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Editorial

The Special Issue on the Economic Impact of COVID-19 on Companies and Consumers (2020–21) in the *Advances in Science, Technology and Engineering Systems Journal (ASTES Journal)* captures an extraordinary moment in recent economic history. The COVID-19 pandemic triggered unprecedented disruptions across global markets, reshaping the ways in which firms operate and consumers behave. This collection of scholarly contributions examines these transformations through a multidisciplinary lens, offering timely insights into the vulnerabilities, adaptations, and emerging opportunities that have defined the pandemic-era economy.

A central theme across the issue is the asymmetrical impact of the crisis on industries and market participants. While sectors such as travel, hospitality, and traditional retail experienced severe contractions, others including digital services, e-commerce, and technology-driven platforms witnessed accelerated growth. The papers in this issue explore these divergences, highlighting how firm size, digital readiness, supply chain integration, and financial resilience influenced organizational outcomes. Small and medium-sized enterprises, in particular, are examined for their heightened exposure to shocks and their varied capacity to respond through innovation, cost restructuring, and strategic pivoting.

On the consumer side, the pandemic introduced notable shifts in spending patterns, risk perception, and decision-making processes. Several contributions investigate changes in consumption behavior, including the rapid adoption of online purchasing, increased price sensitivity, and a growing emphasis on health, safety, and essential goods. The psychological and socio-economic dimensions of these changes are also explored, shedding light on how uncertainty and mobility restrictions have redefined consumer priorities. These insights are critical for businesses seeking to realign their strategies in an evolving demand landscape.

Methodologically, the studies featured in this special issue employ a rich mix of empirical analysis, econometric modeling, surveys, and case-based approaches. This diversity strengthens the robustness of the findings and enhances their applicability across different economic contexts. Many authors utilize real-time data and comparative frameworks to assess short-term disruptions alongside longer-term structural implications, thereby contributing to a more nuanced understanding of the pandemic's economic footprint.

The 2020–21 period serves as a unique backdrop, marked not only by economic contraction but also by rapid policy responses and institutional adaptation. Government interventions, including fiscal stimulus measures, monetary easing, and support programs for businesses and households, are critically examined in several papers. These analyses provide valuable perspectives on policy effectiveness, equity considerations, and the balance between immediate relief and sustainable recovery.

The editorial team acknowledges the dedication of the authors and the invaluable contributions of the reviewers, whose efforts have ensured the scholarly rigor and relevance of this issue. Their collective work reflects the resilience of the academic community and its commitment to addressing urgent global challenges through research and collaboration.

This special issue offers a comprehensive exploration of how the COVID-19 pandemic has reshaped economic systems, influencing both corporate strategies and consumer behavior. By integrating diverse analytical perspectives and empirical evidence, it provides a meaningful

foundation for understanding the ongoing transformation of markets and for guiding future research and policy in a post-pandemic world.

Guest Editor

Dra. Patricia Cano Olivos

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CONTENTS

The Impact of COVID-19 Pandemic and Commodities Prices on Booking.com Share Price
by Meng-Chang Jong, Chin-Hong Pua and Ann-Ni Soh

Ecosystem of Renewable Energy Enterprises for Sustainable Development: A Systematic Review
by Carol Dineo Diale, Mukondeleli Grace Kanakana-Katumba and Rendani Wilson Maladzhi

A Proposed Framework to Improve Containerization from Asia to North America
by Carlos Gabriel Ortega-Diaz, Diana Sánchez-Partida, José Luis Martínez-Flores and Patricia Cano-Olivos

Organizational Agility Assessment of a Moroccan Healthcare Organization in Times of COVID-19
by Fadoua Tamtam and Amina Tourabi

Inventory Management Practices during COVID 19 Pandemic to Maintain Liquidity Increasing Customer Service level in an Industrial Products Company in Mexico
by Ignacio Alvarez-Placencia, Diana Sánchez-Partida, Patricia Cano-Olivos and José-Luis Martínez-Flores

COVID-19 Crises: Global Economic Shocks vs Pakistan Economic Shocks
by Naveeda K. Katper, Muhammad Nawaz Tunio, Niaz Hussain, Attaullah Junejo and Faheem Gul Gilal

An Empirical Comparison of Different Two-Factor Models in the Context of Portfolio Optimisation
by Jamal Agouram, Mouncef Harabida, Bouchra Radi and Ghizlane Lakhnati

Contingency Plan in the Supply Chain of Companies in the Retail Industry in the Face of the Impacts of COVID-19
by Carlos Juventino Ruiz Montoya and José Luis Martínez Flores

Covid-19 Pandemic Lockdown: The Consequences Towards Project Success in Malaysian Construction Industry
by Muneera Binti Esa, Farah Salwati Binti Ibrahim and Ernawati Binti Mustafa Kamal

Strategic Model to Assess the Sustainability and Competitiveness of Focal Agri-Food Smes and their Supply Chains: A Vision Beyond COVID 19
by Yonatan López Santos, Diana Sánchez-Partida and Patricia Cano-Olivos

Resilience Assessment of System Process Through Fuzzy Logic: Case of COVID-19 Context
by Saloua Said, Hafida Bouloiz and Maryam Gallab

Approach to a Logistic Model to Reduce Costs for Delivery at Home of a Seller of Supplies in Times of Coronavirus
by *Hernán Washington Samaniego Guevara*

The Impact of COVID-19 Pandemic and Commodities Prices on Booking.com Share Price

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ABSTRACT

This paper examines the impacts of the COVID-19 pandemic and selected commodity variables on Booking.com share price using the Markov-switching approach. Daily data spans from January 2017 through July 2020 are utilized in this study. Empirical evidence showed that COVID-19, international crude oil price, and gold price affected the Booking.com share price significantly. A positive relationship was detected between international crude oil price and gold price towards stock price whereas COVID-19 showed an inverse impact on stock price. The empirical findings evidenced a 1% increase in COVID-19 cases adversely affecting the share price by -0.27%. Our findings also suggested that the potential of another wave of COVID-19 is relatively higher as the bounce back period was identified as 67 days. The filtered and smoothed probabilities signaled the Booking.com share price chronologically, and transition probabilities were identified. Six cycles were outlined, and the effectiveness of the Markov-switching approach in detecting vulnerable financial forecasting was demonstrated. The adequate dating evolution provided satisfactory input for policymakers, investors, and researchers to design and mitigate volatility in commodities and crises.

