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UM MODELO DE ALOCAÇÃO DE ESTOQUE PARA REDUÇÃO DE CUSTOS NA CADEIA DE SUPRIMENTOS DE UMA EMPRESA DE MEIOS DE PAGAMENTO

AN INVENTORY ALLOCATION MODEL FOR COST REDUCTION IN THE SUPPLY CHAIN OF A PAYMENT MEANS COMPANY

Maurício Gumiero da Silva* E-mail: mauricio.gumiero@unesp.br
Ernée Kozyreff Filho* E-mail: ernee.kozyreff@unesp.br
Elias Carlos Aguirre Rodríguez* E-mail: elias.aguirre@unesp.br
Fernando Augusto Silva Marins* E-mail: fernando.marins@unesp.br
*São Paulo State University (UNESP), São Paulo, SP, Brazil.

Resumo: Gerenciamento da Cadeia de Suprimentos (SCM - Supply Chain Management) tem ganhado cada vez mais relevância no setor, levando as empresas a melhorarem o nível de serviço de atendimento ao cliente e a manter os custos sob controle. Entretanto, foi identificado que o SCM é um campo pouco explorado no mercado de adquirência, sendo então este trabalho uma oportunidade de contribuir para o meio acadêmico. Foi observada também a oportunidade de construir um modelo de estoque considerando o transporte como custo variável, diferentemente da maior parte dos modelos disponíveis na literatura. O objetivo deste artigo foi desenvolver um modelo de alocação de estoque para cadeia de SIMcards em uma empresa brasileira do ramo de adquirência, mantendo o nível de serviço acordado com o cliente. Foram calculados os custos de estoque e de transporte para diferentes ciclos de abastecimento para todas as combinações de bases e operadoras dos SIMcards, de modo a obter a configuração de menor custo total da cadeia. Os resultados mostraram que não se pode considerar os custos de forma individual e considerando ambos os custos, transportes e estoque, tem-se oportunidade de aumento de eficiência na operação estudada.

Palavras-chave: Gerenciamento da Cadeia de Suprimentos. Mercado de adquirência. SIMcard. Modelo de estoque. Custos de transporte e estoque.

Abstract: The Supply Chain Management (SCM) has been gaining greater relevance in the sector, leading companies to improve the level of customer service and keep costs under control. However, it was identified that SCM is a less explored field in the acquirer market, so this work is an opportunity to contribute to the academic research. It was observed the opportunity to build an inventory model considering transportation as a variable cost, unlike most models found in literature. The objective of the study was to develop an inventory allocation model for the SIMcard chain in a Brazilian company in the acquiring sector, keeping the service level agreed with the customer. Inventory and transport costs were calculated for different supply cycles for all SIMcards operators and transportation hubs, to obtain the lowest total cost configuration in the supply chain. The results show that the costs cannot be considered individually and considering both costs, transport and inventory, there is an opportunity to increase efficiency in the studied operation of this work.

Keywords: Supply chain management. Acquiring market. SIMcard. Inventory model. Transportation, and inventory costs.

1 INTRODUCTION

Supply Chain Management (SCM) can be defined as the management of the flow of physical goods, information, and finances within and outside the company with the aim of adding value and achieving customer satisfaction (Mukhamedjanova, 2020; Taschner; Charifzadeh, 2023).

SCM can generate a competitive advantage by providing significant potential for financial returns for companies (Lee, 2021; Jamaludin, 2021). Furthermore, it can be stated that customer satisfaction and the quality of services and products offered are key factors for companies seeking consolidation or growth in the market (Bertaglia, 2016; Aslam, 2023).

The integration of supply chain (SC) redesign and tactical decision-making, as well as the definition of inventory levels and the connection of each point in the chain, pose some of the most challenging problems for a company, which can impact its financial performance (Rodriguez *et al.*, 2014). Thus, a strategy proposed by You and Grossmann (2008) was to define safety stock as a decision variable in the optimization model, ensuring the service level in order to reduce stockouts.

In cases where there is uncertainty about the parameters of the inventory management problem, with uncertain demand and lead times, the use of stochastic programming models is recommended, enabling the discovery of a solution that increases the probability of meeting customer requirements within the agreed-upon timeframe (Miguel *et al.*, 2018).

Therefore, inventory management has become a fundamental objective for reducing inventory costs and improving customer service to the end customer (Mohamed, 2024). It is also possible to review the existing inventory policies in companies, reducing losses while maintaining the desired service level.

The context of the problem studied in this article is within a Brazilian acquiring company, specifically in the logistics chain responsible for the installation, exchange, and retrieval of terminals (card machines).

In the majority of terminals used by customers, transactions are conducted using GPRS (2G or 3G) signals, requiring the insertion of a Subscriber Identity Module Card (SIM card). This is the product that was the subject of study in this research. Taking into account the particularities and complexity of the described operation, it is necessary for the existing inventory policy to ensure the availability of SIM cards at the base for customer service to prevent delays, while avoiding excessive inventory throughout the logistics chain.

Given the presented context, the research question that motivated the development of this article was: would it be possible to have a mathematical programming model that allows obtaining optimal quantities of SIM card inventory, while meeting the agreed-upon customer service levels?

Thus, the overall objective of this article was to develop an inventory allocation model for the SIM card supply chain, while maintaining the agreed-upon customer service level in a Brazilian acquiring company.

Moving on to discuss the justifications for conducting this research, the flexibility of Supply Chain is widely recognized as an approach to managing uncertainties, which can arise from various sources such as demand and supply disruption and variations in lead time (Esmaeilikia *et al.*, 2016; Piprani, 2022). Therefore, it is necessary to identify risks, assess priorities, monitor demand uncertainties and seasonality, and ultimately control inventory management (Govindan *et al.*, 2015; Tadayonrad; Ndiaye, 2023).

The volatility of demand is a challenge in designing a logistics chain, but it is essential that decisions be made considering this uncertainty (Govindan *et al.*, 2017). One potential solution in this case is the inclusion of safety stock throughout the SC, so that even with volatile demand, it is possible to reliably ensure the level of service to the end customer (Rodriguez *et al.*, 2014).

To assess the interest of the scientific community, identify practical applications, and evaluate the contemporaneity of this work, a bibliometric analysis was conducted. Through this analysis, the research opportunities that this article aimed to explore were characterized.

The main sources for article research were the Scopus (https://www.scopus.com) and Web of Science (https://www.webofscience.com). The search considered the combination of keywords such as "Supply Chain Management", "Inventory model", "Cost Reduction", "Acquiring market", and "SIM card", based on Article title, abstract, keywords to Scopus and on Topic to Web of Science. In addition, it was considering only articles, reviews and conference papers, until August 30, 2023.

Table 1 – Number of publications in Scopus and Web of Science

Keywords	Scopus	Web of Science
"Supply Chain Management"	45,487	26,024
"Supply Chain Management" AND "Inventory model"	467	370
"Supply Chain Management" AND "Inventory model" AND "Cost Reduction"	26	39
"Supply Chain Management" AND "Inventory model" AND "Cost Reduction" AND "Acquiring market" OR "SIM card"	0	0

Source: Scopus and Web of Science.

Table 1 shows the combination of keywords with the information about the number of documents found in the two article sources, Scopus and Web of Science.

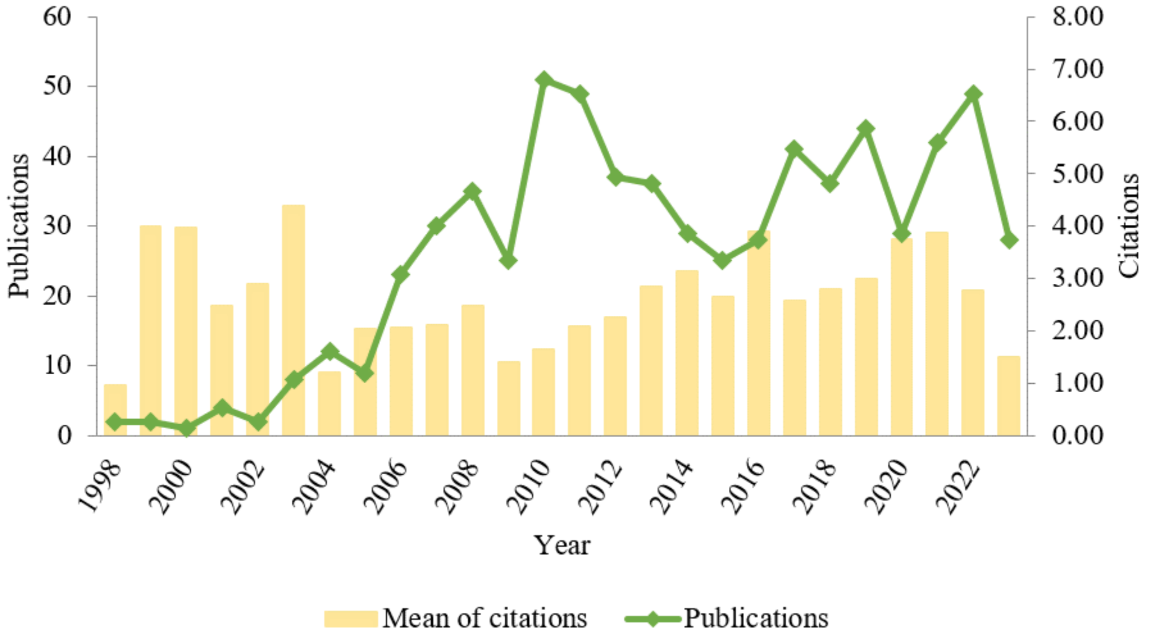
The number of publications considering the keyword "Supply Chain Management" is considerable (Table 1). In addition, through the combination of keywords "Supply Chain Management" AND "Inventory model" the number of articles was 467 documents in Scopus and 370 documents in Web of Science. From these articles, some duplicate documents were found in the two sources. After debugging, a final set of 677 documents was obtained and it was used in the bibliometric analysis.

