified: i) bottleneck resources and ii) non-bottleneck resources. The first means that its capacity is lower than the demand, which limits the system's production. The second means that its capacity exceeds the demand, not limiting the system's production (Goldratt; Cox, 2002).

In the production process, the operation of the non-bottleneck resource occurs before the operation of the bottleneck resource, which is known as the "rope effect" the output will be determined by the bottleneck of the system (slower capacity channel); this determines the "pull" and production speed. If there is excess production of non-bottleneck resources, inventories (inventories) will be generated before the bottlenecks (push). Goldratt (2002) points to the capacity of the bottleneck resource as an essential aspect of the production process, as the maximum efficiency of the operating system. Pi-Fang and Miao-Hsueh (2005) describe that companies that comprise the service segment need efficient production scheduling to manage resources with constrained capacity. This theory recommends using the 'Drum-Pulley-String' or TPC, which aims to improve the system's bottleneck capacity and adjust the non-bottlenecks to maximize the system's efficiency and eliminate unnecessary inventories. However, for Sousa (2002), a single and identifiable bottleneck resource is an essential prerequisite for applying the TPC model and studying the effect of exploiting the bottleneck resource. Thus, the existence of more than one resource with capacity constraints becomes a complicating factor since it requires the use of computational tools that allow all constraints to be adequately explored.

Looking at TOC theory, each subsystem in an industry or company should not strive to maximize its efficiency while ignoring the overall benefits, leading to management and process myopia when using sectoral improvement methods. Subsystem performance resembles chain processes in which weak links compromise the performance of each link in the production chain. The answer to increasing system gain is strengthening the weak links between the different subsystems.

3. Research Methods

According to Pi-Fang and Miao-Hsueh (2005), the main tools of TOC, namely, the Current Reality Tree - ARA, the Scatter Cloud, the Future Reality Tree - ARF, the Pre-Requirement Tree - APR, and the Transition Tree - T.A. seeks to answer three basic questions, namely: What to change in the process?; What to change to?; and How to change?

To answer the first question, one must analyze the symptoms of the current situation by observing the undesirable effects - E.I.s. The tool for this analysis is ARA, which aims to present the existing connections between all the elements and the system constraint. Considering that there are few common causes to explain many of the system's undesirable effects and accepting this assumption, one seeks not to focus the analysis on treating the system's symptoms (Noreen et al., 1995). After the diagnosis of the situation, it is possible to know the awareness of the constraints that act in the system company and prevent the improvement of its performance. Goldratt (2002) points out that there are cases where the restrictions are in the organization's policies.

Regarding the second question, it is necessary to redefine the alternative resources to replace the existing restrictions. According to Pi-Fang and Miao-Hsueh (2005), the reason for the existence of constraints is present in conflicts of the operating rules of the subsystems in the system-business structure, identifying and analyzing the conflict; the appropriate analysis tool will be the Cloud Scatter Diagram. Consequently, this solution refinement process continues until the conflicts are eliminated. The 'Cloud' indicates the direction, but the system solution must still be built. This motivates using another tool; the ARF is recommended to elaborate a new reality. In this new diagram, it is foreseen to look for possible side effects related to the proposed solutions.

Finally, to answer the last question, the ARF is used, indicating what needs to be implemented to improve the performance of the business system, so the next step becomes implementation, and the appropriate tool is APR. Moreover, finally, the Transition Tree (T.A.) is required, which defines the necessary actions and their logical sequence to achieve the intermediate objectives of the APR. In this sense, given the importance of such tools, they are presented below in more detail.

3.1. Current Reality Tree – ARA

ARA is one of the most widely used tools for structuring process elements and connections (Cox III and Spencer 2002). In a more detailed way, it consists of the logical mapping of cause-and-effect relationships to determine problems, bottlenecks, and constraints that cause the E.I.s and that can be observed in the system. Figure 3 represents an ARA applicable to a logistics service process that presents "Customer Dissatisfaction ."However, it is essential to present some considerations to be observed when constructing the ARA: list the main I.S.s strictly related to the studied phenomenon; identify some causal relationship between any of the I.S.s; and extend this process to the other connections of the I.S.s using the logical IF-TEN connection, until all the I.S.s are connected.

