Cuban food distribution chain: Disruptions and resilience

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Abstract:

In the current context, due to the consequences of the COVID-19 pandemic, it interrupted global supply chains by causing unprecedented shocks to supply and demand; food supply chains have been seriously affected. Food supply chains in Cuba are affected by several disruptions. Specifically, the food distribution chain of the basic food basket, which is the object of study of this paper. The objective of this research is to analyse the causes of disruptions in the supply chain. Among these disruptions, the most relevant is the uncertainty in the time of arrival of supplies for lead-time distribution and transportation disruptions. The analysis of transportation disruptions is the focus of this research. In addition, supply chains do not have a methodological procedure to manage the chain in the face of the impact of these disruptions and make it more resilient. We start with a literature review for the analysis of the concepts of disruption and resilience in the supply chain. We use the action research approach in a single case study to understand the disruptions in the food distribution chain in the basic food basket in Cuba. Then, processes are identified, KPIs are calculated and work procedures are implemented based on the analysis of previous methodologies. A procedure that analyses identifies and manages the disruptions of the distribution chain and allows the increase of resilience is the main contribution of this study. With this document, it is possible to identify disruptions in the food distribution chain and establish how to manage them to increase resilience. However, the generalization of these procedures and techniques to other companies in the country and their application requires the development of ICTs to facilitate decision-making.

1. Introduction

The basic food basket includes subsidized and free products that the Cuban population acquires to satisfy their minimum food and other needs. Mainly rice, sugar, beans, noodles, pasta, oil, milk, salt, fish, canned meat, coffee, cigarettes, tobacco and matches. In addition to serving people who, due to some medical condition, have a special diet because they suffer from diseases such as retroviruses, cystic fibrosis and xeroderma pigmentosum, children with low weight and height, among others, for hospitals, children's circles, nursing homes, maternity homes, homes for children without family support and sports centres [1, 2].

According to data presented by the Minister of Domestic Trade Betsy Díaz Velázquez: the basic food basket (a program that has a high priority and weekly follow-up from the territorial levels of government to the president of the country) today reaches more than 11 million registered consumers in Cuba and moves more than 100 000 tons of products monthly, which go to 13 000 retail establishments that sell the basket (warehouses) and passes from the ports to the wholesale warehouses and then to the retail network [3].

The Wholesale Enterprise of Food Products and other Consumer Goods of Villa Clara was created by Resolution No. 59 of November 4, 2002, today called Group of Wholesale Enterprises of Food Products and other Consumer Goods by Resolution No. 660/2011. It is in charge of the methodological management of 17 Basic Business Units that are grouped in a network of establishments present in the 13 municipalities of the province; counting with 23 conventional warehouses to fulfil its mission and annually circulating more than 369 thousand tons of food among them. Specifically, in Santa Clara there are three warehouses 402, 404 and 413. The last two, objects of study of this research. Each warehouse is responsible for receiving, storing and distributing certain types of products to certain destinations. For distribution, the company subcontracts the Santa Clara transport base, belonging to the Villa Clara Provincial Transportation Company (EMPA), which is in charge of transporting and distributing the products to the different stores.

Based on the cargo transport reorganization policy that began at the end of 2005 with the Operation Port-Transport-Internal Economy (OPTEI), with the support of other agencies and under the direction of MINFAR, a set of measures were adopted that transformed and strengthened the transport activity in the country; on September 29, 2008, indications were issued for the generalization of the transport reorganization in the provinces. From that moment on, the sub-directorate of loads and subordinate bases were created in each municipality of the province. The activities to be developed by the administrators of the transport bases are diverse, among them, and linked to the objectives of the research, the feedback through the OPTEI management post of the fulfilment of the transports planned for the day, especially regarding the transfer and distribution of the basic food basket. Hence, the importance of collaboration and communication among EMPA supply chain management stakeholders to avoid cargo spoilage, increased transportation costs, order delays, and order non-compliance [4].