Publications were distributed from 1998 to 2023 among 311 sources, and with average citations per document of 23.86. Also, it was obtained about three co-authors per document with an international co-authorships index of 15.66%.

In this way, the number of publications over time is illustrated in the Figure 1, where 2010 was the year with the highest number of publications (51), followed by 2011 and 2022 with 49 publications respectively. It is also important to note that 51.85% of the documents were published in the last decade, with an average number of citations per year ranging from 1 to 4 citations, approximately.

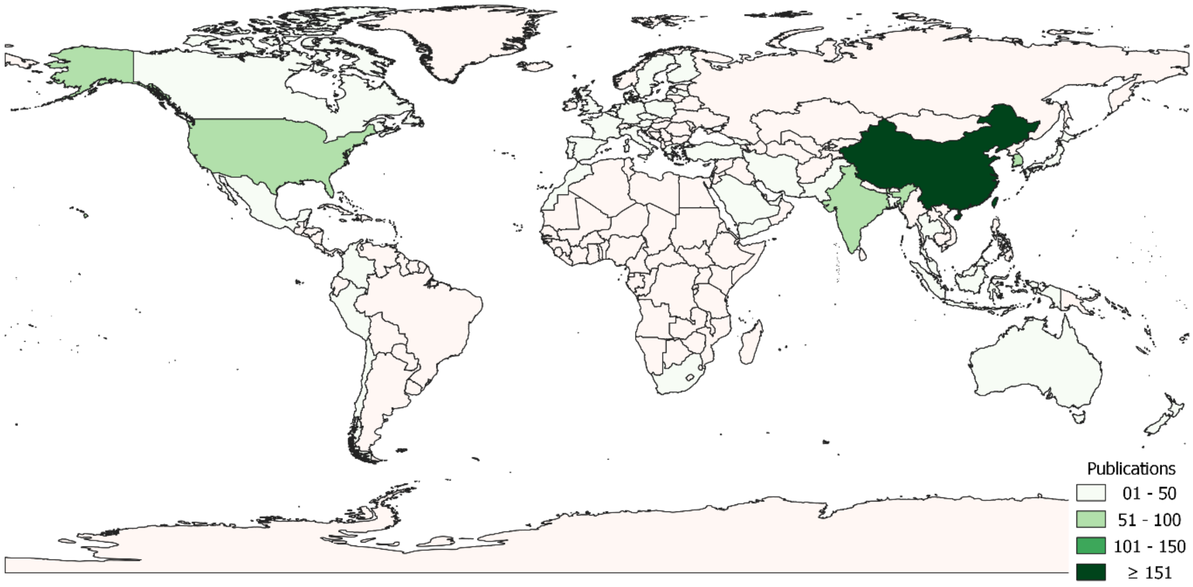
In addition, Figure 2 shows that the documents were published by 46 countries, identifying that China (203) was the country with the highest number of publications, followed by India and the United States with 79 and 67 documents respectively. Moreover, it was found that Brazil did not have any publications during this period.

Figure 1 – Number of publications over time, by combination of keywords "Supply Chain Management" AND "Inventory model"



Source: Scopus and Web of Science.

Figure 2 – Number of publications by country of the corresponding author



Source: Scopus and Web of Science.

Meanwhile, using the keywords "Supply Chain Management" AND "Inventory model" and adding "Cost Reduction", the number of publications found was lower, with 26 documents in Scopus and 30 in Web of Science (Table 1). Also, by adding the keywords "Acquiring market" OR "SIM card", no publications were found.

Through the conducted research, it was found that there is an unexplored field considering SCM in the acquiring market, increasing the relevance of this work by contributing to this topic. An opportunity to build an alternative inventory model was also identified, considering transportation as a variable cost, unlike most of the models found in the literature.

2 THEORETICAL BACKGROUND

According to Samvedi, Jain, and Chan (2013), risk is inherent in almost all SCM activities as they occur due to the uncertainty of what will happen in the future. These authors also state that due to the increasing pursuit of efficiency, companies are becoming more exposed to these risks.

External risks, such as environmental and social events, can lead to disruptions in the SC. While these may not be entirely controllable, it is important to create means of managing how to handle these interruptions (Silva, 2017). As an illustration of such exceptional situations, in 2020, the SCM experienced a series of impacts caused by the COVID-19 virus outbreak and a global pandemic, resulting in disruptions to the SC unlike any other cases in recent times (Ivanov, 2020).

For Golan, Jernegan, and Linkov (2020), the most common goal of SC modeling is to optimize efficiency and reduce costs. However, the trade-offs between efficiency, flexibility, and resilience may not be fully resolved. The concept of a resilient SC involves the ability to recover from negative impacts of unknown disruptions and adapt to uncertainties in future events.

On the other hand, one of the main internal risks in SCM, and perhaps the one that can have the greatest impact on the customer, is demand uncertainty (Sato; Tse; Tan, 2020). Indeed, demand variation can lead to stockouts at a certain stage of the SC, causing the customer not to receive the product within the agreed-upon timeframe. To mitigate the risk of stockout in the SC, it is necessary to build safety stock that ensures customer service (Rodriguez *et al.*, 2014). According to Schuster and Tancrez (2017), the level of safety stock depends on demand variability, lead times, and the required service level.

One of the key factors in calculating safety stock is the safety factor (α), which is directly related to the service level that the company is willing to provide to the customer. By identifying customer service revenues and SC-related expenses, it is possible to establish the service level that maximizes the company's profit contribution and the necessary inventory level. Beyond a certain point, an increase in logistics costs results in only a small increase in revenue or sales, thereby reducing the overall profit obtained (Ballou, 2011).

According to Ballou (2011), it can be observed that higher levels of logistic service offered to the customer generate higher sales revenue. However, beyond a certain point, increasing logistic service requires a significant investment, leading to higher logistics costs, yet not generating a significant increase in sales revenue. Thus, there is a certain service level that provides a balance between costs and revenue, and maximizing the company's total profit.

