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RESEARCH ARTICLE

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THE IMPACT OF PANDEMIC IN SUPPLY CHAIN MANAGEMENT IN AN ELECTRONIC INDUSTRY

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ABSTRACT

The logistics, social and economic impact caused by the SARS-CoV-2 pandemic has unprecedentedly affected the supply chain of the electronics industry. Logistics was in high demanded during this pandemic period, and it was key actor for chain balance, even faced so many challenges. The objective of this case study is to demonstrate the supply chain of an electronics industry in the industrial pole of Manaus, evaluating the scenario before and during the pandemic, its main difficulties, from the shortage of raw materials up to the high costs of international freights. The final good industry is totally dependent on component industries, the complicating factor is that in general the components are supplied by Asia, and arrive in Manaus by sea and air transport. At the height of the pandemic, ports were closed and flights were canceled, causing impacts on the supply chain. Some components are produced by local industries, however they also suffered shortages of virgin raw materials for processing, triggering consequences on the entire supply chain. The method used was a case study, and used a strategic tool such as SWOT analysis, a quality tool such as ISHIKAWA, and a risk mapping tool such as GUT Matrix and 5W2H action plan. Data were collected through interviews, observations and archival information, allowing the researcher free to walk in the direction of construct solutions, with the author's own experience, who works in the area, an important component of contextualizing the research. From the observation of the data, it was evidenced that the analyzed industry started a crisis management, and actions to mitigate and manage the impacts of the pandemic on its logistics chain and despite the challenges faced, the company's business continuity results were achieved, and bringing maturity to the integrated logistics chain management process.

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INTRODUCTION

The world trade increase has led to significant growth in GDP over the last 99 years. Logistics supply chains have become the world's leading enablers as commerce and the world is connected through integrated supply logistics chains. It's increasingly recognized that it is through logistical efficiency and effective supply chain management that the goals of cost reduction and service improvement can be achieved (CHRISTOPHER, 2007). In this new globalized scenario, the focus of logistics evolves not only towards

transport, but towards the customer. JÚNIOR and NUNES (2012), highlight that more demanding customers, emerging markets, geographic conditions and technology changes demand better levels of operations. In this way, organizations seek new alternatives and the effectiveness of operational processes as tools to remain in the market. The logistics oriented to customers aims to ensure the right product, in the right quantity, at the right time and place, in order to maximize the efficiency and effectiveness of the operations system (SOBRAL and PECCI, 2008). In this sense, any interruptions in the logistics chain, such as: Crises with tsunamis, earthquakes, military wars between nations, terrorist attacks as 9/11, epidemics or

pandemics as SARS-COV-2 affected business around the world with the shortage of raw material and leads to disruptions in integrated supply chains and consequently to economic recessions. This economic crisis has resulted in substantial erosion of market capitalization worldwide. The impact of SARS-CoV-2 is very significant not only on people's health but also on the world economy. All companies, including the electronics industry that was the subject of this research, are trying their best to keep people safety and mitigate the impacts of the economic crisis caused. Logistics are the protagonist in the recovery process and for stabilization to the new normal. Trade is an integral part of economic activity and development. In an economic system, countries exchange various products, whether intermediate goods, inputs or services. International trade creates a network of economic activity that are generally called trade networks or integrated supply chains. Supply chains are the main enablers of world trade and the world is connected through them. The world economy is strongly connected and influenced by supply chains and their developments. The most efficient and competitive companies are those that are having the best supply chains. Global competition is forcing organizations to develop appropriate strategies to reduce costs, optimize processes and improve customer service. Companies have realized that substantial cost savings and market benefits can be achieved through more effective management of their global supply chain. Advances in corporate information and communication systems are being widely disseminated with innovation processes and industry 4.0, which opens up the processing capacity and access to data analysis, market information, competitors, and especially customer behavior. One of the main objectives of the supply chain is to link markets, distribution system, manufacturing processes and partners to serve your customers in different parts of the world with lower cost and higher service levels. Various developments in technologies, trade policies have led to strong economic growth in the world. Supply chains have facilitated the globalization of commerce for quite some time now, and several disruptions have challenged this globalization such as SARS-COV-2 started in late 2019.