1. Introduction

COVID-19 was declared as a Public Health Emergency of International Concern by the World Health Organization (WHO) at the end of January 2020. It is now well established that COVID-19 has greatly impaired the world economy, especially the tourism industry, with airplanes grounded, hotels closed, and restrictions placed on travel around the world. The World Tourism Organization (UNWTO) stated that the pandemic has placed the whole world on lockdown, and most destinations worldwide are still implementing COVID-19 related travel restrictions on international tourists. In [1], the author documented a double-digit (-22%) decline in international tourists in 2020Q1, with 57% reduction in arrivals in March, which is equivalent to a total loss of 67 million international tourists and USD80 billion in tourism export revenues. The UNWTO foresees a total decline of 58% to 78% in international tourist arrivals in the year 2020, and a total of 100 to 120 million tourism jobs are directly at risk in the current scenario. This is by far the worst outcome since 1950 in the history of international tourism, a circumstance that will bring an abrupt end to a 10-year stretch of continuous growth following the financial crisis of 2009.

Due to the fast spread of the COVID-19 pandemic, most countries are responding quickly and effectively through international cooperation, particularly in terms of healthcare systems and financial support to protect people against the loss of their livelihoods. This step has moved closely to achieve several Sustainable Development Goals (SDGs), which are good health and well-being (Goal 3) and partnerships for the goals (Goal 17). Scientists around the world are working on potential treatments and vaccines to reduce the number of people infected and the number of deaths due to the pandemic and its related effects. Due to the outbreak of COVID-19, the UNWTO foresees the tourism industry facing an unprecedented challenge. The UNWTO accordingly hosted a virtual high-level meeting with key UN agencies, member states, and the private sector to work together as the Global Tourism Crisis Committee in responding to the emerging situation and to ensure that tourism is ready to lead recovery efforts.

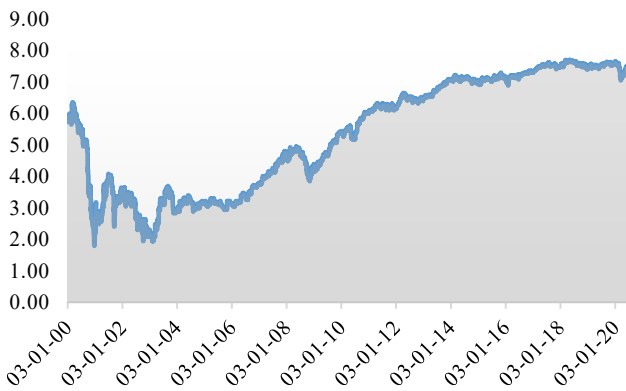
Along with the rapid development of the tourism sector, the hospitality industry is one of the key pillars in receiving and serving tourists. Hotels are considered pivotal tourist facilities as one of the drivers of investment and employment in tourism [2]. Currently, the hospitality industry is facing an unprecedented challenge due to the worldwide lockdowns put in place by various countries. Booking.com is one of the world's leading digital travel

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platforms, operating on numerous well-known online platforms such as Agoda, Villas, and Kayak. With its significant contribution and diversify profile, the Booking.com share price was chosen for this study. Figure 1 reveals that the share price of Booking.com is sensitive not only to economic crises (dot-com bubble and subprime mortgage crisis) but also health crises (SARS outbreak and H1N1). These incidents have previously disrupted the travel industry, limiting the ability and willingness of tourists to travel to certain destinations, which result in a decline in demand that affects the travel industry as a whole. Due to the COVID-19 pandemic, the total revenue for Booking.com was USD2.3 billion in the first quarter of 2020, a decline of 19% from the preceding year. Furthermore, net cancellations were USD12.4 billion, marking a 50% increase from over a year ago [3]. Thus, very little is known about the impact of COVID-19 on hotel stock returns. In addition, the oil price slump has contributed further to stock volatility. The sharp decline in oil price is mainly due to agreements between OPEC+ members to reduce oil production and the fact that global demand for crude oil has declined dramatically due to the COVID-19 pandemic. In short, the stock market faces dual shocks from the COVID-19 pandemic and oil price changes. With respect to these issues, this study has two primary aims: first, to investigate the impact of COVID-19 on hotel stock market performance; second, to ascertain the impact of commodity price volatility on the hotel stock market.



Source: Nasdaq, 2020.

Figure 1: Booking.com Share Price, January 2000-July 2020

2. Literature Review

The COVID-19 pandemic has had a tremendous impact on the world economy and has put millions of people as well as jobs at risk. Tourism is among the hardest-hit industries during the pandemic. The hotel industry is one of the most highly interlinked industries in tourism, and almost every part of a hotel’s operations from room occupancy rate, staffing plan, and stock price have been affected by COVID-19. The stock market is an interesting topic that has prompted many empirical studies to be carried out from economic and financial perspectives. However, the health crisis has only recently become a topic of interest, and the impact of COVID-19 has not yet been widely analyzed. Additionally, the effect of COVID-19 on international tourism is extremely challenging to estimate, considering the unparalleled and rapidly changing complex nature of the crisis. Thus, the current study will enrich the literature by examining the impact of COVID-19 on the tourism stock market. In previous studies, [4] explored the impact

of macroeconomic variables, terrorist attacks, and natural disasters on hotel stock returns. The researchers also pointed out that the SARS outbreak caused a decline in hotel stock returns recorded at an approximate value of -25.9%, followed by the impactful declines resulting from earthquake (-22.3%) and the 9-11 terrorist attacks (-12.5%). Similarly, [5] analyzed the effect of SARS on fluctuations in Taiwanese hotel stock prices. They also identified that the tourism industry experienced the highest decline in overall stock prices in the Taiwanese Stock Exchange, recording a decline of approximately 28.9% one month after the SARS outbreak. They indicated that the average hotel stock prices were exposed to above-market risk during the SARS outbreak.

International crude oil price fluctuations have substantial effects on different areas of the financial sector, especially the stock market. In [6], the author investigated the relationship between oil price and performance of the US stock market, identifying a clear adverse link between oil price and stock market performance. Similarly, [7-10] also found evidence of an adverse connection between oil price and stock price. In contrast, [11-13] detected a positive relationship between the oil price and the stock price. In [14], the author stated that oil-exporting countries were positively associated with the stock market, whereas the adverse impact occurred in oil-importing countries. Other key determinants such as gold [15, 16], GDP [17, 18], exchange rate [16, 18-19], and economic crises [10, 20-22] were employed in previous studies.

3. Methodology

Instead of using the traditional single-state approach, Markov-switching regression techniques that confirm the validity of crises were applied in this study. A similar approach was applied in different tourism issues by [23-25] with constructive findings. The current study tends to establish the links among different crises and tourism demand forecasting, with tourism stock price as the proxy variable. In examining the behavior of the commodity market towards world tourism performance together with the health crisis, inclusive of COVID-19 as the dummy variable into the regression, remedial measures or precautionary steps can be tackled cautiously for the next crisis occurrence. All the variables were extracted in the high frequency on a daily basis from January 2017 to July 2020 to capture the most recent information. The selected variables comprise the share price of Booking.com as a proxy for world tourism, and the commodity variables are international crude oil price and gold price. Table 1 displays the descriptive statistics of the selected indicators.