Undoubtedly, the management of this supply chain represents a complex issue to analyse due to the large number of actors involved and the breadth of activities involved; where the distribution and transportation of products has become a high priority issue for the country in recent years. However, in the context of the new normal caused by the COVID-19 pandemic, the economy has suffered serious consequences as a result of the closure of productive activities due to the additional processes generated to contain the spread of the virus [5]. The temporary closure of factories as a result of the confinement measures, restriction of mobility to free movement and social distancing, had an impact on the labour force, as well as on freight and goods transportation services, which have been forced to reduce supply. All those companies that claimed to have a world-class distribution channel and logistics have found themselves faced with a problem that has put all their systems to the test, evidencing how transportation and distribution logistics has gained much more strength and has become a differentiating element among companies trying to increase their resilience to satisfy their customers to the maximum.

At present, the warehouses under study have been presenting problems fundamentally linked to transportation issues, an activity that depends on the vehicles sent by the Santa Clara transport base, among them: excess of operability in the transportations, which results in not achieving a stable planning, trucks used without the maximum of their capacities, extensive routes due to the little use of engineering tools in the decision making related to them, irregularity in the assignment of the loads to the vehicles, which causes deficiency in their delivery, lack of communication among the actors of the chain due to the lack of organization and control existing in the entity, noncompliance of orders in time with the client and increase of the transportation costs. All of this, together with the economic effects of the COVID-19 pandemic and an intensified economic blockade, the supply in Cuban warehouses of some of the supplies included in the regulated family food basket suffers delays due to the non-arrival on time of imported products and inputs, disruptions s in production flows and inefficiencies in the product distribution processes.

This situation, added to the current shortage conditions of several products in the country, has led many of them to be regulated for sale to the population, which is undoubtedly a particularly sensitive issue. Even in recent months, the distribution and delivery to the population of coffee and cigarettes, products of very high demand, has been strongly affected by the elements previously mentioned [6]. There are two main disruptions that encompass these problems, depending on the link in the supply chain: products not being in the warehouse in time for distribution (supply disruption) and transportation problems due to lack of collaboration between the actors in the chain (transportation disruptions) [7]. For this reason, the objective of the study is to establish a working methodology to manage transportation disruptions and improve resilience in the distribution chain. This document is structured in four sections. The next section describes the procedure and the tools to be used. The third section proposes the analysis of the tools used with the support of monitoring and control indicators. Finally, conclusions, limitations and future research are proposed.

2. Proposed methodology

The document is divided into four main stages, as shown in Figure 1:

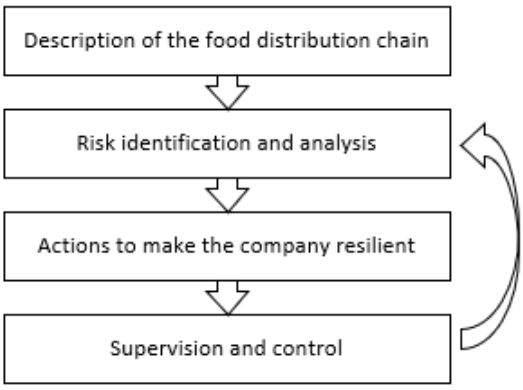

Figure 1: Proposed Methodology

The selected process is described, taking into account the General Guide for the Characterization of Potential Supply Chains [8]. The main transportation policies applied in the country are summarized and a SWOT matrix is established for each of the actors involved in the transportation of products [9, 10]. The second step is to determine the risks and/or disruptions in the chain with the support of risk estimation tools [11-14].

Next, a set of measures is proposed to increase the chain's resilience to transport disruptions [15]. Mainly the redesign of all distribution routes in the 12 zones into which Santa Clara's warehouses are divided. Finally, the monitoring and control of the means of transport used with the proposed integration indicators is proposed [16]. Here there is a feedback with the identification and analysis of risks.

3. Results and Discussion

3.1. Description of the food distribution chain

In order to diagnose the supply chain under study, the products for the end customer were first identified. Warehouse 404 is responsible for the distribution of rice, grains, sugar, salt, oils and fats. Warehouse 413 distributes canned food, pasta, coffee, cigarettes, tobacco, matches and noodles. In the correct functioning of the chain, it can be seen that there is a strong commitment by the government that every first day of the month the products of the regulated family basket must be in the warehouses and that each link in this chain complies with its plan. However, there is no integrated planning between the management of the entities involved and all planning is done in individual cases. This is due to the fact that the supply chain does not have a coordinating entity because each member has different interests and responds to different organizations. Work should be done on training, on the link between scientific organizations, managers and specialists of the member entities and, above all, emphasis should be placed on the use of engineering tools for decision making as to what and how to transport.