MATERIALS AND METHODS

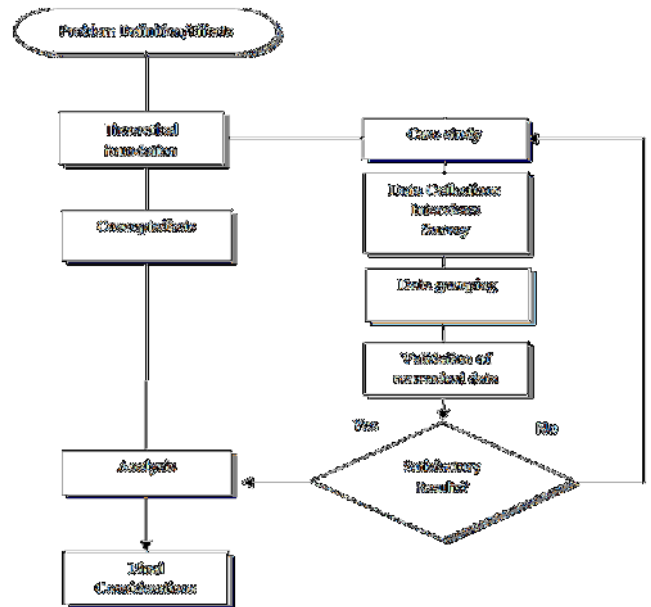
Key Tools for mitigation: This part describes the means used to achieve the general objective of this research, which was to analyze the impact caused by the pandemic on the integrated logistics of supplies in the electronics industry, demonstrating from the shortage of raw material from local and international suppliers, as well as the unavailability of global transportation, and how the electronics industry took actions to mitigate the effects on its supply chain, trough of management and quality toos used. The research method used was the case study, which allowed an in-depth analysis of the object of study, in this case, the effect on the electronics industry, being concerned with questions such as "how" and "why" of the problem studied (ACEVEDO and NOHARA, 2007). Were used some strategic management tools such as SWOT analysis, and quality analysis such as ISHIKAWA, and risk mapping tools such as GUT matrix and 5W2H action plan.

Data Collection: In this research were used: interviews, observations and archival information (documentary research). The interviews carried out were of the unstructured type, where the researcher is free to develop each situation in any direction he considers appropriate, allowing the interviewee to decide how to construct the response (LAVILLE and DIONE, 1999). We use quantitative reports and surveys on the impact of SARS-COV-2 on the logistics chain, economic development, global value chains, world trade, transport and SARS-COV-2 reporting.

This research was developed through a real case study inside an electronics company in the industrial pole of Manaus. The research took place with a problem of production lines shutdown as an effect of the impact of the SARCOV-19 pandemic on the supply chain logistics. Through the theoretical foundation of the theme, and the collection of real data, interviews with those responsible for the

actions, the data were grouped and validated so that they could explain the problem, but could also guide us on how to use management and quality tools, could mitigate the effects of the pandemic on the logistics chain, with satisfactory results for the research.

Search Flow:



Source: Author (2022).

Figure 1. Search flow

RESULTS AND DISCUSSIONS

Impact of SARS-COV-2 on corrugator paper industry: A supplier to the electronics industry: The cardboard industry was one of the most affected in the period of social isolation. Basically, the paper industry bases its cardboard on raw material collected by recycling collectors in cooperatives, and with the prohibition to leave the house. These collectors began to receive emergency aid intended by the government for people without income during the period of mandatory isolation. As a result, paper companies used their available stock and in the uptum faced one of the biggest shortages of intermediate paper ever seen in the industry. Evidently, the price up drastically in proportion to the lack of supply.