It should be noted that sometimes the cause itself is insufficient to create the effect. Such cases are tested with the caveat of insufficient cause and are refined by reading "IF cause THEN effect" as follows. What is the missing dependent statement that completes the logical relationship? Add this to your diagram using the AND connector (represented graphically by a horizontal line that cuts through both connecting arrows). The AND in this relationship is called a "conceptual AND," meaning that both entities connected by the AND connector must be present for effect to exist.

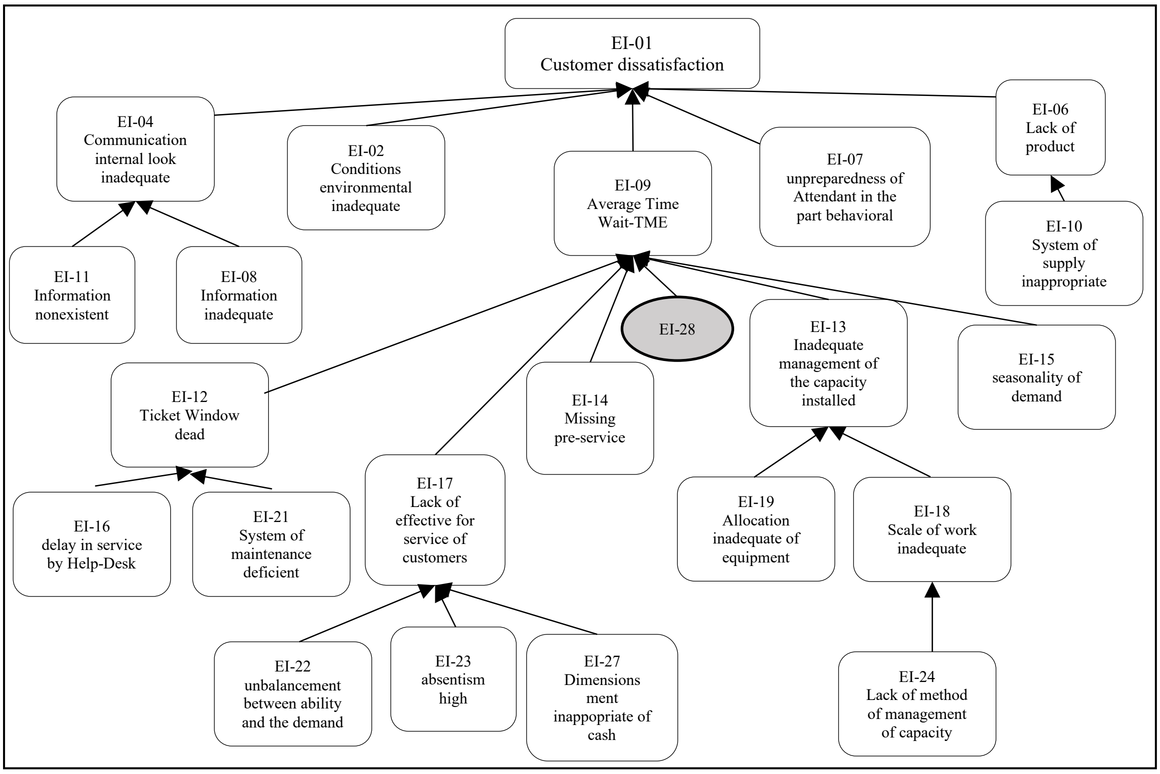

Fig. 3: ARA of an attendance process.

3.2. Dispersion Diagram – D.D.

In the ARA, several undesirable effects caused by many causes were observed. Many of the effects of the tree are caused by operator unpreparedness. To avoid interfering with the system's constraint at random, the Dispersion Diagram (D.D.) was developed to indicate the direction of decision-making. Based on this context, Figure 4 represents a D.D. applied to the service process under consideration.