For the analysis of the chain's problems, each of the problems that hinder the fulfilment of the chain's main objective and their causes, which were identified through a brainstorming session with the experts, are evaluated, considering the causes that lead-time non-compliance.

Tables 1 show the current problems of each link as well as the strategy to be applied.

Table 1: Strategies for each chain link

	Current problems	**Strategies**
Supplier	Delivery of poor-quality products. Delays at the port. Delays in lead- times.	Expand new suppliers.
EMPA	No use of the capacity of the vehicles in the loading process. Little informatization of the processes.	Implement procedures that contribute to improve transportation management. Plan activities that contribute to the informatization of processes.
Transport base	Delays in lead time due to the capacity of the trucks and the non-existence of the optimum pre-established route. Impunctuality of the drivers on arrival at the warehouses for the dispatch of merchandise.	Improve transportation management. Obtain new distribution routes. Implement corrective measures for workers.
Client (stores)	Storage capacity and conditions.	Conduct a study of the conditions for the storage of products in the stores

In the last years, the transport policy has changed, especially since the COVID-19 pandemic. The movement of basic commodities has been

Table 2: Transportation disruptions

Failure mode	Effect	Causes	RL
Storing incorrect information	Insufficient control of efficiency indicators.	Information and control system.	H
Technical equipment failures	Accidents and impossibility to use the equipment.	Lack of maintenance.	H
Lack of transport planning	Incorrect use of resources.	Little innovation and lack of knowledge and tools.	H
Truck replacement	Compatibility of loads. Use of static and dynamic capacity.	Breaking and maintenance	H
Raw material to transport	Transportation is not provided.	Supply disruptions	S
Closed roads	Creation of new distribution routes or transportation traffic backlogs	Flood, events and repairs	S
Roads poorly paved	Wear and tear of the vehicles.	Road wear and tear	S
Driver replacement	Lack of knowledge of the stores and work procedures in each zone.	Fluctuation in employment	S
Lack of equipment maintenance	Accidents and impossibility to use the equipment.	Lack of tools	S
Late arrival at goods dispatch	Delayed transportation and failure to take advantage of the job labor time.	Job Indiscipline	S
Damage to the goods.	Missing distributions.	Natural events, human negligence	S
Traffic accident	Failure to complete the objective, loss of cargo or human lives.	Negligence of the driver, technical failures of the equipment and outside	S
Traffic violations	Fines and merchandise delay.	Driver's negligence	S
Crime and merchandise theft	Delays in orders and product shortages.	Staff negligence, abuse of power, and other external	S

Legend: RL (risk level), H (high), S (Significant)

rationalized and prioritized and the documentation required for their control has been established. This documentation [17] is included in the balance sheet, which includes the following steps:

- Updating of the inventory of freight transport means and calculation of transport capacity, according to BC-1 and BC-2 models.
- Determination of the transport demand, according to Model BC-2.
- Preparation of the transport plan, according to models BC-3, BC-4 and BC-5.

At the Santa Clara transport base, the components for the elaboration of the SWOT matrix were identified through direct observation, document analysis and the exchange with managers and workers of the base. It can be seen that taking advantage of the cargo base's opportunities is fundamental to better manifest its strengths and reduce its weaknesses to a minimum. To prepare the SWOT matrix for UEB 413, we proceeded in a similar way as we did with the transport base. Thus, the ideal strategy for the warehouse is to make the most of the strengths to neutralize the threats and benefit from the opportunities.

3.2. Risk identification and analysis

Once it has been established that one of the fundamental disruptions are those related to transportation, the failure modes, causes and their effect on the institution are determined. In addition, the consequence, the probability of occurrence and the level of risk are estimated. The table 2 shows the risks that are classified as high and significant for the food distribution chain.