Material Type	Category	Dec/19	Dec/20	Dec/21	Gap
		BRL Price/Ton	BRL Price/Ton	BRL Price/Ton	
Corrugator Paper Box	Covering Paper	R\$ 2.700,00	R\$ 3.600,00	R\$ 5.100,00	89%
	Fluting Paper	R\$ 1.950,00	R\$ 4.430,00	R\$ 4.868,00	150%

Source: RISI (2021).

Figure 2. Paper Comparison price up

This shortage was exacerbated by record exportation from the food industry, which grew the most during social isolation, being one of the sectors that gained the most profit during the pandemic taking advantage of social isolation and food consumption. In addition to the food industry, other sectors that took advantage were chemical industries that sold septic alcohol, protective masks industry, cleaning industry and home appliances, with the vacuum cleaner being the champion in sales in the period.

Impact of SARS-COV-2 on the EPS-ISOPOR Industry: A supplier to the electronics industry: The EPS Industry has also been impacted by the raw material shortage caused by the pandemic. Several petrochemicals around the world stopped producing expanded polystyrene during social isolation and circulation retention policies.

The largest exporter to BR is the USA, which faced one of the most severe health crises of SARS-COV-2, with 78 million confirmed cases, with 950 thousand deaths. Despite the rise in prices, even with the reduction in consumption, there was no significant increase in the transit time for the purchase of expanded polystyrene from the USA.

Instruction of the Federal Customs Service of Brazil No. 1,976/20, of September 18, 2020 are the main legislation on PADIS. See below the price up in the previous and during the pandemic scenarios. There are four companies in Brazil that manufacture this type of component, however the inputs for the manufacture of integrated circuits are

Material Type	Category	Dec/19	Dec/20	Dec/21	Gap
		BRL Price/Ton	BRL Price/Ton	BRL Price/Ton	% Price/Ton
EPS Cushion	Expanded polystyrene	R\$ 3.275,35	R\$ 4.630,00	R\$ 7.622,46	133%

Source: CMAI-IHS (2021).

Figure 3. EPS Comparison price up

Material Type	Category	Dec/19	Dec/20	Dec/21	Gap
		USD Price/Unit	USD Price/Unit	USD Price/Unit	% Price/Unit
Integrated Circuit	DRAM	USD 3,08	USD 3,68	USD 4,68	52%

Source: IC Insights (2021).

Figure 4. IC Comparison price up (USD)

Material Type	Category	Dec/19	Dec/20	Dec/21	Gap
		Dólar: 1:4,1096	Dólar: 1:5,4178	Dólar: 1:5,5569	
		BRL Price/Unit	BRL Price/Unit	BRL Price/Unit	% Price/Unit
Integrated Circuit	DRAM	R\$ 12,66	R\$ 19,94	R\$ 26,01	105%

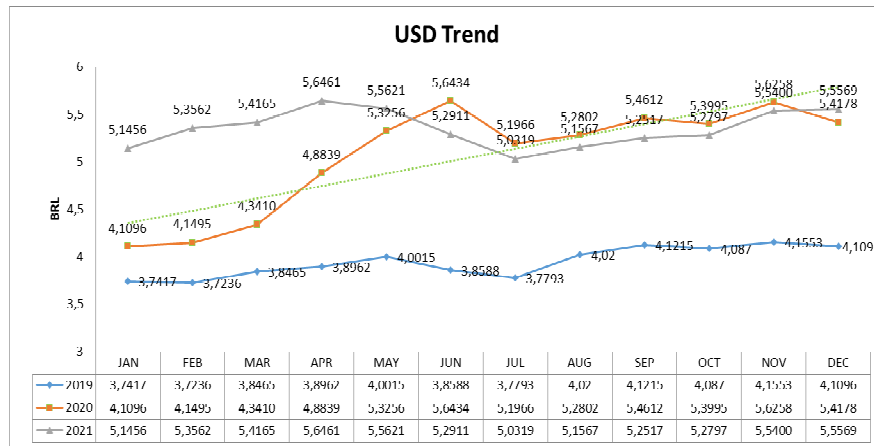
Source: IC Insights (2021).