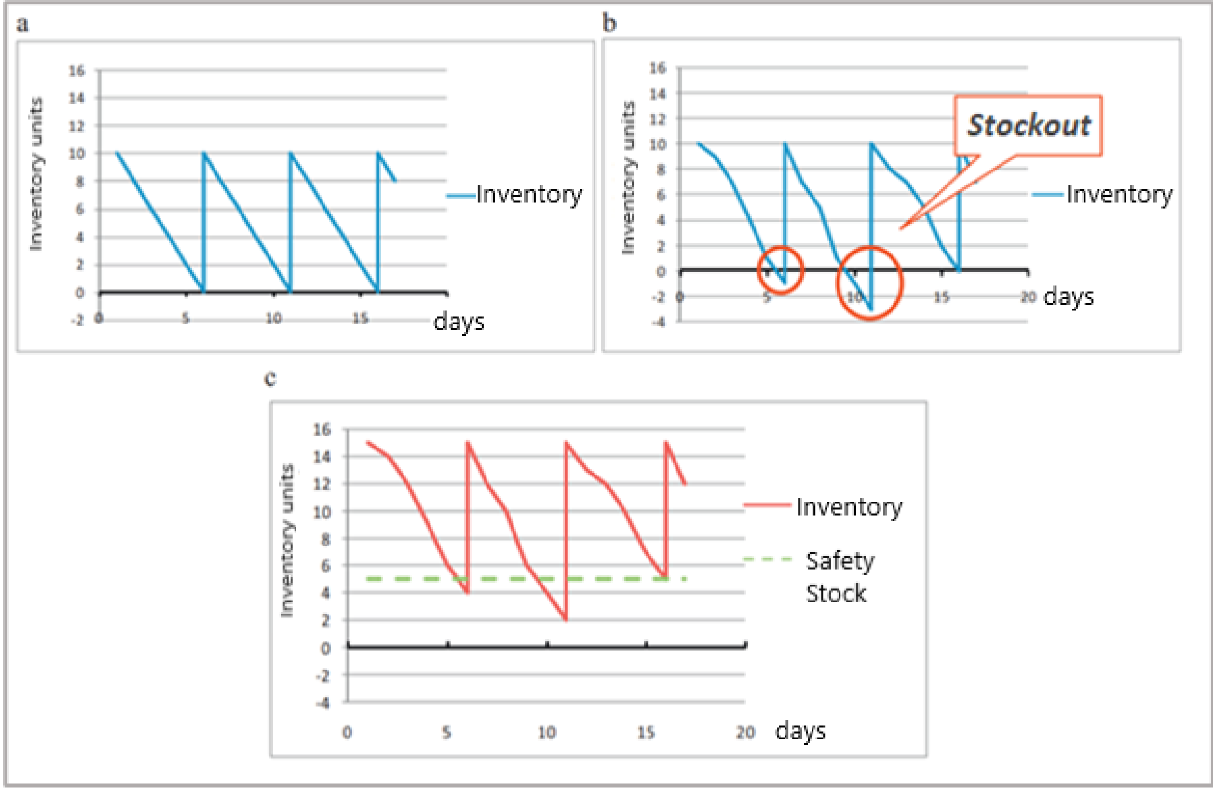
Another important factor in inventory calculation is transportation lead time, which consists of many components such as order preparation, product transit, waiting time, delivery time, among others. Therefore, reducing delivery time can lead to a reduction in the need for safety stock without impacting the service level.

Rodriguez *et al.* (2014) emphasize the need for a supply policy for inventory management. They proposed a periodic review of inventory, with the replenishment quantity defined as the difference between the current inventory level and the inventory level at the time of review.

For deterministic demand, a constant demand rate is assumed, where the same quantity is requested in each period, which is exactly the expected demand in the lead-time period. However, in scenarios where demand is uncertain, this situation does not apply. If the inventory level is not adequately calculated and the demand is higher than expected, there will be lost sales or order delays. If there is lower demand, there will be excess inventory.

In Figure 3, graphs (a) and (b) show different inventory trends over time, considering deterministic and uncertain demand, respectively. Considering safety stock for the scenario in graph (b) in Figure 3, the result is shown in graph (c) of Figure 3, where it ensures that demand will be met (Rodriguez *et al.*, 2014).

Figure 3 - Inventory evolution with (a) deterministic demand, (b) uncertain demand and (c) uncertain demand and safety stock



Source: Adapted from Rodriguez *et al.* (2014).

The implementation of safety stock, however, if not structured and executed with the correct systematics, can lead to excess inventory and unnecessary costs for the company.

For Jha and Shanker (2014), costs and delays need to be constantly reduced to achieve optimal SC performance, and an integrated decision-making approach for production, inventory, and delivery operations has shown to be effective. Thus, the fundamental challenge in SCM decision-making is to mitigate inventory costs in the supply chain while still providing high-quality customer service (Jiang; Shi, 2019).

Lee *et al.* (2012), Jha and Shanker (2014), and Sarkar *et al.* (2015) developed inventory management models considering a service level constraint, rather than calculating a cost for not meeting customer demand, while also taking into account stochastic demand with a normal distribution. This way, the models are simplified, focusing solely on inventory and transportation costs.

Shin *et al.* (2016) formulated the inventory problem by considering a service level constraint and the transportation cost as a variable parameter based on the transported volume. The authors explain that a portion of the transportation cost is fixed and not directly dependent on the quantity transported. Therefore, transportation costs can be reduced by increasing the volume of the shipment.

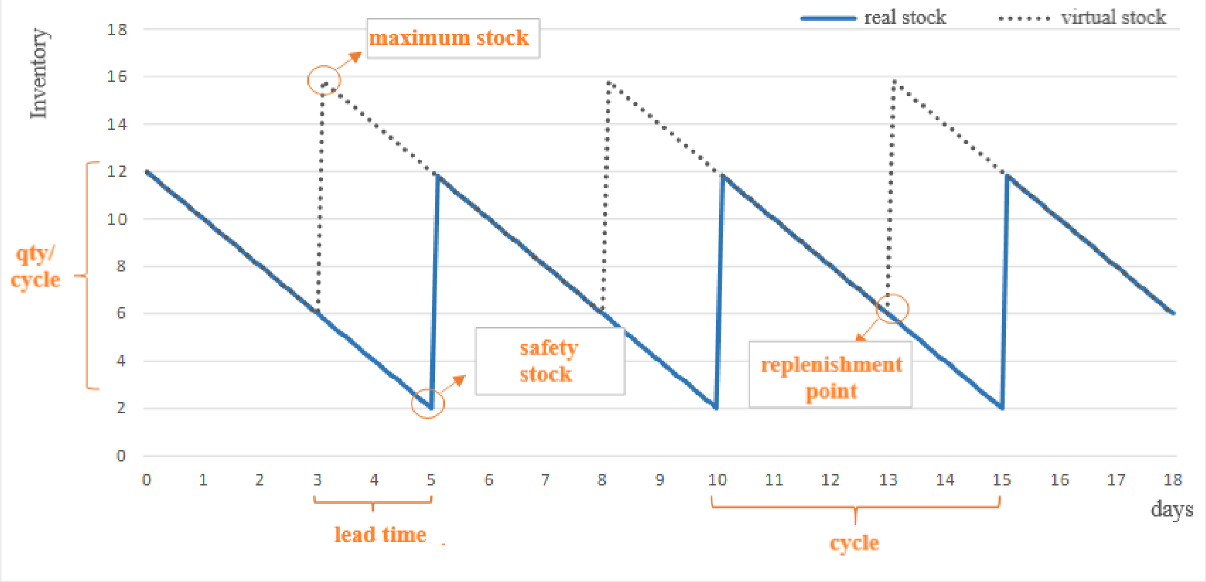
As per Jha and Shanker (2014), costs and delays need to be consistently reduced to achieve optimal SC performance. Consequently, the stock replenishment policy is a crucial component for controlling and minimizing these costs, while maintaining the agreed-upon service level with the customer (Jiang; Shi, 2019).

The continuous review model utilized by Lee *et al.* (2012), Jha and Shanker (2014), and Sarkar *et al.* (2015), which incorporates a service level constraint, is represented in Figure 4.

The peak point in Figure 4 corresponds to the moment when the virtual stock reaches its maximum level in the replenishment cycle. Therefore, it can be affirmed that the stock requirement in this chain is equal to the value of the stock at its peak point. To calculate the maximum stock point (P_max), the safety stock (S_safety), lead time stock (S_lead time), and cycle stock (S_cycle) are added, as represented in (1):

$$P_{máx} = S_{safety} + S_{leadtime} + S_{cycle} \qquad (1)$$

Figure 4 – Current inventory policy



The lead time stock (S_leadtime) refers to the stock in transit, which is calculated by multiplying the lead time k by the daily demand μ as shown in (2):

$$S_{leadtime} = k.\mu \tag{2}$$

In Figure 4, lead time inventory can be seen between the resupply point and peak periods. Finally, the cycle stock (S_cycle) is the amount of stock sent to the base at each shipment, given by (3), where μ is the average daily demand and C is the cycle, a parameter related to the frequency of supply:

$$S_{cycle} = C.\mu \tag{3}$$

3 MATERIALS AND METHODS

The research was developed based on a real problem of an acquiring company, where the study of the process was carried out, along with identification of the relevant variables of the model and data collection, thus being able to be classified as applied research with a quantitative approach.

Among the methodologies of the quantitative approach, this research can be classified as normative empirical, given the empirical nature of the data, concern with the applicability of the result in the real process and the development of a policy to improve the current situation (Miguel *et al.*, 2018).

To better understand the observed environment, identify problems and formulate strategies and facilitate decision-making, the modeling and simulation method was used (Miguel *et al.*, 2018).

Mathematical programming models were used to solve the inventory sizing problem in the SC studied. The possibility of emergencies occurring in the procedures involved was included in this modeling, such as the demand for products and transport lead times between the stages of the SC.

The steps of the article following the suggestions of Arenales *et al.* (2015), were:

- Modeling - the problem in question was studied in detail, with the aim of identifying the main variables of the process, the mathematical relationships existing between them and the objective of the research. At this stage, the result was the mathematical model that represented the studied problem.