Table 1: Descriptive Statistics of the Selected Indicators

	LBOOKING	LBRENT	LGOLD
Mean	7.514	4.056	7.209
Median	7.530	4.127	7.168
Maximum	7.699	4.454	7.924
Minimum	7.049	2.197	7.048
Standard Deviation	0.105	0.291	0.109
Skewness	-1.257	-2.377	1.264
Kurtosis	5.410	10.280	4.786

According to [26], the general definition of the piecewise linear switching regression model is as follows:

$$y_t = \sum_{j=1}^r (\phi'_j q_t + \varepsilon_{jt}) I(c_{j-1} < s_t \leq c_j) \quad (1)$$

where $q_t = (w'_t = y_{t-1}, \dots, y_{t-p}; x'_t = x_{1t}, \dots, x_{kt})$ denotes the explanatory variables and observable switch variable [27] interpreted the scheme of switching regression as follows:

$$y_t = \begin{cases} \beta_1 \cdot x_t + \varepsilon_t, & \text{when } S_t = 1 \\ \beta_2 \cdot x_t + \varepsilon_t, & \text{when } S_t = 2 \end{cases} \quad (2)$$

where the exogeneous regressors are represented by y_t and x_t , the vector of real numbers is denoted by β_t , the non-observable state variables are shown by S_t , and the Gaussian white noise by ε_t .

The Markov-switching regression model is presented in the following section. The COVID-19 pandemic is captured by a dummy variable with the outbreak detected at the end of 2019.

$$Booking_{i,t} = \begin{cases} \beta_0^{(1)} + \beta_{Brent,t}^{(1)} + \beta_{Gold,t}^{(1)} + Dum_{COVID-19,t}^{(1)} + \varepsilon_t^{(1)} & S_t = 1 \\ \beta_0^{(2)} + \beta_{Brent,t}^{(2)} + \beta_{Gold,t}^{(2)} + Dum_{COVID-19,t}^{(2)} + \varepsilon_t^{(2)} & S_t = 2 \end{cases} \quad (3)$$

Upon the coefficient determination, the transition probabilities of the regression model were presented to examine the timeframe of the tourism cycle moving from one regime to another. The longer timeframe indicates that a recession might take a longer time to recover from a crisis. The matrix of transition probabilities from one state to another state is presented below:

$$\pi = \begin{bmatrix} p_{11} & p_{21} \\ p_{12} & p_{22} \end{bmatrix}, p_{xy} = Prob(S_t = y | S_{t-1} = x) \quad (4)$$

Furthermore, the smoothed and filtered probabilities where $Prob(S_t = y | y_1, \dots, y_T)$ can be obtained as well. The graphical illustration of the world tourism cycle detected the reference chronology of crises happening from 2017 to 2020 worldwide. Moreover, the empirical results underwent a series of diagnostic checks for the residuals. The best fit of the model can be determined by the residual diagnostic tests, which include the plot of residuals against a fitted value and the normality probabilities plot for normality distribution testing. Further research can also apply a similar approach to different fields of study.

4. Results and Discussion

Hotels play a vital role in the tourism industry and have been categorized as one of the most vulnerable industries during the COVID-19 pandemic. This section discusses the impact of the COVID-19 pandemic and commodity variables on hotel stock price (Booking.com) through a Markov-switching approach. Table 2 reveals that international crude oil price, gold price, and the COVID-19 pandemic significantly affected the share price of Booking.com in both regimes. In regime 1, the international crude oil price and gold price are positively associated with the share price of Booking.com, while the COVID-19 pandemic adversely affected the share price. Oil is one of the most tradeable commodities, and a crash in oil price reflects fear of economic recession. The world economy, including oil-producing countries such as the US, Saudi Arabia, and Iran, has been disrupted due to the COVID-19 pandemic. In addition, the pandemic is also having huge impacts on the tourism industry, manufacturing industry, and factories that consume a large portion of energy in production but

have been shut down. Thus, the demand for crude oil has dropped dramatically. Our empirical results show that oil price and stock price move in the same direction. A 1% decline in oil price weakened the share price of Booking.com by 0.20% during the COVID-19 pandemic in regime 1, as shown in Table 2.

Table 2: Markov Switching Model Results

Regime 1: Recession		
Variable	Coefficient	p-value
(Intercept)	3.142	0.000***
LBRENT	0.200	0.000***
LGOLD	0.504	0.000***
COVID-19	-0.268	0.000***
R-squared	0.855	
Regime 2: Expansion		
Variable	Coefficient	p-value
(Intercept)	0.582	0.000***
LBRENT	0.345	0.000***
LGOLD	0.762	0.000***
COVID-19	-0.020	0.000***
R-squared	0.847	

Gold acts as a good diversifier and is categorized as a Safe Haven, which is beneficial to investors [28]. Hence, investors feel even more confident when the gold price increases and leads to a rise in stock price. In this study, the results show that gold price is positively associated with stock price, which is consistent with the findings of [15-16]. In regime 1, a percent increase in gold price will lead the share price of Booking.com to rise by 0.50%. As expected, the COVID-19 pandemic had a negative impact on the hotel's stock performance. The results demonstrate that a percent rise in COVID-19 cases will lead to Booking.com's share price to be reduced by 0.27% during the recession. This negative relationship also implies that tourists feel a high risk to travel because safety is a fundamental condition for international tourists. The values of the adjusted R² are higher than 80% in both regimes, signifying that the variability of the dependent variables can be explained accordingly by the selected explanatory variables.

Table 3: Matrix Transition Probabilities

	Regime 1	Regime 2	Duration (days)	P
Regime 1	0.985	0.015	67	= $\begin{bmatrix} 0.985 & 0.015 \\ 0.015 & 0.985 \end{bmatrix}$
Regime 2	0.015	0.985	67	

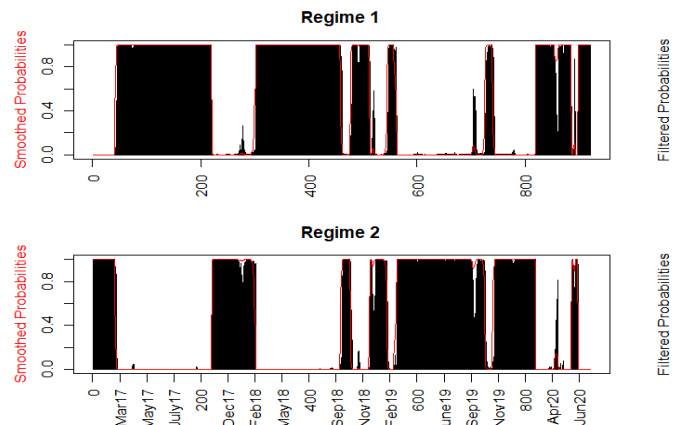


Figure 2. Graphical Illustrations of Smoothed and Filtered Probabilities

Table 3 demonstrates the two-state transition of matrix transition probabilities. The measurement of the expected duration for the regime-switching period is defined as $1/(1-P_{00})$, in which the higher transition probability value reveals that it is relatively more difficult to shift from one regime to another. Findings reveal that the model shows 98.5% to stay in regime 1, and only with a 1.5% probability of shifting to regime 2. Therefore, the expected duration to shift from regime 1 to regime 2 is 67 days during the COVID-19 pandemic. The shorter expected duration results from the matrix transition probabilities illustrates that the potential of another wave of COVID-19 is relatively higher, as the bounce back effect shown in Table 3 is stronger. This may be due to resumed domestic and international economic activities and lifted restrictions on travel and activities.