Figure 5. IC Comparison price up (BRL)

Material Type	Category	Dec/19	Dec/20	Dec/21	Gap
		Week	Week	Week	Week
Integrated Circuit	Leadtime	6 Weeks	12 weeks	20 weeks	+ 14 weeks

Source: Author (2022).

Figure 6. Lead time increasing for IC



Source: BR Central Bank, adapted by author (2022).

Figure 7. Exchange rate trend

Impact of SARS-COV-2 on the IC Industry: A supplier to the electronics industry: The Brazilian government encouraged the semiconductor industry through the program called PADIS. The acronym is Support Program for the Technological Development of the Semiconductor and Displays Industry. It is a set of federal tax incentives instituted with the objective of contributing to the attraction and expansion of investments in the areas of semiconductors and displays. These incentives include photovoltaic cells and modules/panels for solar energy, as well as strategic inputs for the production chain, such as silicon ingot and purified silicon. PADIS provides interested companies with exemption from certain federal taxes and contributions levied on the industrial implementation, production, import and sale of the benefited equipment. However, on the other hand, companies are obliged to make minimum investments in research and development (R&D) activities. Law No. 11,484/07, Decree No. 6,233/07 and Normative

imported, and they suffered doubly the impacts of the pandemic: a) Scarcity of raw materials for manufacturing, and b) High dollar caused by the recession world economy. Although the items are manufactured in Brazil, they are not billed to the market based on the average central bank dollar. In addition to the rise in prices above, this type of component had a significant increase in acquisition time. With a globally technological world, the search for integrated circuits has become a huge challenge for different types of industries, as all products are now electronic and require integrated memories.

Impact on the variation of the dollar in BR due to pandemic: Faced with the economic recession caused by the pandemic, the real had a significant devaluation against the dollar. Of course, some imported raw materials and/or their transportation costs negotiated in US dollars also experience this increase in BRL (reais). The variation between Dec 2019 to Dec 2021 was 35%. Unfortunately, it is a

permanent effect on the economy, which will only recede as the real strengthens.

Impact of SARS-COV-2 on the Plastic Injection Industry: A supplier to the electronics industry: The impact of the pandemic on the plastics transformation business had different nuances, ranging from companies that faced mass cancellation of orders in the face of initial uncertainty, to those that began to occupy their productive capacity with the manufacture of essential items for hygiene care aimed at contain the spread of the coronavirus.

worldwide disorganization of lack of containers. In the recovery, it was not so easy to get new allocations and unfortunately, in order not to miss shipments from Asia to Brazil, many companies had to choose to pay the price of spot containers.

Actual Impact Mitigation Actions using strategic & quality tools

Crisis Committee: The organization created a crisis committee to manage the effects of the pandemic.

Material Type	Category	Dec/19	Dec/20	Dec/21	Gap
		BRL Price/Ton	BRL Price/Ton	BRL Price/Ton	% Price/Ton
Plastic Injection	HIPS	R\$ 3.366,46	R\$ 4.894,39	R\$ 7.622,46	126%

Source: HIS-CMAI (2022).

Figure 8. Plastic resin Comparison price up (BRL)

Impact on airfreight: (Leadtime and Price)

Freight Way	Category	Aug/19	Aug/20	Aug/21	Gap
		Price	Price	Price	% Price/Ton
Air (Cub)	Price	USD 4,90	USD 15,00	USD 21,00	329%
	lead time	5-7 days	20 days	25 days	+20 days

Source: Author.

Figure 9. Price Comparison of air transportation price up (SPOT)

Impact on sea freight: (Leadtime and Price)



Source: Author.

Figure 10. Scenario of 2019 for Sea transportation leadtime: (Before pandemic)



Source: Author.