- Collection and Analysis - this stage was dedicated to data collection, resolution of the modeled problem and construction of different possible scenarios. As already mentioned, given the uncertain nature of some important parameters, such as product demand (mix between products, variation in regional demand or total volumetry) and transport lead time between the SC links, a stochastic approach was adopted for the resolution of the constructed model.
- Conclusions - based on the results of the analysis, the best scenarios and applicability in the operation were evaluated.
- Validation - with the historical data, a backtest was performed to validate the result for later implementation in the real operation.

4 RESULTS

In the company studied, it was observed the use of a stock policy of continuous review in the supply of stock of SIM cards from the DC to the bases. In the current policy, the resupply cycle lasts five working days, however, the cycle can assume different values without reducing the level of service offered in the model, provided that all other parameters are accepted.

To illustrate this effect, two scenarios with changes in the number of cycles were simulated. Figure 5, for example, shows a scenario with the same transport lead time, daily demand and safety factor as Figure 4. However, a cycle of 3 instead of 5 days was considered.

It can be highlighted, analyzing Figure 5 in relation to Figure 4, the following points:

- With the same safety factor, the safety stock was maintained. Therefore, the level of service is the same in both cases.
- With the cycle reduction, the filling frequency increases. This becomes visually clear when a larger number of “saw teeth” is observed in the same analyzed period.
- With the reduction of the cycle, the quantity sent at each supply has been reduced from 10 to 6.

- The maximum point went from 16 to 12, thus reducing the need for stock in the SC.

Figure 5 – Inventory policy (shorter cycle)

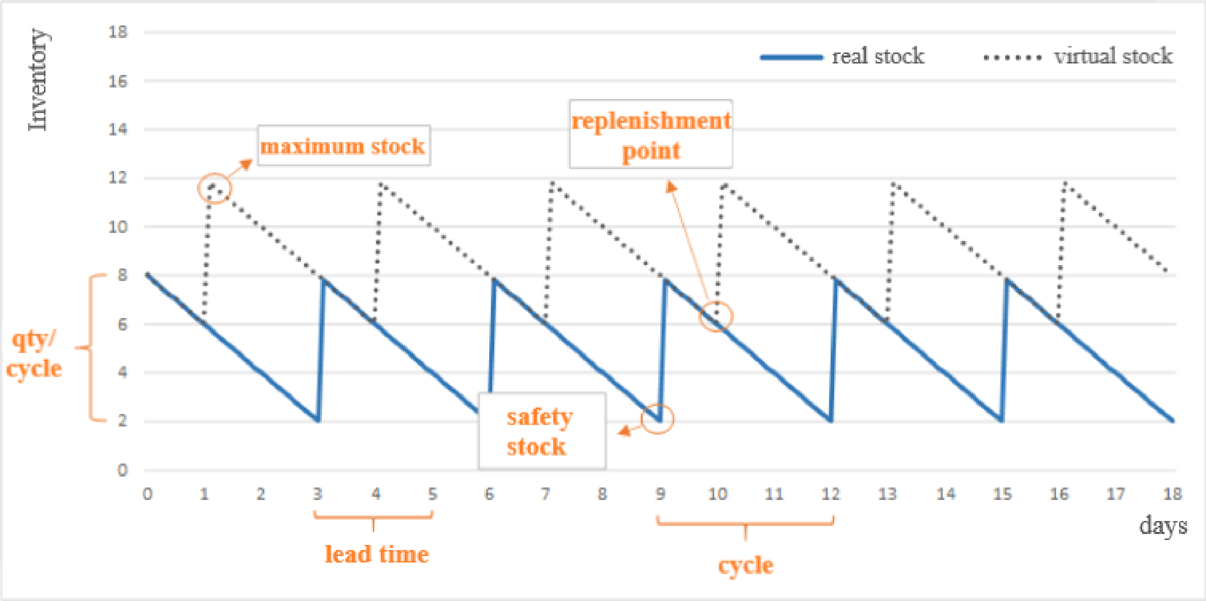
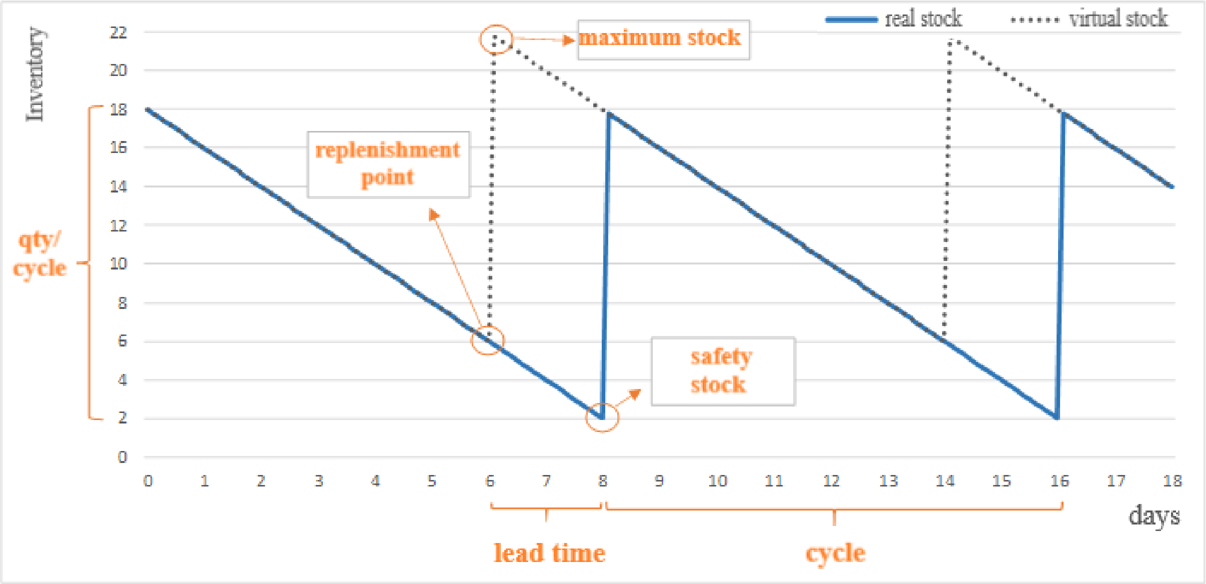


Figure 6 shows a scenario with the same transport lead times, daily demand and safety factor as in Figure 4. However, a cycle of 8 instead of 5 days was considered.

It can be highlighted, analyzing Figure 6 in relation to Figure 4, the following points:

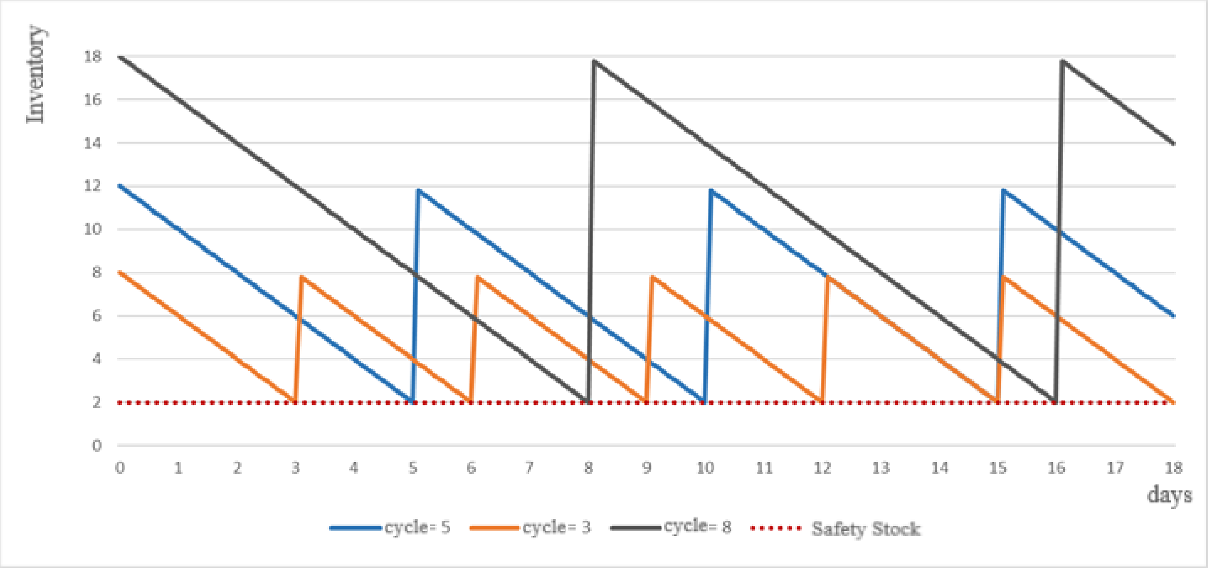
- With the same safety factor, the safety stock was maintained. Therefore, the level of service is the same in both cases.
- As the cycle increases, the supply frequency reduces. This is visually clear when a smaller number of “saw teeth” is observed in the same analyzed period.
- As the cycle increases, the amount sent at each fill increases from 10 to 16.
- The maximum point went from 16 to 22, thus increasing the need for stock in the SC.