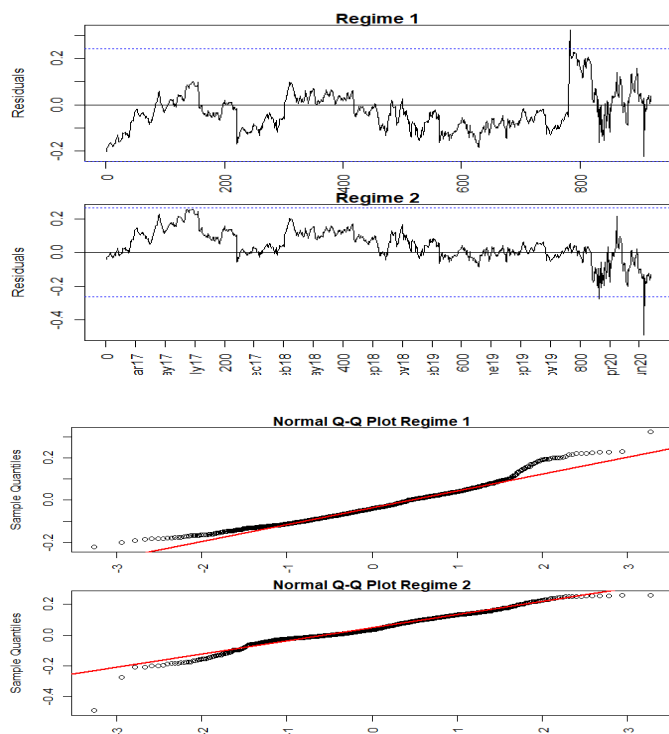


Figure 3. Diagnostic Checking Analysis Outcome

The graphical illustrations of the smoothed and filtered probabilities from the Markov-switching regime model are depicted in Figure 2. A total of six states/shaded areas for the crises were detected, spanning from January 2017 to July 2020. The argument on oil production cutting among oil-producing countries that started in 2017 is well captured in the first shaded area, as illustrated in Figure 2. The second state captured the worst point drop in the history of the Dow Jones in February 2018. In addition, US markets lost nearly USD2 trillion in October 2018, which is identified in the third shaded area, and the fear of US-China trade tension continued in February 2019 and November 2019. Finally, the COVID-19 pandemic is successfully captured in the sixth shaded area. This proves the effectiveness of the Markov-switching approach in detecting economic crises. Figure 3 illustrates that the residuals are considerably fitted against the values. Following the normal Q-Q plot closely, the residuals are like white noise and are moving towards the normal distribution.

5. Conclusion and Policy Recommendation

This paper examines the impact of the COVID-19 pandemic on share price of Booking.com through the Markov-switching approach. The empirical findings reveal that the highly contagious disease had negatively influenced hotel stock market performance. Furthermore, a positive associated relationship was identified among international crude oil price, gold price, and stock price. The results also provide strong evidence that the model stays persistent within each regime up to more than 90%. Several economic crises have been captured through smoothed and filtered probabilities under this study. Our findings have several implications. First, they contribute to the current literature regarding the impact of the COVID-19 pandemic on hotel stock performance. Second, the investors have a better understanding of the dynamic relationship between the commodity variables and stock market. Specifically, they are able to adopt more appropriate strategies to safeguard against oil and gold price fluctuations and future crises. Finally, the findings are helpful in providing the government and policymakers with useful insights about the impact of crisis on the stock market, and thus to design a feasible policy to protect the country and society. Further research is needed to fully understand the implications of COVID-19 on the stock market. This would be a fruitful area for further work by taking into account the impact of COVID-19 across different industries. Additionally, future work can utilize different elements and methodologies to gather extra information regarding COVID-19's impact on tourism-related industries.

Conflict of Interest

The authors declare no conflict of interest.

Acknowledgments

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Ecosystem of Renewable Energy Enterprises for Sustainable Development: A Systematic Review

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ABSTRACT

In the Global sphere, the social, environmental, and economic pillars are the main contributors and accelerators to the sustainable development goals. As a result, the latter creates a platform for interdisciplinary researchers, society and decision-makers to collaborate in formulating ways to minimize factors contributing to environmental concerns. Energy is currently referred to as one of the scarce resources. The scarcity of electricity is mainly experienced in the rural areas of most countries in the world. The mandate of the green economy is to introduce innovative ways to redress the inequalities and lack of access, especially when it comes to Energy. Based on the sector's efforts, questions arise as to what comprises the ecosystem that can be accelerated to enhance entry to the sector. Hence, the researchers focus on Renewable Energy with specific reference to the entrepreneurial motives to meet sustainable goals. The applicable sustainable goals are goal 7 (affordable and clean Energy) and Goal 8 (decent work and economic growth). Furthermore, Energy contributes to modern access and poverty reduction to accelerate the transitioning to a Green economy. The current paper hopes to answer the following questions: Firstly, how Renewable Energy enterprise can contribute to sustainable development goals theoretically. Secondly, how can the theoretical energy enterprise ecosystem be contextualized in the South African context? A theoretical review was conducted through a literature review of which n=47 sources met the criteria that the researchers set for ecosystem variables. The overarching goal of the paper is premised on various works of literature building the ecosystem of the elements highlighted by most researchers in the field of renewable energy enterprises or business ventures. From the various models, the framework emerged singling out the critical success factors of the ecosystem of the Renewable Energy enterprise. The theoretical ecosystem consists of accelerators, social factors, sustainable development goals, as well as selected business models. The latter ecosystem was then contextualized in the South African context for a complete framework. Some of the critical drivers derived from the latter broad ecosystem are: Renewable Energy Feed-in Tarrif (REFIT), Utility Renewable Energy business model, Customer renewable energy business model, Energy Justice (distributive justice), Off-grid (Mini-grid), Saurian Liting lamp, Renewable powered irrigation system.

1. Introduction

This current paper is emanating from the paper *Green Entrepreneurship Model Utilising the System Dynamics Approach: A Review* presented at IEEM 2019 Conference in Macau [1]. There are always pressures around social, economic,

and political phenomena as part of the triple bottom [2] to meet the green economy expectations and ways were researchers, and society at large can contribute to the process. Figure 1 shows the data world rural electrification rate & Electrification Growth rate.