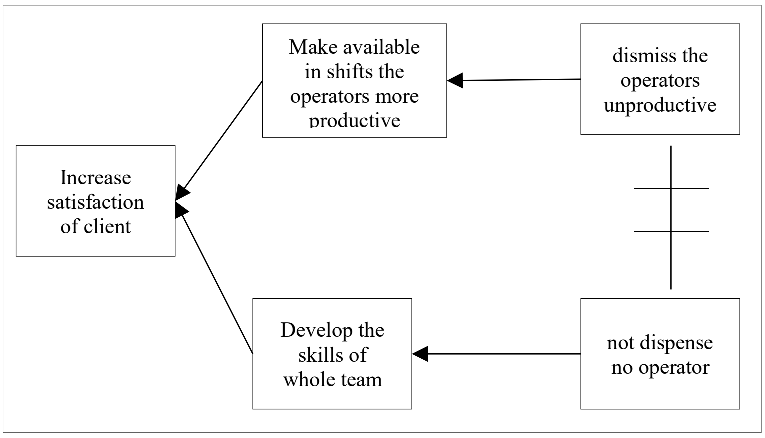

Fig. 4: D.D. applied to the service process in logistics management.

Figure 4 shows that one must decide between developing the competencies of the team of operators or allowing only the high-performance operators to act in the process, dismissing the other team members. This way, you cannot have both alternatives implemented simultaneously.

3.3. Future Reality Tree – FRA

As exposed by Cox III and Spencer (2002), the cloud indicates the direction to be followed, but the FRA contemplates the vision of the new reality of the system. In Figure 5, presented below, the service process is demonstrated, considering the option of not allowing the dismissal of any operator and opting to train the entire team. The following item presents the tools used to answer the third and last question: "How to change?

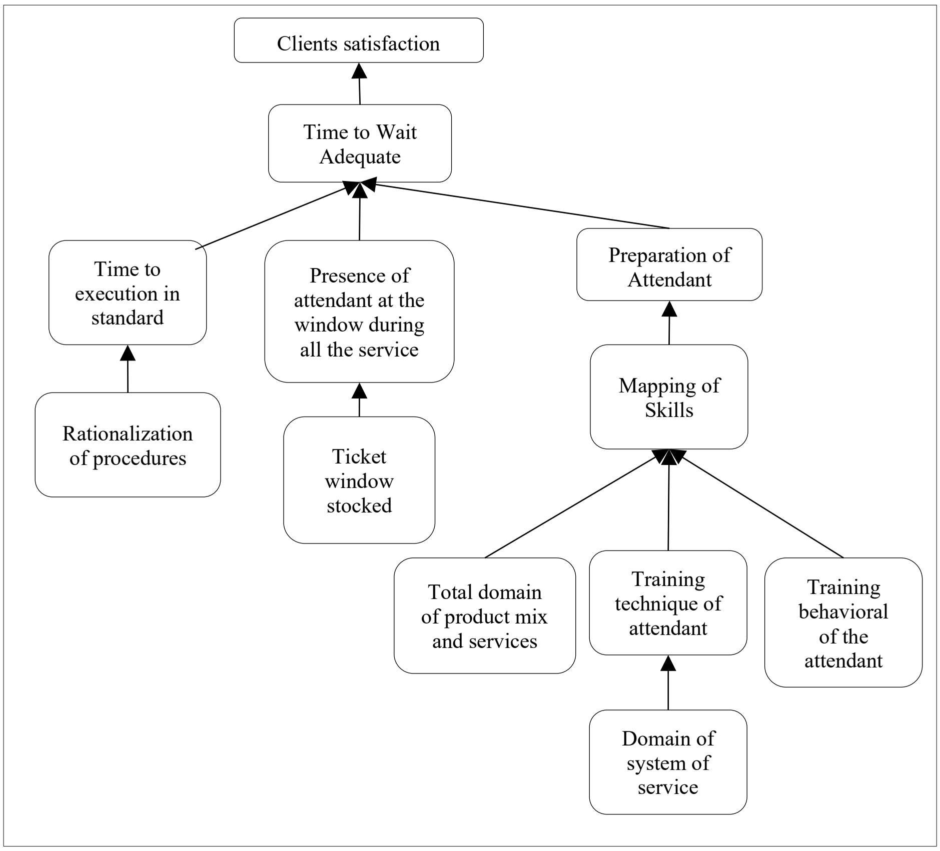

Fig. 5: ARF of the service process.

3.4. Prerequisite Tree - APR and the Transition Tree - TA

Similarly, in Figure 6, APR and T.A. are presented concurrently for the service process.