Figure 6 – Inventory policy (longer cycle)



Finally, Figure 7 compares the actual stock of the three models represented in Figures 2, 3 and 4. It can be observed, in Figure 7, the safety stock being equal in the three cases presented, maintaining the level of customer service, while the stock needed for each of the cycles is different.

Figure 7 – Comparison of different cycles

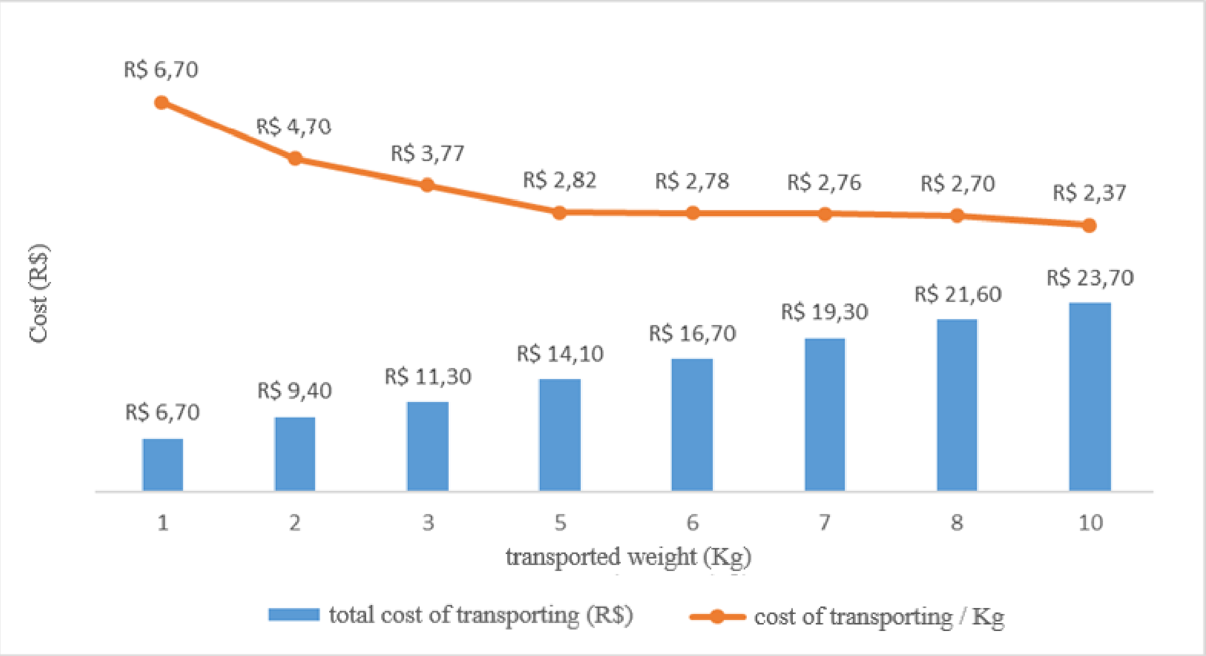


Through the data provided by the studied company, it is observed that the transport cost per weight decreases as the total weight per shipment increases. This feature is common in freight tables on the market, because with the consolidation of cargo, transport companies improve the use of trucks and routes, reducing idleness and thus carrying out transport at a lower cost, so that they can lower the price charged as the total load to be transported increases.

This correlation can be seen with the example shown in Figure 8, involving freight values ([cost/kg]) of one of the carriers used by the company experiencing a certain DC route – base.

As shown in Figure 8, the total freight cost increases as the transported weight increases. However, the freight cost per kg drops significantly between 1kg and 5kg and continues to fall, with a lesser intensity, in the range of 6kg to 10kg. In this case, the cost of transporting ten loads of 1 kg will be R$ 67.00 (10.R$ 6.70), while the cost of transporting a single load of 10 kg is R$ 23.70. That is, a 65% lower cost.

Figure 8 – Price increase versus carrier weight increase



Source: Company studied.

With the data and examples shown above, it can be concluded that the cycle used, despite not interfering with the desired service level, directly affects inventory and transport costs (Table 2), so there must be an optimal point that minimizes the sum of inventory and shipping costs.

Table 2 – Inventory Cycle and Transport Ratio

Cycle (days)	Service Level	Inventory costs	Transport costs
higher	keeps	higher	lower
lower	keeps	Lower	higher

To build the model, it was necessary to calculate the cost of inventory and transport in the supply chain for each product (SIM card per operator), origin (DC) and destination (base). For the calculation of the annual stock, the monthly cost paid to each operator per active SIM card (C_sc) and the stock necessary for the operation of the SC according to the defined parameters (P_max) were considered. Thus, one can consider the annual inventory cost according to (4):

$$C_{stock} = 128C_{sc}.P_{máx} \tag{4}$$

For each supply cycle, the volume corresponding to the cycle stock (S_ciclo), as described in (4), is sent to the base. The value corresponding to this supply can be found in the freight table of the contracted carriers, represented in the example in Table 3, where the quantity refers to the transported volume (S_cycle).

To calculate the total transport cost for the year, multiply the freight cost of each supply (C_freight) by the number of trips per year, as shown in (5), considering the du_year the total number of business days per year:

$$C_{transport} = C_{\text{freight}}.\left(du_{year}.\mu \;/\; E_{cycle}\right) \tag{5}$$

In Table 3 there is an example of a freight table considering CD SP as origin and base “X” as destination. For each volume of carrier SIM card there is a corresponding freight cost (C_ freight).

Table 3 – Example of a freight table considering CD SP as origin and base “X” as destination (Fictitious data)

Quantity	**Freight cost ($C_{freight}$)**
10-20	R$ 15.00
30-40	R$ 18.00
40-50	R$ 18.00
60-70	R$ 20.25
80-90	R$ 24.30
90-100	R$ 26.26
100-120	R$ 28.22
120-140	R$ 32.20
140-160	R$ 36.33
160-180	R$ 40.61
180-200	R$ 45.03
200-220	R$ 47.29

Finally, the proposed model can identify which cycle minimizes the total cost, considering each product (SIM card per operator), origin (DC) and destination (base), given that, the total cost is the sum of transport costs and cost of stock, as shown in (6):

$$C_{total} = C_{transport} + C_{stock} \tag{6}$$

Inventory and cost calculations were performed for the 420 combinations of bases and carriers in order to obtain the cycles with the lowest total cost. The treatments for each base versus operator combination were carried out in the same way as previously presented.

For reasons of confidentiality of the company's information studied, the data used were not shown explicitly and the results of the analysis were presented in a relative way (percentage variations) and graphically.

To better explore the results and analyses, the 105 databases were separated into clusters according to demand. This division was based on the format used in the company studied and is defined in Table 4.

Table 4 – Clusters of bases

Monthly Demand	Base Cluster
< 250	P
250 a 2,000	M
> 2,000	G

Source: Company studied.