Figure 11. Scenario of 2021 for Sea transportation leadtime: (During Pandemic)

Freight Way	Category	Aug/19	Aug/20	Aug/21	Gap
		Price	Price	Price	% Price/Ton
Sea (40" feet)	Price	USD 1.980,00	USD 2.200,00	USD 4.580,00	131%
	lead time	47 days	52 days	77 days	+ 30 days

Source: Author.

Figure 12. Historical trend of sea freight prices - Contract Scenario

Freight Way	Category	Aug/19	Aug/20	Aug/21	Gap
		Price	Price	Price	% Price/Ton
Sea (40" feet)	Price	USD 4.500,00	USD 10.000,00	USD 26.000,00	478%
	lead time	47 days	52 days	77 days	+ 30 days

Source: Author.

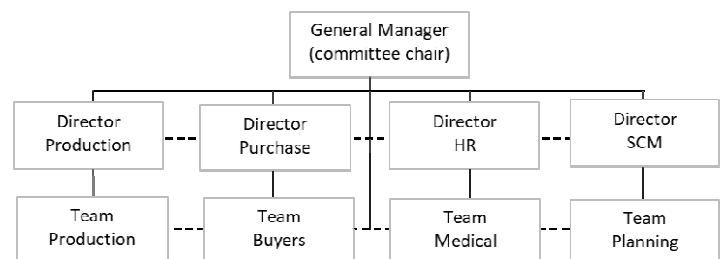
Figure 13. Historical trend of sea freight prices –SPOT Scenario

Despite the 126% increase in the cost of self-impact High Impact Polystyrene (HIPS), there were no delays in deliveries from plastic injection suppliers, as Manaus has a large manufacturer of HIPS resin, which has prepared enough stock to serve the companies in Manaus.

There are two modes of contracting ocean freight:

- a) Price per contract, based on your monthly allocation.
- b) SPOT Price – Sporadic, when you want to bring a container outside the contract.

At the height of the pandemic, many companies suspended operations and renegotiated space allocations on ships, which caused a



Source: Author.

Figure 14. Organizational chart of a Business Crisis Committee adapted to SARS-COV-2

GUT Matrix

Problem Description	Gravity (G)		Urgency (U)		Tendency (T)		Final Priority
Change the breakfast time of the administrative staff to 7:15 am, in order to rotate the teams and ensure the necessary distance.	Not Serious	1	Resolve as soon as possible	3	It will get worse in the medium t	3	7
Close list of VPN requests to define employees who will be released for home office	Not Serious	1	Can wait a while	2	It will get worse in the long ru	2	5
Check with the doctor about the need for release of pregnant women and people over 60 years old, as they are in the risk group	High Serious	5	solve with some urgency	4	It will get worse quickly	5	14
Provide backup masks on routes, to replace those who forget	Lite Serious	2	Resolve as soon as possible	3	It will get worse soon	4	9
Implement mask use for all employees and visitors	High Serious	5	Needs immediate action	5	It will get worse soon	4	14
Increase the points of Alcohol in Gel on the Plant	High Serious	5	Needs immediate action	5	It will get worse quickly	5	15

Source: Author.