Figure 1 illustrates the rural electrification and electrification growth rate from the 1990s to 2016. The red line demarcates rural electrification growth rate and the blue line demarcates rural

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electrification rate (percentage of rural population). Rural electrification is a process of giving access to the commodity to the population in rural areas [3, 4]. Energy is one of scarce commodity, where millions of people, especially in the rural areas, are not connected to the electricity grid, due to lack of affordability [4].

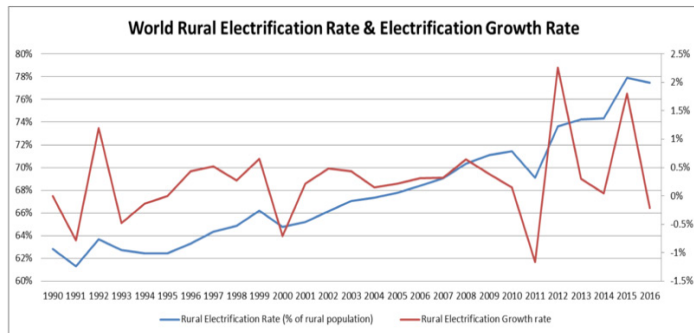


Figure 1: World Rural Electrification Rate & Electrification Growth Rate [3].

The green economy’s mandate is to introduce innovative ways to redress the inequalities and lack of access, especially when it comes to energy [5]. Large numbers of people use fires and fuel lighting for basic energy needs [2], particularly in rural areas. The success factors or contingency plans were then introduced as an alternative mechanism such as renewable energy [2]. The latter serves as an effort to ensure that everyone can be able to light their houses or businesses. In hoping to minimize the challenge of the majority of South Africans without access to electricity, the country has a solar park in the Northern Cape. The solar park is to improve living, promote sustainable tourism. The latter strategy attracts tourists and investors, contributing to the economy of the country [4].

Furthermore, from the efforts on the sector, questions arise as to what would be an ecosystem that can be accelerated to enhance entry to the sector. The current research proposes a focus on specific reference to the entrepreneurial motives in efforts to meet sustainable development goals. Efforts have been made to explore renewable energy enterprises [6, 7] but have not focused on sustainable development goals or social focus within the area. The applicable sustainable development goals identified are Goal 7 (Affordable and Clean Energy) as well as Goal 8 (Decent work and Economic growth) [8] Furthermore, Energy contributes to modern access, and poverty reduction [8-10], to accelerate the transitioning to Green economy. The idea is to focus on one Green economy thematic area, which is Energy, and refining the research to focus only on enterprise within the energy sector.

The paper is premised through various works of literature building the ecosystem, taking into consideration the elements highlighted by most researchers in the field of Renewable Energy enterprises or business ventures. From the various models, the framework emerged singling out the ecosystem of the Renewable Energy enterprise. The theoretical ecosystem consists of accelerators, societal factors, and sustainable development goals as well as selected business models. The latter ecosystem is then contextualized in the South African context for a complete framework. The subsequent section will focus on literature review, research questions, methodology, results and discussions, and future recommendations.

2. Research questions

The research questions were formulated through the research gaps that were identified while reviewing literature and where possible research contributions can be made setting future research agendas. The research questions are as follows:

- How can theoretical Renewable Energy enterprise ecosystem be contextualized in the South African context?
- How can Renewable Energy enterprise contribute to sustainable development theoretically?

3. Research Background

The Literature review discussed in the paper is premised on accelerators and barriers to the Renewable Energy in the formulation of key drivers which can be part of the framework. Furthermore, the theory behind the ideas on how Renewable Energy can be used to contribute to sustainable development goals will be discussed below.

3.1. Accelerators to Renewable Energy

Through the review of literature, support mechanism implemented worldwide are in the form of the non-financial and financial mechanism as well as strategic programmes [9-11]. A generic business framework such as utility renewable energy business and customer renewable energy business model has been developed to facilitate manufacturing to consumption value chain to support Renewable Energy enterprises in the international markets [12-14]. Due to the diffusion of energy supply, support as an investment can accelerate the planning and implementation of the scarce commodity [15].

Other factors such as the biographical determinants such as age, level of education have demonstrated to the adoption of Renewable Energy technology. The generation that tends to adopt to the technology has been proven to be the younger generation than the older generation [16].

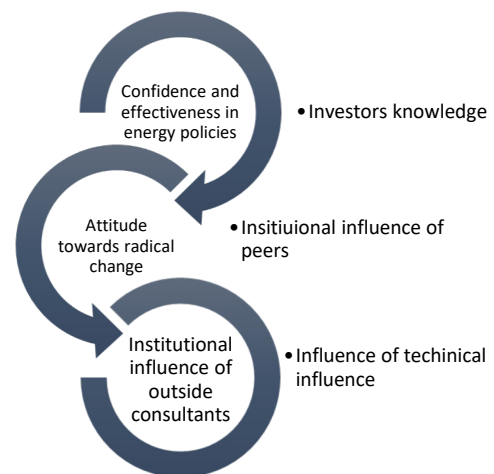


Figure 2: Renewable energy non-financial support mechanisms [15].

Figure 2 depicts the non-financial support mechanisms that could accelerate Renewable Energy. Scholars such as [15] have raised that non-financial support needs to be the cornerstone of the planning and implementation of Renewable Energy. The

renewable Energy serves as a "new kid on the block"; therefore, scepticism comes somewhat derails the implementation.

3.2. Access of the commodity by the society through sustainable development goals

In contribution to the access of the commodity by the society, the authors are proposing using sustainable development goals as a framework. Thematic areas of the green economy are inclusive but not limited to Green Energy, sustainable water, waste, agriculture, trade-in low carbon products, cleaner and green technology, green buildings, green chemistry and sustainable transport (mini car/cycles) as well as air quality [17]. Enabling the green economy involves innovation [18] of which needs attention and serves as a research agenda.

There are 17 sustainable development goals namely: *Goal 1 Eradication of poverty; Goal 2 No hunger, Goal 3 Good health, and well-being, Goal 4 Quality education, Goal 5 Gender equality, Goal 6 Clean water and sanitation, Goal 7 Affordable and clean energy, Goal 8 Decent work and economic growth, Goal 9 Industry, innovation and infrastructure, Goal 10 Reduced inequality, Goal 11 Sustainable cities and communities, Goal 12 Responsible consumption and production, Goal 13 Climate Action, Goal 14 Life below Water, Goal 15 Life on land, Goal 16 Peace and Justice and strong institutions, Goal 17 Partnerships to achieve a goal* [19].

Efforts have been made to introduce Energy technologies and policies is to reduce poverty and facilitate Clean Energy [20]. The need to contribute to societal need by reducing the electricity bills for those who cannot afford them, serves as a crucial social context [21], needing collective actions and commitment of relevant stakeholders inclusive of professionals in the field of Industrial Psychology, Industrial engineering, Energy practitioners, community members, governments officials and politicians.