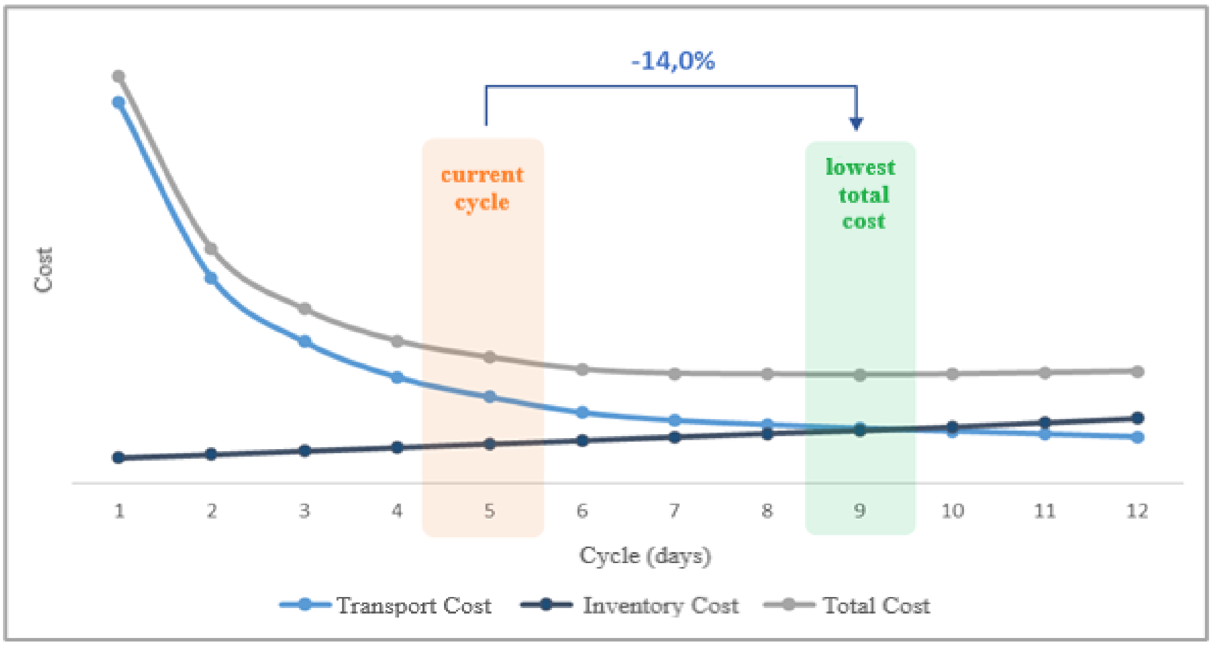
To exemplify the results of the 420 bases versus operator combinations and compare them to each other, a combination of each cluster was selected. The data of the selected options are in Table 5.

Table 5 – Data of the selected combinations

Cluster da Base	Operator	Daily demand (μ)	Standard deviation (σ)	CD	Lead Time (k)	Lead Time Standard deviation (σk)	Availability (α)
P	B	8.4	6.2	PR	3.0	0.4	99%
M	B	54.9	25.2	SP	3.0	0,3	99%
G	A	199.5	75.4	SP	1.0	0,1	99%

Source: Company studied.

Figure 9 – Cost analysis of a P base

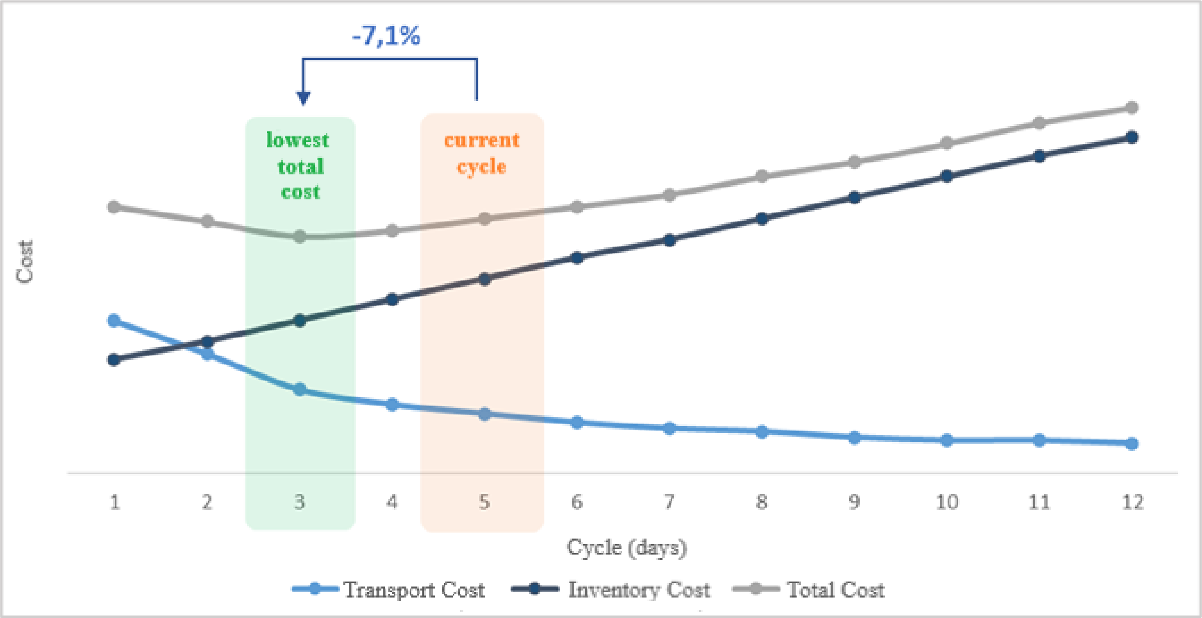


Source: Company studied.

The first analysis made refers to the chosen combination of cluster P, represented in Figure 9. As it is a base with low daily demand, it should be noted that the cost of transportation is a significant part of the total cost. In this way, the total cost is higher in smaller cycles, where the transport cost is higher.

The cycle with the lowest total cost is 9 days, which represents a reduction of 14.0% compared to the current cycle of 5 days. It can also be observed that the costs referring to cycles of 7 to 12 days are close, with no great cost variation between them. In Figure 10, the costs of the chosen combination of cluster M are represented. In this case, the transport cost has a lower total cost compared to the base P. In this way, the cost of inventory has a greater impact and the cycle of the least total cost is 3 days, resulting in a 7.1% reduction compared to the 5-day cycle.

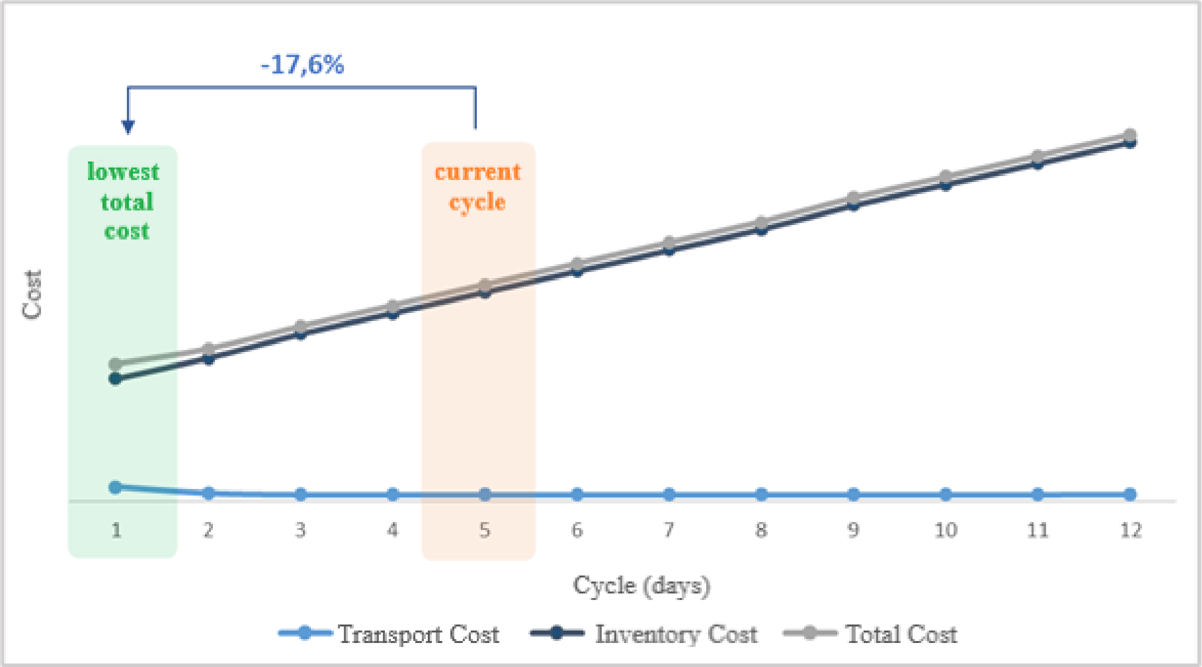
Figure 10 – Cost analysis of an M base



Source: Company studied.

Finally, in Figure 11, the costs of the chosen combination of cluster G are represented. In this case, with higher daily demand, the cost of inventory is even more representative than in base M, and, as shown in Figure 11, the total cost curve is virtually the same as the cost of inventory curve. Thus, the cycle with the lowest total cost coincides with the cycle with the lowest inventory cost (1 day), causing a reduction of 17.6% in relation to the 5-day cycle. It is the largest reduction among the combined bases represented in Figures 9, 10 and 11.

Figure 11 – Cost analysis of a G base



Source: Company studied.

Based on these analyses, it can be seen that the greatest cost reduction is in base G, which occurs from a reduction in the supply cycle. As on these bases the cost of transport is not very representative, the cost of inventory is what directs the choice. Therefore, the shorter the cycle, the less inventory is needed in the chain. Table 6 consolidates the results of the analysis of the cycles with the lowest total cost of the 420 bases versus carrier combinations.