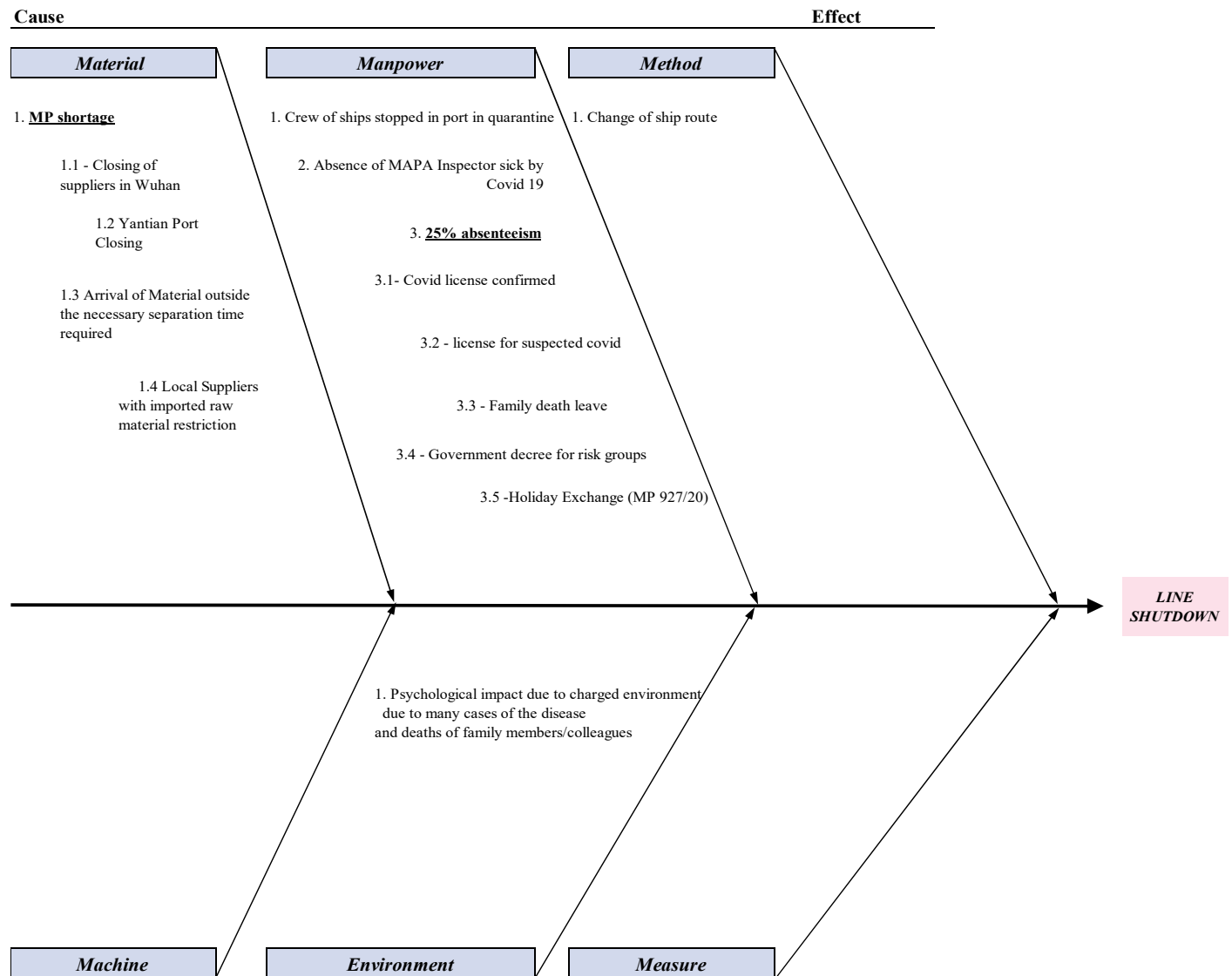
Figure 15. GUT Prioritization Matrix for plant health risks

Problem Description	Gravity (G)		Urgency (U)		Tendency (T)		Final Priority
Ship delay due to port congestion	Serious	3	solve with some urgency	4	It will get worse in the long ru	2	9
Lack of allocation of containers within the contract	Lite Serious	2	Resolve as soon as possible	3	It will get worse in the long ru	2	7
Material shortage due to Wuhan city closure	High Serious	5	Needs immediate action	5	It will get worse in the medium t	3	13
Ship delay due to covid-contaminated crew in Manaus.	High Serious	5	Needs immediate action	5	It will get worse quickly	5	15
Lack of Integrated Circuit due to closure of factories in China	Serious	3	Resolve as soon as possible	3	It will get worse in the medium t	3	9
Lack of local transport to pull container from port	Not Serious	1	Can wait a while	2	It will get worse in the long ru	2	5
Limitation of flights from Asia to BR	Serious	3	Can wait a while	2	It will get worse in the medium t	3	8

Source: Author.