Understanding culture and community needs from a social perspective, spearheaded by social scientists to study the area of Renewable Energy in Sub Saharan Africa [21] is needed, of which the authors believe that this best practice could be implemented in the South African context, to understand and tailor services and products to society leveraging on societal needs. Accelerators and support for Renewable Energy need to be contextualized in Rural, Urban, and semi-rural areas to create the impact and effective implementation. To echo the latter statement, the study conducted in Bangladesh investigated the impact of the implementation of Renewable Energy in rural areas and found that Renewable Energy contributes to social, economic and environmental benefits [22].

The benefits of Renewable Energy can benefit people living in rural areas through better quality of living and health as the majority living in Bangladesh use kerosene, candle and often have to walk a long distance to fetch wood for cooking [22]. Renewable Energy through natural resources such as biogas, solar, wind, hydropower can benefit the society of rural of Bangladesh [22].

3.3. Barriers to Renewable Energy

Some of the challenges identified are wage or salary disparities, skills shortages, shortage of coal, producers,

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corruption, mismanagement of funds and resources, lack of policy framework, limited absorption of solar manufacturing plants [3]. Developing countries do not have adequate resources, such as technology, lack of institutional support, lack of skills and lack of regulatory policies especially when it comes to Renewable Energy [23, 24] of which the same challenges may be the case in the South African context.

The negative impact of oil prices fluctuation is affecting the economic and political sphere of the continent [25]. According to [26], investors from other continents are reluctant to do business in Africa.

The lack of competencies, failure to create a new value proposition, and competition have been demonstrated to serve as barriers in Renewable Energy ventures [6, 26, 27]. The cornerstone query of creating a market arises, in establishing potential customer clientele, as well as the capacity of understanding the importance of adoption of Renewable Energy and how the technology can be utilised to ensure effectiveness and viability of enterprises [6, 13, 27, 28].

Upon reviewing the literature scholars have demonstrated that the effect of price control, inability to adopt new technologies and lack of market diversification further added to the challenges of full implementation of Renewable Energy technologies [25].

Further barriers, especially in the African context, is the issue of connection to the grid, inability to build relationships with established companies, lack of trade and distribution organisations [23]. In the South African context, it was discovered that barriers in the Energy project are credit risk, market risk, risk of change of legislation as well as technological risks [29].

The lack of the necessary infrastructure and education has been found to be obstacles in quest of the adoption of Renewable Energy as technology [30]. Thus, From the research point of view, lack of research and innovative way incorporated within research methodologies to Renewable Energy as technology serves as a challenge. In [5], the author asserts that the specific research methodologies such as quantitative methodology forms part of the puzzle and may become a solution in implementing the Energy programmes. Further challenges that researchers raise are weak electricity grids, corruption as well as future entrepreneurs in the field of renewable Energy having challenges in handling the complexity of adoption of Renewable Energy as a technology [3, 5, 25, 26].

4. Purpose statement

Upon explaining the research background above, purpose statement is then formulated as follows: Various scientists have conducted empirical studies in an attempt to understand Renewable Energy, sustainable development goals, climate change, Renewable Energy enterprise [31-35] but with less focus on Renewable Energy enterprise in quest of creating a framework nor less focus on mapping the Renewable Energy ecosystem with Sustainable Development goals and societal factors within the South African context theoretically, which the current study fulfils. Studies have been conducted globally and within African context within the Renewable Energy, Renewable Energy enterprise and sustainable development goals [6, 7, 20, 21, 24, 25,

34, 36] with non-existent focus particularly within the South African context in formulation of the ecosystem nor mapping the sustainable development goals utilising the ecosystem.

Table 1: Findings of the ecosystem for environmental entrepreneurship

The theoretical ecosystem of renewable energy enterprise	Contextualisation of theoretical ecosystem Renewable energy enterprise to South African context
Market incentives Demand and supply of renewable energy services	Equity official development assistance.
Infrastructure governance Government subsidies [11, 37]	Empowerment of previously disadvantaged groups, i.e. women, people of colour and disabled people Awareness conferences, symposiums
Best practices/lessons learnt from developing countries.	Human resource development policies and BBBEE
Financial support Venture capital Budget provisions, grants, loans, equity financing [36]	South African Government, subsidies Development Bank of Southern Africa (DBSA), Private energy entities, partners and cooperatives financial support.
Alternative forms of Energy Solar Energy [21] Off-grid (Mini-grid) Saurian Lilting lamp [38;39] Power plants [38] Biomass Renewable powered irrigation system Imported Hydropower generation Rural Energy Enterprise Development (AREED)	Mitigation programmes with local municipalities, baseline studies, solar Energy Stakeholder (Green youth Indaba local government, Department of Energy, Department of environmental affairs, an innovation hub

5. Methodology

The research methodology followed was in the form of systematic review. The rationale for using a systematic review as a methodology afforded the authors access to the various methodologies and outcomes within the areas of renewable energy enterprises and sustainable development goals. This enabled the researchers to formulate a framework with triangulation of efforts from previous researchers. Furthermore, the rationale for systematic review is to explore the area under investigation. The systematic review as a methodology was beneficial, especially during the COVID-19 pandemic, which has affected the entire world, as interviews or questionnaires would not have succeeded during these challenging times. The use of online data collection still poses challenges due to social inequalities and the majority of people not having access to emails or not being able to afford online video platforms in South Africa.

A systematic literature review was considered as the Research methodology of the current research paper which focussed on peer-reviewed articles utilising search engines such as Google scholar, Energy policy, Journal of cleaner production, Renewable and Sustainable Energy Reviews, Renewable Energy, Energy, Sustainability and Society. The introduction and findings were used to select the relevant articles for inclusion. A theoretical review was conducted through a literature review of which n=47 sources (peer-reviewed articles) met the criteria that the researchers set for ecosystem or variables sorted from 89 articles. Duplication of results were further removed. The themes were analysed through thematic content analysis, where themes such as key drivers of Renewable Energy enterprise, sustainable development and Renewable Energy enterprise, the applicability of renewable Energy in the South African context as well as access to renewable Energy sorted from 85 peer-reviewed articles are the outcome.

6. Findings

Figure 3 illustrates how the most prominent Sustainable Development Goals can be achieved theoretically using the Renewable Energy Enterprise ecosystem. The subsequent section under discussion will the explain thoroughly the mapping thereof.