Table 6 – Ideal cycle per combination

Ideal cycle	Bases P	Bases M	Bases G
1	3	9	28
2	1	38	20
3	6	36	11
4	12	26	4
5	12	31	1
6	17	28	2
7	21	13	1
8	14	9	0
9	23	6	1
10	6	5	0

11	3	3	0
12	3	0	0
13	5	2	0
14	2	1	0
15	7	1	0
16	5	4	0

Source: Company studied.

From Table 6 it can be highlighted:

- On P bases, the lowest cost cycles are concentrated between 4 and 9 days. Of the 140 combinations referring to the P bases, in 76% of the cases the ideal cycle was longer than the current cycle of 5 days. As shown in Figure 9, with the transport cost symbol in the total cost, there is a gain when the cycle is increased.
- On M bases, the lowest cost cycles are concentrated between 2 and 7 days. Therefore, there is no pattern of increase or reduction from the current cycle to the ideal cycle, so they need to be analyzed on a case-by-case basis. It can also be highlighted that only 4% of the 212 combinations had the ideal cycle equal to 1 day (daily supply). This occurs due to the high cost of transportation for small volumes, as shown in Figure 10.
- In the G bases, the ideal cycles are concentrated between 1 and 3 days, and of the 68 combinations, 93% had the ideal cycle shorter than the current cycle of 5 days. With the higher daily demand, gains have been made with the reduction of the cycle and, consequently, with the reduction of the total stock. It can also be observed that, as there are bases with a very high demand in this cluster, there were 28 combinations that had the ideal cycle of 1 day (daily supply).

Table 7 shows the results of the cost analysis, including variations in transport costs, inventory and total ideal cycles in relation to the current cycle of the 420 combinations base versus operator divided into the three clusters P, M and G. Still in Table 7 it is possible to observe the representativeness of the reduction of each cluster in relation to the total cost reduction.

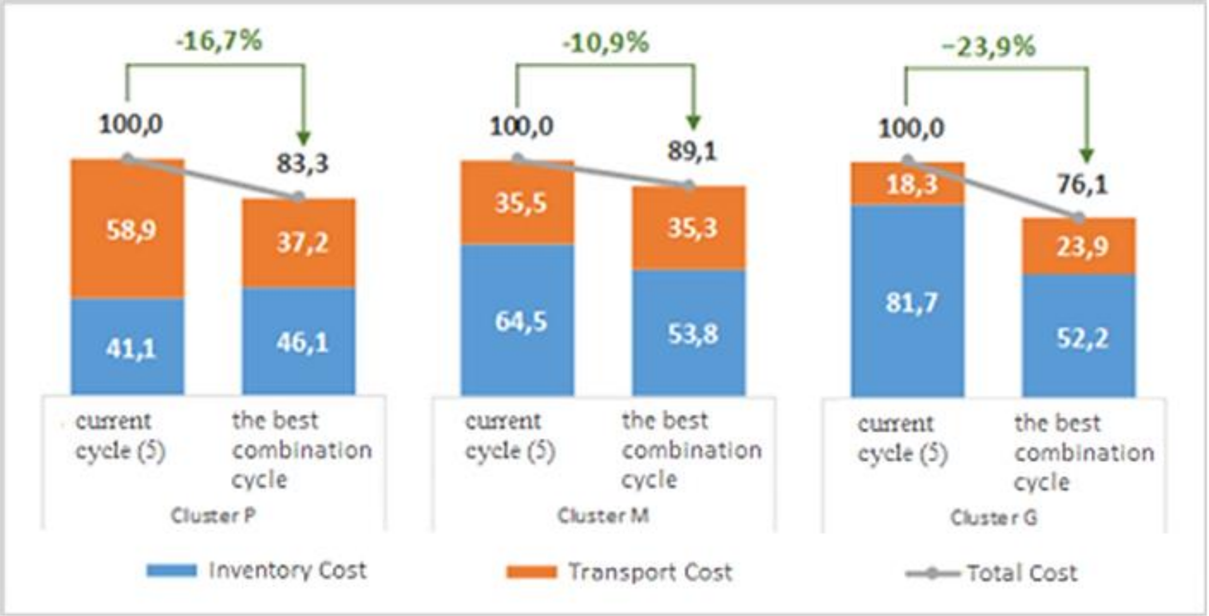
Table 7 – Cost variation of the ideal cycle versus current cycle of the combined 420

Cluster	Transport Cost	Inventory Cost	Total Cost	Share
P	-36.8%	12.2%	-16.7%	14.6%
M	-0.3%	-16.7%	-10.9%	25.3%
G	30.6%	-36.1%	-23.9%	60.0%
Total	-2.90%	-24.2%	-17.5%	100%

Source: Company studied.

To complement the information in Table 7, Figure 12 shows the same results graphically, identifying the relevance of the cost of transport and inventory in each case. For comparison purposes and not to expose sensitive data, the total costs of the initial scenarios (5-day cycle) were equal to 100 and the other numbers were calculated proportionally.

Figure 12 – Cost variation of the ideal cycle versus current cycle of the combined 420 Bases



Source: Company studied.

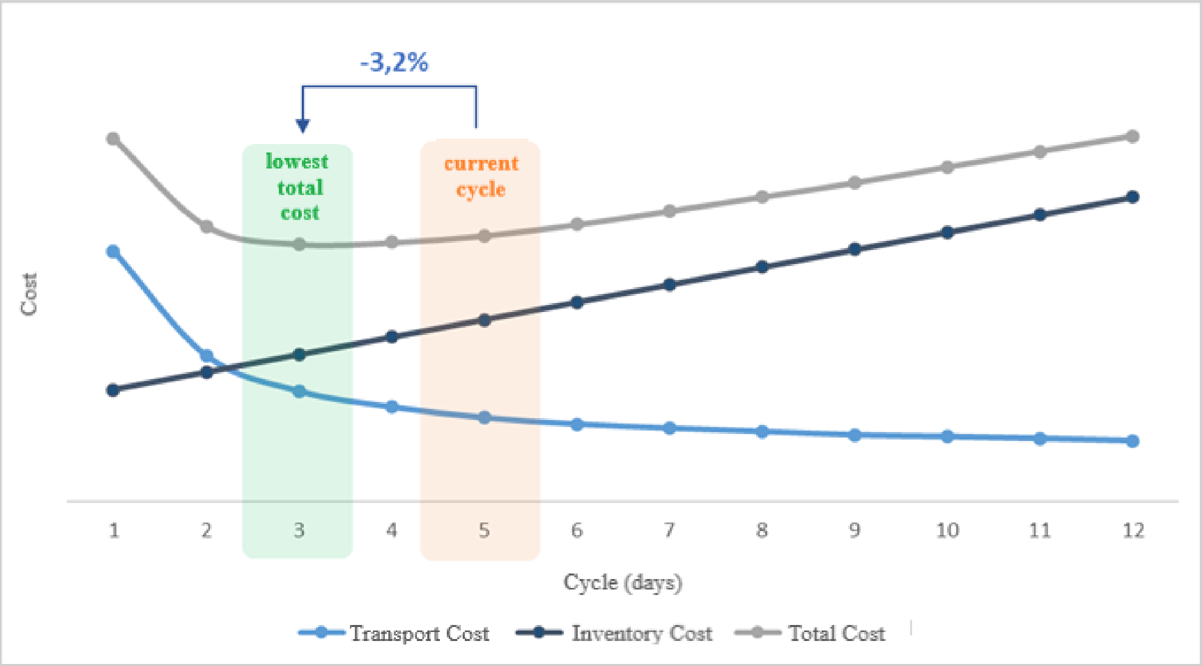
It is observed that there was a reduction in the three clusters presented. However, the variation of transport costs and inventory differ from each other. In cluster P there was an increase in cycle days in most combinations as seen in Table 7, leading to a large reduction in transport costs (-36.8%), while the cost of inventory increased (+12.2 %). The total cost reduction was 16.7%. However, as the bases of this cluster have a low demand, this variation corresponded to only 14.6% of the total reduction.

In cluster M, the reduction in the cost of inventory was 16.3% while the cost of transport practically remained the same (-0.3%). Among the three clusters analyzed, this was the one with the lowest variation, given that the calculated cycles with the lowest cost were closer to the current cycle, as seen in Table 6. The variation in this cluster represented 25.3% of the total reduction.

Finally, in cluster G there was a large reduction in the cost of inventory (-36.1%). However, with a 30.6% increase in transportation costs. Even so, the total cost reduction was 23.9%, the highest among the three analyzed clusters, representing 60.0% of the total reduction.