Figure 16. GUT Prioritization Matrix for logistics risks

Ishikawa



Source: Author.

Figure 17. Ishikawa diagram related to (causes) of line shutdown

The creation of a crisis committee for a company must involve the main directors, managers in the company's decision-making process for assertive decision making. In the SARS-COV-2 scenario, we absolutely include the company's medical team for decision-making. The organization chart above is just an example created in the study of the real case analyzed in the electronics industry. Of course, each company is free to develop the ideal format adapted to each situation. The committee is an excellent cross-functional group in the decision-making process and was very helpful in the case of this researched company.

GUT Matrix: Above, it is possible to see by the colors that the actions with the highest score should be prioritized, from highest to lowest in priority scale. Three actions in pink are very serious, and should be a priority.

5W2H

CAUSE	FACTOR	What	Why	Where	When		Who	How	How much
		what will be done?	why will it be done?	where will it be done?	when will it be done?		by who will it be done?	how will it be done?	How much will it cost?
		ACTION PLAN	EXPECTED OUTCOME	PLACE OF PERFORMANCE	Start (dd/mm/yyyy)	Duration (days)	OWNER	HOW WILL IT BE DONE?	COSTS
Material	Raw Material Shortage	Evaluate matched CKD stock coverage	Simulate production plan and line autonomy	Manaus Plant	01/05/2020	2	Director SCM	Evaluate ETD/ETAF list of CKDs that have already left the origin	RS -
		Ask suppliers for their up-to-date resin inventory	To check the impact of the injected parts (Styrofoam and Plastic)	Manaus Suppliers	01/05/2020	3	Director Purchasing	Email all suppliers, and compare total inventory with our available CKD demand	RS -
		Change the modal from sea to air from WIFI Board and Remote Control	To make the wedding of CKD Kits in transit or at home	Manaus Plant	01/05/2020	2	Director Purchasing	Check material availability and cost/freight for approval	RS 50.000,00

Source: Author.

Figure 18. 5W2H Action Plan for material cause

CAUSE	FACTOR	What	Why	Where	When		Who	How	How much
		what will be done?	why will it be done?	where will it be done?	when will it be done?		by who will it be done?	how will it be done?	How much will it cost?
		ACTION PLAN	EXPECTED OUTCOME	PLACE OF PERFORMANCE	Start (dd/mm/yyyy)	Duration (days)	OWNER	HOW WILL IT BE DONE?	COSTS
Manpower	25% absenteeism	Check hiring of temporary workers	To make up for absences by covid	Manaus Plant	01/05/2020	15	Director HR	Search the CV's bank or contact an HR agency	RS 85.000,00
		Monitoring the treatment of covid patients	Ensure they are complying with medical protocols and prescriptions	Manaus	01/05/2020	30	Medical Team	Phone number	RS 200,00
		Recess using MP 936/20	For the factory in alternating teams, to take advantage of the government incentive in salary complementation.	Manaus Plant	01/05/2020	30	HR Director/GM Directot	Evaluate which direct labor employees can go on recess and rotate teams	RS 30.000,00

Source: Author.

Figure 18. 5W2H Action Plan for the cause of manpower

SWOT

	Internal environment		External environment
strength	1. Health Team with 7 experienced people	opportunities	1. Increase in sales due to isolation (people at home)
	2. Global Logistics Team in Asia		2. Emergency government assistance
	3. Company with solid capital to face crises		3. Solid contract with shipowners in the resumption
	4. Production of Verticalized Displays		
Weakness	1. 25% absenteeism at the peak of Covid	threats	1. Wuhan plant (Epicenter) was closed, and was a supplier to BR
	2. Low possibility of working from home office		2. Lack of Containers Globally
			3. Delays of Ships by Contaminated Crew
			4. Long transit time from Asia/Manaus

Source: Author.