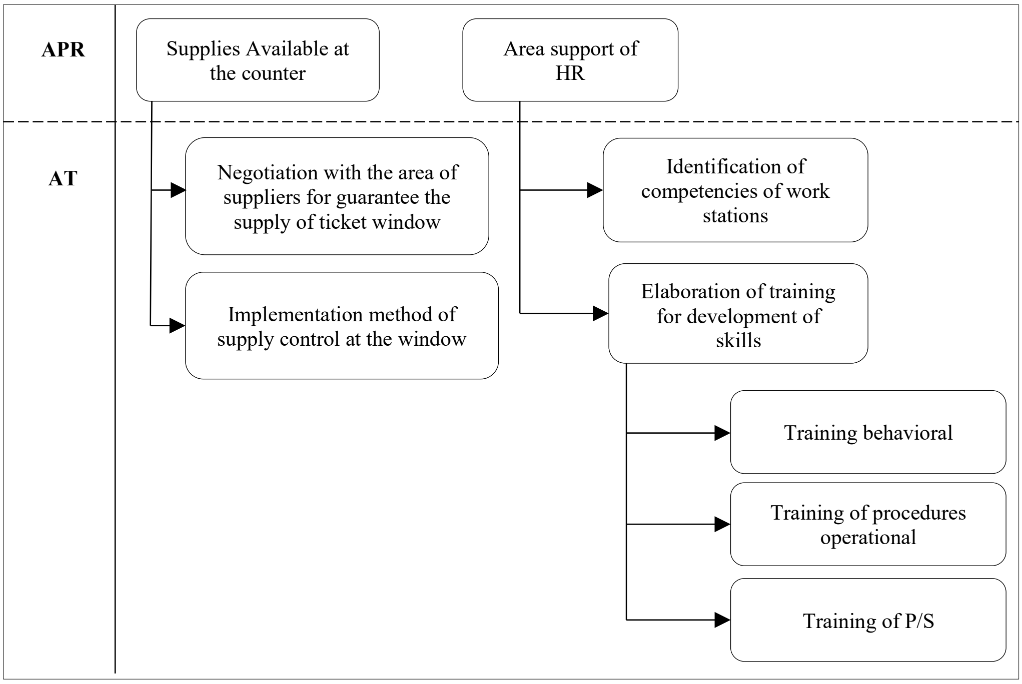

Fig. 6: APR and AT of the service process.

As can be seen in Figure 6, the T.A. in which the actions needed to achieve the intermediate objectives of the APR are defined, addressing the impact points of the constraints that interfere with the reality of the context.

4. Results and Discussions

The application of its principles characterizes the practical implications of this study through the TOC process implementation. It is important to note that most of the databases consulted had used TOC in product production processes; in the present research, the challenge of using it in service-generating processes was considered. As for the use of TOC, the following results were observed:

- The great advantage demonstrated by applying TOC was the objectivity in viewing the overall performance of the value chain by looking at the processes analyzed. While many organizations have difficulty expressing their mission, TOC has proven extremely useful in defining the management gaps that prevent the system from achieving its optimal gains, such as the case of Process and Service services. TOC focuses primarily on increasing productivity, despite the levels of investment along the production chain, associated costs and shipping expenses can be significantly reduced with its use (Souza, Pires, 2010; Jesus Pacheco; Júnior; Matos, 2021; Battesini; ten Caten; Jesus Pacheco, 2021).
- The TOC helps find the potential waste points of the business system and the bottlenecks generated in dispensable inventories, making it possible to implement improvements according to a set of proposed actions (Boyd; Gupta, 2004; Zhao; Hou, 2014). In the Service, Process researched, without the application of TOC, some decisions could have been made that would have immediately improved the gain of operations (local optimum), such as hiring more employees and increasing the number of counters, regardless of the adequacy of the system, among others. With the application of TOC, it was sought to apply the tools to identify the constraints. In this way, it is possible to achieve global gains (process), no longer generating values not perceived by the customers of the process. For example, it is possible to increase the

productivity of the service by changing the dimension of the reference, of the service system, or the dimension of the infrastructure, allowing only high-performance employees to occupy the bottleneck workstation (Alsakarneh et al., 2022; Khonglumtan, Srisattayakul, 2022; Xu, Kim, 2022); and

- By having a tested and structured method for process management, TOC catalyzes the reconfiguration of the organization's processes by utilizing several highly feasible tools and correlating with a systemic vision based on the interdependence relations between the elements and the environment, generating feedback cycles as observed previously in Figure 6.