3.3. Actions to make the company resilient

Due to the importance of transportation and the risks involved, it was decided to determine the optimal routes from each warehouse to the warehouses. For this purpose, a map was created using Google Maps and ArcGIS to determine the distance matrix of the warehouses in each of the zones into which the municipality of Santa Clara is divided. Then with the use of the traveling agent method programming [18], the best food distribution routes for each of the 12 zones are determined.

Example of a work system proposal for the distribution of coffee and cigar products due to the high consumption of the population and the scarcity of their production due to the impact of Covid 19. The same is done considering the zones established by the warehouse for the distribution of coffee and cigars (and the rest of the products of the UEB), zone 4 Camajuaní Urban-Rural is chosen (for being one of the longest distances covered in its routes). The route is composed of 12 stores whose demand for coffee is one pack per family member and for cigars is 5 packs per nucleus.

Determining that the best sequence obtained, which minimizes the distances between nodes by visiting them only once and returning to the starting point, is: Warehouse 413 - Río Plata - La Ideal - El Acuario - La Victoria - El Arroyo - La Armonía - El Bélico - Viñales - El Camino - La Vereda - Comercial Capiro - La Bonita - Warehouse 413, with a total distance of 13.65 km.

Based on this information and the values of loading and unloading times, it is possible to determine the travel time and the vehicles needed. This information is useful for the load balancing of the warehouse and the transport base, allowing them to plan the demand and the transportation plan according to the BC-2, BC-3, BC-4 and BC-5 models.

3.4. Supervision and control

Once the analyses have been carried out, a set of indicators are proposed for the control of disruptions among the supply chain actors analyzed. The indicators shown in Table 3 (A and B) are divided into two groups. They depend on the characteristics and information requirements of the company they represent. These indicators should be evaluated on a monthly.

Table 3A: Indicators for transport base

Transport base	
Existing equipment	Units
Equipment at work	Units
Average static capacity	T
Cargo to transport	T
Number of trips to be realized	Units
Possible load	T
Fixed-term certificate of deposit (CDT)	%
Customer Acquisition Cost (CAC)	%
Rotation of vehicles	Units
Distance to be traveled	Km
Load distance	Km
fuel consumption	L
Traffic	t – Km
Average distance from 1t	Km
Consumer index	Km / L
Diesel - Traffic Index	L / t – Km
Revenues	CUP

Table 3B: Indicators for food company

The Wholesale Enterprise of Food Products and other Consumer Goods of Villa Clara	
Warehouse cost per m^2	$
Delivery cost	$
Transportation cost per truck	$
Transportation cost per unit delivered	$
Warehouse inventory	Units
Inventory rotation	Units
Orders delivered on time	Units
Orders delivered complete	Units
Percentage of merchandise wastage	%
Average number of times the same product is taken to the same store	Units
Use per trip of the static and volumetric capacities of the vehicle	Units
Time required to transport the basic basket to all store	days
Use of working time	%
Average number of trips to each store	%
Relationship between the type of cargo to be moved and the truck transporting it	Yes/ No

4. Conclusion

The policies adopted by Cuba in recent years are aimed at centralizing transportation and use of more efficient schemes and means for this activity, through the improvement of the cargo balance and the MITRANS directives. The integration of the Santa Clara transportation base with the Wholesale Food Company, as actors involved in the supply chain of the distribution of basic food basket products, is fundamental to achieve the optimization of the resources involved in the process. The application of tools such as the general guide for the characterization of potential supply chains, the SWOT matrix, risk estimation tools, the redesign of routes with the traveling agent and the creation of indicators made it possible to understand the current characteristics of the chain and enhance resilience to transportation disruptions. The results obtained are very useful for transportation planning through load balancing, efficient use of resources, transportation management at different hierarchical levels and the evaluation of performance indicators at each level, all of which contribute to increasing the level of customer service in the supply chain under study. However, the generalization of these procedures and techniques to other companies in the country and their application requires the development of ICTs to facilitate decision-making.

For future research, it is proposed to continue with the study of disruption due to supply shortages, another of the main disruptions s in the chain. In addition to the potential resilience of the institutions based on a strategy of collaborative work among the chain's actors.