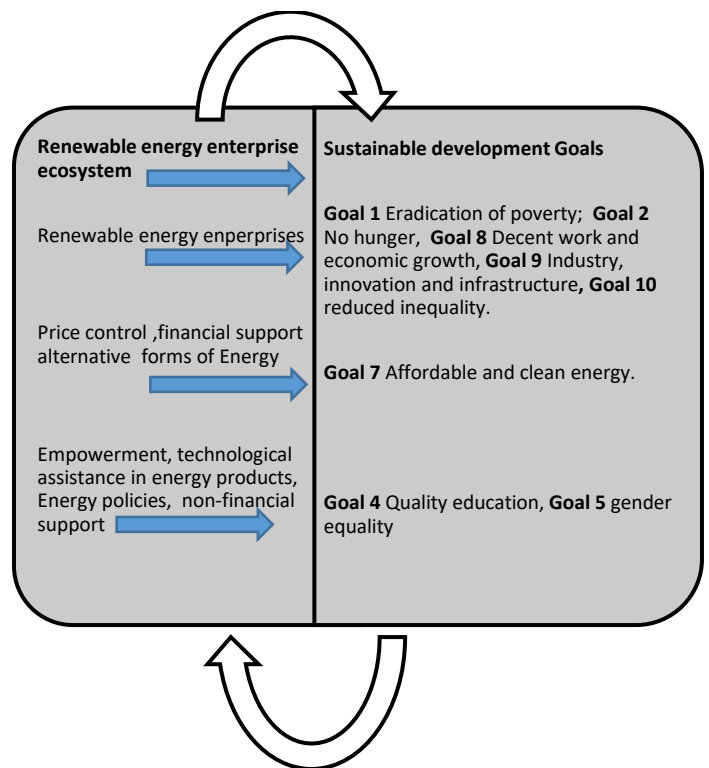


Figure 3: Theoretical Mapping of a renewable energy ecosystem and sustainable development goals

7. Discussions

7.1. Discussion of Renewable Energy enterprise Ecosystem within the South African context

Through the review of literature, one of the support mechanisms in the sectors is market incentive [39], which can be described by demand and supply or willingness to support the products or services of Renewable Energy. Alternatives, such as

Solar, off-grid options, especially mini-grids, have been suggested by [40] for rural areas to foster access to Energy.

Majority of business models have not considered the high-level business planning and strategies, before focusing on specifics of business development [41, 42]. The latter notion will equally contribute to entrepreneurship in Renewable Energy in ensuring enough planning, introducing and managing high-level game-changers as well as policies in regard to entrepreneurship in Renewable Energy.

Natural resources such as wind, solar power stations, and water need to be quantified to measure and form part of the baseline in assessing the readiness of the adoption and diffusion of Renewable Energy. Another sustainable sector that has proven to benefit the planning and implementation of Renewable Energy is the agricultural sector, through irrigations system and implementation of Energy park and monitoring [15].

Electrification plans similarly to what Ghana has implemented [23] can benefit South African context. The electrification plan can be possible with baseline studies and projections or estimation where potential areas may be without electricity [23]. Furthermore, some of the initiatives that can be implemented is the Rural Energy Agency similarly to what Tanzania has implemented [23].

Additional support and efforts made in the South African context is the Renewable Energy White paper, long term mitigation programme scenarios, as well as the Renewable Energy Feed-In Tariff (REFIT) as well as Energy policies and Act to support and regulate the Energy technologies [6, 29, 30, 37]. A generic business framework such as utility Renewable Energy business and customer Renewable Energy business model has been developed to facilitate manufacturing to consumption value chain in quest to support Renewable Energy enterprises in the international markets [12, 13].

Infrastructure governance is another support mechanism whereby policies and training can be piloted to the stakeholders. Stakeholders can consist of sustainability specialists, private and public sectors and communities at large. The implementation of a renewable-powered irrigation system [24] can be introduced to minimise challenges of scarcity of resources drawing from [19, 24]. The entrepreneurial confidence in development, consulting and distribution of renewable-powered irrigation system, a budget provision from the government need to support SMEs in the Energy sectors.

The issue of crime and corruption may need to also be factored in budget allocation in the form of investing in security services to safeguard the power stations and Energy technologies.

South Africa is a democratic country where law triumphs all undesirable behaviour and regulate the system. The Energy justice and legal perspective can be implemented when contributing to the sustainable Energy particularly, distributive justice of equal access to resources even to society who cannot afford the services [43].

In [8 10], the author asserts that there should be different tailored types of funding to promote access to Energy in the form of Grants, financing, loans, Equity official development assistance, equity financing and technical assistance in Energy products and services. To translate this mechanism in the South African context, the National Youth development agency, could be a spearhead for funding and include the criteria to promote Energy products, services, consulting or distribution.

The South African national youth development could work hand in hand with Green youth Indaba as well as an Innovation hub where several youth programmes are housed in South Africa, to ensure the sustainability of entrepreneurship in targeting the youth. The authors are proposing the implementation of Green change dynamics as a development programme whereby green readiness of change and managing fear of the unknown within Green initiatives could be introduced to facilitate awareness and training initiatives within Green Energy enterprises, which could be instilled onto the society, to contribute to the level of confidence in Sustainable Energy enterprises sectors.

Clientele and or customers as well as demand and supply serve as the corners and hub of every business incubators. One important factor that will determine the success or failure of a business is customers and customer attitudes, which is often overlooked. However, in the green entrepreneurship field, efforts have been made regarding customer attitude towards green entrepreneurship [44, 45]. Through the analysis of literature, the Utility Renewable Energy business model as well as Customer Renewable Energy business model deemed to be the proposed framework as discovered by scholars in ensuring the monitoring and viability of maintaining clientele with the use of technological assistive programme and stakeholder liaison [9, 12, 13, 46, 47].

Lessons learnt in the form of learning best practices from developed countries, and neighbouring African countries need to be replicated in the South African context, to share the success factors on Energy and advances on technological factors [24]. Furthermore, there should be system management of key holders such as knowledge dissemination through conferences and workshops, the guidance of the search and sponsorship to steer the direction of research and to find how best to formulate policies within the area of Renewable Energy, market niches as well as resource mobilisation such as infrastructure, tax-exempt and micro-financing [48]. The latter mechanisms of financing structures would offer affordable Renewable Energy for a better quality of life to societies at large. In [49], the author asserts that there should be a monitoring tool rating system to ensure that the infrastructure implemented is sustainable. The proposed monitoring tool is sustainable infrastructure rating system [49]. Drawing from this discovery, the authors in the current paper assert the rating system can be used specifically when implementing Energy technologies, services or distribution of renewable Energy tools.

Vat returns, Government subsidies, tax incentives for innovation, price control, demand assurance, venture capital are some of the supporting mechanisms implemented worldwide [9-11] of which we believe that South Africa can also implement these mechanisms. A need for strong coordination and memorandum of understanding with the countries who have

developed these mechanisms is needed, to allow exchange programmes within the SMEs in Energy, particularly targeting Youth, Black people, women as well as people living with disabilities as these group, still fall in the designated, previously disadvantaged backgrounds. To broaden the latter perspective, Broad-Based Black Economic Empowerment (BBBEE) will need to also include additional lenses of facilitating Green entrepreneurship and points to be allocated respectively in the form of tendering systems within the advances of Energy sectors.