Figure 19. SWOT analysis of the electronics company in the face of the pandemic

An action in beige is little serious, and should be second. Two actions in green are not serious, but they can get worse in the medium/long term period. Above, it is possible to see three actions have top priority, an action despite being very serious has second priority. Two actions are serious and worsen in the long term, and one action, even if serious, generates an impact in the long term. This prioritization process is extremely relevant in crisis and conflict situations. The research company uses task prioritization processes in a very agile and practical way, giving greater focus on more critical activities that generate greater impact on the operation. The fishbone diagram, or Ishikawa, generally has a more quality focus. However, the research company uses the tool for root cause analysis of serious day-to-day problems. In the case evaluated above, the line stop is an effect/impact of the lack of material generated by the impact of SARS VOC 2 and its logistic impacts.

We demonstrate above, a tool widely used in industries for the PDCA cycle. We evaluated an action plan of the two main causes of the Ishikawa diagram for the line stop. a) Scarcity of raw materials, and b) Lack of manpower. These causes were immediately mitigated by the actions proposed in the research object. As shown above, facing a pandemic scenario is not easy for any company. Only those that have it frequently review their strategic plan and take action to correct their weaknesses. The electronics company evaluated is a strong multinational in their internal environment, and in its industrial segment, so it went through the worst moment of the pandemic with advantages and opportunities in relation to other competitors. The segment of this company is entertainment, and therefore, in the worst scenario of social isolation, people needed to stay at home. This company saw this opportunity, and using the capital turnover of the emergency aid approved by the government and injected into the economy, this company expanded its online sales channel and boosted sales in such a difficult period, that is, and at the moment of difficulty that opportunities are found.

FINAL CONSIDERATIONS

With this research, it was possible to understand how important the logistics chain is for the economy, and especially for organizations, we identified in an overview the consequences of the pandemic in the chain. We demonstrate how business management and quality tools can mitigate the impacts of the pandemic on the supply chain. In this system view, we investigated the impacts that SARS VOC 2 caused in the supply chain of the electronics industry and its respective suppliers, such as, cardboard industry, EPS-Styrofoam industry, IC-Integrated Circuit Industry, and Plastic Injection. Both were affected by the impacts of SARS VOC 2 on the logistics chain, and consequently affect the electronics industry, presented and studied in this research due to their interconnection. In this research, we present the pre-pandemic scenario (2019) and the scenarios during the pandemic (2020/2021), including increases in costs and deadlines. We know that the pandemic is not over yet, but with the advance of vaccination in Brazil and in the world there is already hope for the end. The object of study of this work was successfully achieved, as we demonstrated through strategic and quality tools that even in the face of a crisis it is possible to direct its available resources to mitigate the impacts of a crisis such as SAR COV 2 not only in the electronics industry, but also in other industries and governments. The supply chain was the protagonist in this pandemic scenario. As studied in the research, it only takes a port like Yantian in China to stop operations for 15 days, to cause a record congestion of shipping containers and ships worldwide. Before SARS COV 2, logistics became the biggest gear for turning the world economy. The impact of SARS COV 2 on integrated logistics caused an imbalance never seen before in a globalized world, however the same integrated logistics was fundamental to the global economic recovery. Even with high prices for international sea and air freight, logistics was fundamental in sending material and equipment to mitigate even greater losses without logistical efficiency. Imagine hospitals without equipment, and completely lacking in supplies to combat the health crisis. It was identified that the pandemic also caused opportunities for some segments and changed the behavior of the work environment. Some markets, such as: hospital market, laboratories, and medical safety equipment were the markets that grew the most during the pandemic. In the state of Amazonas, military logistics were fundamental for the delivery of oxygen in January 2021 due to the lack of local supply of an industry in the pole of Manaus. The specific objectives of this research were also achieved because it is possible to assess the impacts of the SARS COV 2 pandemic on the supply chain of an electronics industry. It is also expected that this research will be useful for the formation of human and scientific knowledge, and that from it society will benefit from scientific knowledge added to supply logistics during a pandemic, and how management and quality tools can contribute to mitigate future pandemics.

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