5. References

[1] J. I. Guillén Martínez, "Propuestas económicas para el futuro de Cuba," Foro Cubano-Divulgación, vol. 4, no. 38, 2021.

[2] C. Mesa-Lago, "La unificación monetaria y cambiaria en Cuba: normas y efectos sociales," Foro Cubano-Divulgación, vol. 4, no. 31, 2021.

[3] Cubadebate. (2018). Servicios a la poblacion al cierre del 2018

[4] M. Schenk, K. Richter, A. Müller, and E. Glistau, "Efficient transportation intelligently organizing flows of goods," in Applied mechanics and materials, 2013, vol. 309, pp. 235-240: Trans Tech Publ.

[5] T. Notteboom, T. Pallis, and J.-P. Rodrigue, "Disruptions and resilience in global container shipping and ports: the COVID-19 pandemic versus the 2008–2009 financial crisis," Maritime Economics Logistics, vol. 23, no. 2, pp. 179-210, 2021.

[6] Granma. (2022). Explica atraso en la venta de productos de la cansta familiar normada (Redacción Digital | internet@granma.cu 7 de febrero de 2022 10:02:51 ed.).

[7] R. Aldrighetti, D. Battini, D. Ivanov, and I. Zennaro, "Costs of resilience and disruptions in supply chain network design models: a review and future research directions," International Journal of Production Economics, vol. 235, p. 108103, 2021.

[8] A. Martínez Báez, A. J. Acevedo Urquiaga, J. A. Acevedo Suárez, and T. López Joy, "Diagnóstico de la cadena de suministro de los laminados de acero en Cuba," Conference: CUBAINDUSTRIA 2016 At: La Habana, 2016.

[9] Y. Han, H. Lyu, P. Pan, G. Dai, S. Bi, and L. Wang, "Practice & SWOT Analysis of Drop-and-Pull Transportation Mode in Ningbo City," Journal of Service Science Management, vol. 15, no. 1, pp. 1-9, 2022.

[10] Glistau, E.; Schenk, M.; Coello Machado, N. I. (2015): Logistic strategies and tools. In: The publications of the XXIX. microCAD, international scientific conference: University of Miskolc, 9-10 March, 2015 - Miskolc: Universität, Paper C1_1, in sum. 8 pp.

[11] M. Cañas Osorio And A. Serna Grisales, "Gestión De Los Riesgos Operacionales En El Transporte Primario Del Aguacate Hass En El Norte Del Valle Del Cauca. ," 2020.

[12] J. C. Garay Forero, "La covid-19 como una alerta para que el régimen de regulación de los servicios públicos se enfoque en la administración del riesgo y fomente la resiliencia (COVID-19 an Alarm for Utilities Regulation Regime to Focus on Risk Management and to Incentivize Resilience)," Revista Contexto, no. 55, 2021.

[13] M. A. Coronado, M. Colorado , and J. Osorio-Gómez, "Gestión del riesgo operacional en el proceso de transporte de producto terminado en el sector azucarero. Operational risk management in the transport of finished product process in the sugar sector. ," Scientia et Technica Año XXIV, Vol. 24, No. 04, diciembre de 2019. Universidad Tecnológica de Pereira. ISSN 0122-1701 y ISSN-e: 2344-7214 2019.

[14] Glistau, E.; Illés, B.; Coello Machado, N. I. (2010): Quality management methods in logistics. In: XXIV. MicroCAD; T szekció: Magdeburg-Miskolc egyetemi együttmuködés. - Miskolc : Univ., ISBN 978-963-661-924-4, pp. 13-20.

[15] K. Katsaliaki, P. Galetsi, and S. Kumar, "Supply chain disruptions and resilience: A

major review and future research agenda," Annals of Operations Research, pp. 1-38, 2021.
[16] L. A. Mora García, "Indicadores De La Gestión Logística Kpi “Los indicadores claves del desempeño logístico”," 2007.
[17] R. 53, "Indicaciones Metodológicas para la Elaboración del Plan de la Economía Nacional. Plan 2022," República de Cuba Ministerio de Economía y Planificación 2021.
[18] J. A. Yépez, "Desarrollo de un modelo de planificación de rutas basado en el problema del agente viajero," QUITO/UIDE/2021, 2021