An analysis was also carried out considering the possibility of having only one cycle for all bases, which represents the current situation for the company studied. To represent the analysis carried out, the results are represented in the same way as in Figures 9, 10 and 11. However, in this case, the costs of the 420 combinations of bases versus operators were added together.

Figure 13 – Comparison between single cycle



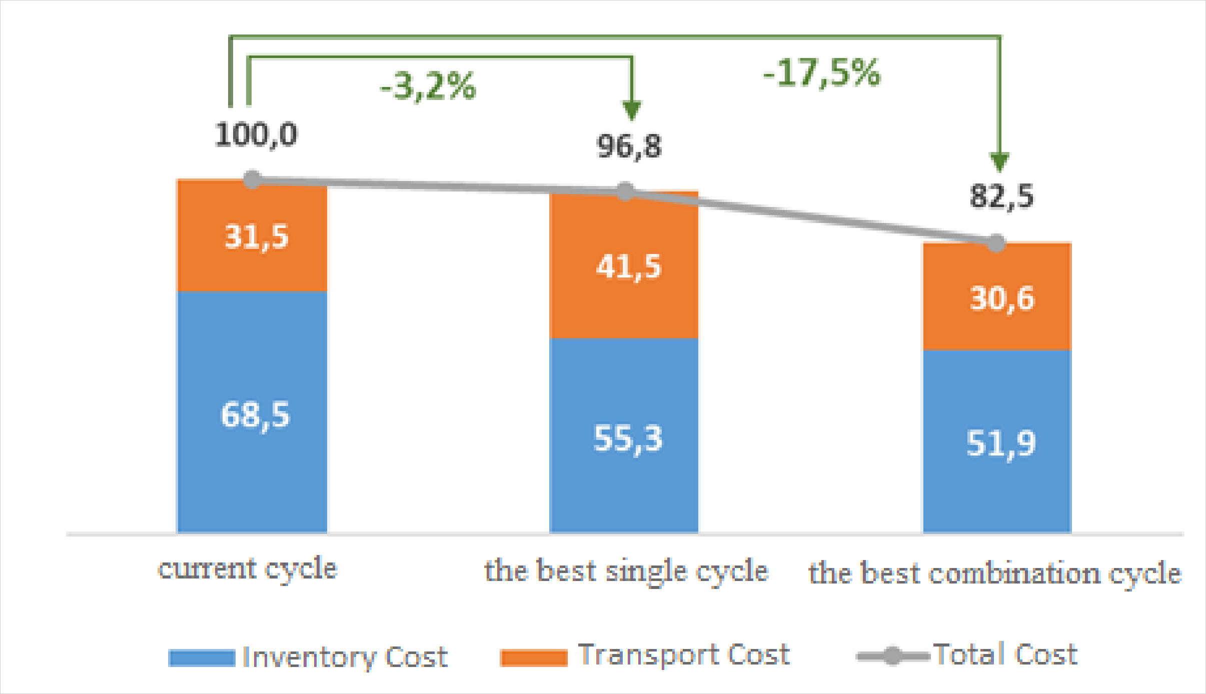
Source: Company studied.

In this result, it can be seen that the resulting cost curves in Figure 13 are combined from the customized curves in Figures 10, 11 and 12. The high transport cost causes a large increase in the total cost in the 1- and 2-day cycles, while from the 4-day cycle onwards, the reduction in freight costs does not offset the increase in inventory costs. Thus, the cost grows as the cycle increases. The minimum point on the total cost curve is in the 3-day cycle, where there is a 3.2% reduction in relation to the total cost of the 5-day cycle.

As the bases have parameters and variables that are very different from each other, such as daily demand, freight table and transport lead time, considering a single standard cycle for all bases reduces the possibility of optimizing costs on a case-by-case basis, and does not promote a great deal of efficiency gain. However, if there is a need to have a single cycle, the 3-day cycle is indicated for this case.

Figure 14 shows a comparison of transportation costs, inventory costs and total costs for the current cycle (5 days), the best single cycle (3 days) and the best combination cycle.

Figure 14 – Comparison of costs between different configurations



Source: Company studied.

5 DISCUSSION

The results indicate that costs cannot be considered individually, since a lower cost of transport or a lower cost of inventory does not necessarily correspond to the lowest total cost scenario. Considering both factors, it was identified that changing the supply cycle can lead to a significantly lower total cost than the current scenario.

By separating the bases by demand, it was found that the behavior of transport and inventory costs are very different. In bases with lower demands (P), the cost of transport is an important component and sometimes even greater than the cost of inventory. Therefore, efficiency is gained with load confirmation using cycles greater than the current one (5).

However, in bases with greater volumetry (G), transport is practically irrelevant, thus the cost of inventory is the main driver for choosing the cycle. Therefore, the shorter the cycle, the lower the total cost. Finally, the bases with protective demand (M) present a behavior that lies between the bases P and G.

Considering the ideal cycle calculation for each of the 420 combinations studied, a cost reduction of 17.5% was obtained in relation to the current cycle. The cost of transport had a slight reduction (-2.9%), while the reduction in the cost of inventory was more pronounced (-24.2%).

The greatest reductions occurred in the G bases both proportionally and in representativeness. Therefore, it can be concluded that the calculated cycles allow, in general, a significant reduction in the cost of inventory, without creating an increase in the cost of transportation.

To further explore these aspects, an analysis was performed with the possibility of having only a single cycle for all bases (as currently it is 5). In this case, the cycle with the lowest cost was 3 days, with a not very expressive reduction (-3.2%) compared to the current cycle. This is due to the particularities of each of the bases, which have different parameters as presented in the analyzes of the P, M and G bases.

Therefore, when considering a single standard cycle for all bases, the opportunity to improve costs is lost. However, if there is a need to have a single cycle for all bases, the 3-day cycle is indicated.

Finally, the supply cycle is just one of the parameters of the inventory policy. Therefore, it is a relatively simple change to carry out within an operation that can bring efficiency not only in the chain of SIM cards of the company studied, but also in other products and SC of other companies.

6 FINAL CONSIDERATIONS

In the model presented in this article, some factors were considered constant, but it is possible to change them by seeking new configurations that can bring more efficiency to the SC. Thus, by changing the safety factor (related to the probability of customer service), in addition to reducing inventory costs, the cost of transport will gain greater control for the analyses, bringing different configurations than those projected in this article and increasing efficiency for the SC.

Transport-related parameters can also be explored, such as delivery time and shipping prices. By performing sensitivity analysis on the model described here, it is possible to identify where it is possible to obtain greater cost reductions and the proportion of these parameters with partner carriers.

In summary, this article analyzed the transport and inventory costs of each combination in a comprehensive way. A next step may be to evaluate possible combined arrangements for sending DCs to the bases in order to further improve transport and reduce the total cost.

Finally, it should be noted that the formulation presented in this article is not limited to SIM cards, as the model can be used to analyze the costs of other products in the studied company.

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Os Autores

Maurício Gumiero da Silva
Graduated in Mechanical Production Engineering from São Paulo State University (UNESP) and holds a Master's degree in Production Engineering with a focus on Operational Research from the same institution. He has over 10 years of professional experience, primarily in logistics and planning. Currently, he serves as the Supply Chain and Budget Coordinator at Itaú.

Ernée Kozyreff Filho
Graduated in Aeronautical Infrastructure Engineering from the Aeronautics Institute of Technology, holds a Master's degree in Production Engineering from the same institution, a Master's degree in Mathematics from Texas Tech University – USA, and a Ph.D. in Production Engineering from Texas Tech University – USA. He specializes in mathematical optimization and is currently an Analytical Projects Engineer at Klabin SA.

Elias Carlos Aguirre Rodríguez
Graduated in Statistical Sciences from the National University of Trujillo – Peru (2019) and holds a Master's degree in Engineering in Production from São Paulo State University – UNESP (2023). He has experience in Probability and Statistics, Computer Science, and Production Engineering, with a focus on Applied Statistics, Multivariate Analysis, Demography, Data Science, Sampling Techniques, Data Analysis, Machine Learning, Operational Research, Optimization, Simulation, and Decision-Making Methods.

Fernando Augusto Silva Marins
Graduated in Mechanical Engineering from São Paulo State University – UNESP (1976), holds a Master's degree in Operational Research from the Aeronautics Institute of Technology (1981), a Ph.D. in Electrical Engineering from the University of Campinas (1987), and completed a Postdoctoral fellowship at Brunel University in London, England (1994). He is a Full Professor in the Production Department at the School of Engineering and Sciences, Guaratinguetá Campus, UNESP, and a PQ2 Researcher at CNPq. He has experience in the field of Production Engineering, with an emphasis on Operational Research and Logistics, primarily working on the following topics: Logistics and Supply Chain Management, Optimization Models in Operational Research, Decision Support and Simulation Methods.

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