As a disadvantage, it was identified that its application in isolation generates fewer advantages. The research recommends that TOC be used with the aid of other management technologies. The TOC guides the intervention in the bottleneck without considering the action's cultural, operational, and political viability within the logistics system. The service logistics value chain was characterized, as shown in Figure 7.

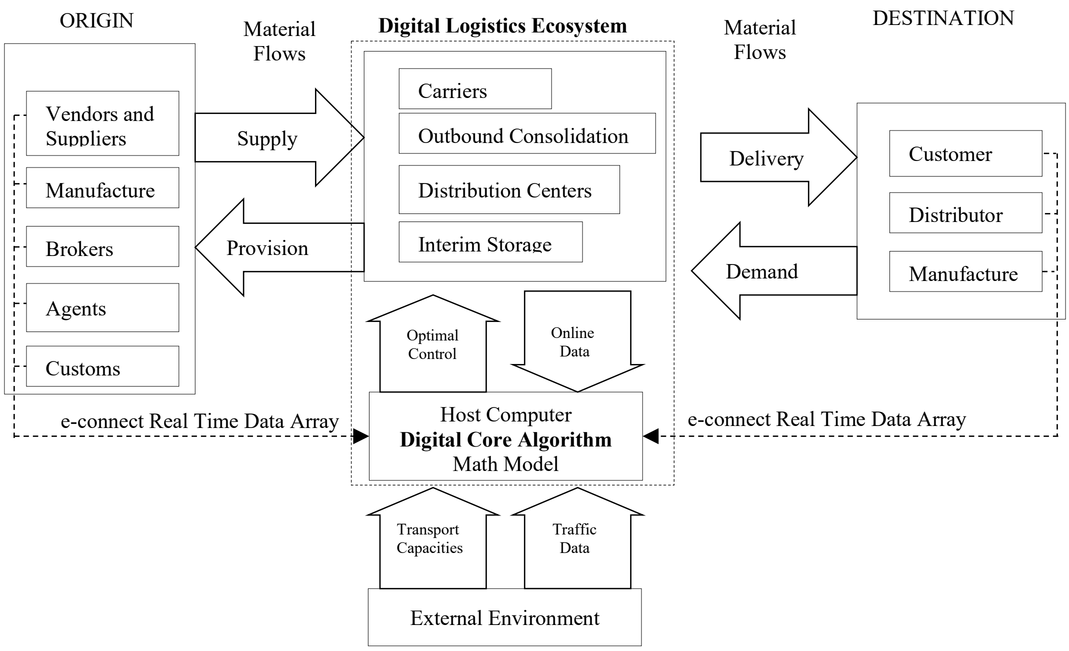

Fig. 7: Context of final logistical processes.

The service logistics value chain was designed in a macro and straightforward way, as shown in Figure 7, encompassing the resources, added values, and references, as well as the relationships among the following end processes: Service Process, Forwarding Process, Handling Process, Forwarding and Distribution Process, with their respective operations and support networks.

5. Conclusions

According to studies concerning the Theory of Constraints, one notices that it presents a methodology based on gain, not cost. Thus, the company's goal is to maximize its gain, and to this end, it establishes a decision model. The maxim of the Theory of Constraints is that the "sum of local optimums is not equal to the total optimum."This means that demanding maximum efficiency from a resource that is not a bottleneck will not contribute to optimizing the company's global result.

The research development suggests that the theory of constraints can be helpful as a managerial tool in the logistics services environment. In the face of the information obtained with the application of the Theory of Constraints, one can make decisions such as: negotiating contracts or substitute suppliers aiming at reducing the prices of the inputs acquired; outsourcing the service, if it is more advantageous; increasing the number of other services; increase the number of other decisions. On the other hand, in view of the greater scope and participation of TOC in the context of the logistics management of tangible products, this paper points out, while a study limitation, the low level of information available, involving the Theory of Constraints and the logistics management, in the face of the scenario of the services.

It is understood that the Theory of Constraints provides information that identifies the points restricting the gains of a company or entity. Thus, the role of managers is to make decisions that are consistent with the results obtained by applying the theory. Finally, by analyzing the data presented in the case, it can be inferred that the prioritization of services with a higher net margin per limiting factor of production guarantees the optimization of the company's global result. Therefore, the Theory of Constraints presents itself as a valid instrument to support the decision-making process in logistics management for several service sectors.

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