A further area of consideration is how can different business models such as Pty Ltd (public companies), private companies, close corporation, partnerships, benefit from Renewable Energy at the same time saving the planet. Furthermore, the authors are of the opinions that once the mapping of success factors of different business models can be understood and investigated, support such as lessons learnt, specific funding and non-financial support can be tailored to different Renewable Energy enterprises.

Globalisation in the current context can be seen as a contributing factor, whereby the country such as South African can benefit from markets internationally. In [38], the author echoes the latter statement in supporting imported goods and services such as imported technology for hydropower generation and Biomass. Scholars have demonstrated that through biomass combustion with coal and setting the technologies to exposed heat generate electricity in an effective way [15]. The latter then has further been tested to have saved enterprises when it comes to cost and effective way to the adoption of Renewable Energy [15].

Although imports may also impact on the level of emissions and the cost of Energy services or products, the import of resources serves as the immediate mechanism as South Africa lack enough resources to engage in Energy thematic area effectively. This may imply that concessions and discounted rate may need to be negotiated between two countries embarking on exports and imports. The researchers are of the opinion that there should be public and private organisations willing to train and invest in imports and exports when it comes to Energy enterprises. The introduction of Public-private partnership (PPP) of policies to accelerate the Energy technologies as well as community members being included from the planning to implementation phase in collaboration with NGOs similarly to Nepal's initiatives [32], is needed and may need to be implemented in the South African context.

Saurian lighting low-cost solar lamps as part of renewable Energy [38] serves as a green entrepreneurship initiative that could be explored in the South African context especially in the rural areas and restoring access of Energy to the society.

Further research conducted in other parts of African countries promulgated by UN is African Rural Energy Enterprise Development (AREED) programme and national strategy for the Development of Renewable Energy [23], which South Africa could benefit from the initiative in accelerating entrepreneurship and collaboration in the sector. The need to contribute to society by reducing the electricity bills for those who cannot afford as a form of contributing to the social context when it comes to Energy [19] serves as a priority. Drawing from this idea, the current researchers are of the opinion that once this idea could flourish,

this may serve as an incentive for the society to support the enterprises in the sector.

7.2. *Discussions of Renewable Energy enterprise ecosystem to Sustainable development Goals*

In this section, the authors then used the theoretical framework highlighted above through the analysis of literature to map the sustainable development goals to the Renewable Energy ecosystem as depicted in figure 3. A further contribution of the paper is that the authors are arguing that in order to accelerate the sustainable development goals, each thematic area of the green economy needs to be explored and systematically mapped onto the sustainable development goals for an impact. In contribution to the sustainable development goals, the authors are proposing using sustainable development goals as a framework for selecting specific sustainable development goals in mapping the elements of the Renewable Energy enterprise ecosystem.

In order to effect the latter objective the theoretical renewable Energy ecosystem can be used as follows: in order to facilitate the access to the markets, the price of Energy products and services needs to be monitored with set policies and governments subsidies or alternative financial mechanisms upon which the Goal 1 Eradication of poverty, Goal 2 No hunger, Goal 8 Decent work and economic growth, Goal 9 Industry, innovation and infrastructure, Goal 10 Reduced inequality can be accelerated and achieved.

The alternative forms of Energy such as Solar, off the grid, saurian lighting lamp and hydro-powered Energy [21, 30, 38] can further accelerate Goal 7 Affordable and Clean Energy for the better quality of life and livelihoods. Then for further evaluation monitoring and sustainability continuous learning, non-financial support empowering of women and youth, as well as people of colour, can further accelerate Goal 4 Quality education.

8. **Future recommendation**

The next steps will be to test and validate the proposed key accelerators and ways to minimise the barriers that may affect entry to renewable Energy enterprises. Furthermore, scientific empirical data will be needed to test the theoretical contribution of the mapping of sustainable goal with renewable Energy as Green economy thematic area. Furthermore, research on which type of business survives and gets on the markets quick receiving enough support serves as a future research agenda.

9. **Conclusion**

The paper explored various works of literature building the ecosystem through the elements highlighted by most researchers in the field of Renewable Energy enterprises or business ventures. Enabling the green economy involves innovation [17], which in the current study, Renewable Energy enterprise ecosystem serves as the innovation the current authors are proposing. The researchers are of the opinion that once this milestone of capacity building in terms of climate change, and the Green economy is fully implemented then this mechanism can be a wheel to Renewable Energy ecosystem in the transition to green economy.

The theoretical ecosystem consists of accelerators, societal factors, sustainable development goals, as well as selected business models. The latter ecosystem was then contextualised in the South African context for a complete framework. Some of the accelerators of Renewable Energy are financial and non-financial support mechanisms, generic business models such as customers and demand and monitoring. In answering how can theoretical Renewable Energy enterprise ecosystem be contextualised in the South African context research question: The applicability in the South African context was discussed highlighting the access to Energy by the society at large through reducing of inequality, entrepreneurship and eradication of poverty in drawing from sustainable development goals. In answering the research question: How can Renewable Energy enterprise contribute to sustainable development goals theoretically: Is through the relevant theoretical contribution of eradication of poverty, decent work for all, access to clean and affordable Energy as well as the quality of education. From the analysis of literature rating system, quantification and measurable goals need to be in place to ensure that the plans for implementation of the Renewable Energy are in place. The researchers are then proposing that entrepreneurial markets to be enabled in this arena, and that is where the motives of entrepreneurship would highly contribute to the sense of social gain and uplift and contributing to sustainable development goals with less attention on profit generation.

The benefits of Renewable Energy, as explained above, can benefit people living in rural area through better quality of living and health. Majority of people living in Bangladesh use kerosene, candle and often have to walk a long distance to fetch wood for cooking, Renewable Energy through natural resources such as biogas, the solar, wind, hydropower can benefit the society of rural of Bangladesh [21]. The latter benefits can also benefit most part of rural areas, and some townships in South Africa as some communities are still using candles, paraffin stove and often have to fetch water and wood to cook.

Conflict of Interest

The authors declare no conflict of interest

Acknowledgment

IEEM, IEEE 2019 conference motivated and sparked the need to produce another paper emerging from Green entrepreneurship paper the authors presented and published as well as the emerging paper on environmental entrepreneurship the authors produced to be included on Scopus special review. The spark of an idea led to authors focusing on one Green economy thematic area, which is Energy, and refining the research to focus only on the enterprise within the Energy sector. Furthermore, large parts of the paper were presented through poster presentation during 1st annual French South Africa Innovation days held in South Africa CSIR December 2019. The authors will like to thank the coordinators and planners of the latter event. Furthermore, the Authors will like to give thanks to their respective higher learning institutions namely Rhodes University and University of South Africa.

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A Proposed Framework to Improve Containerization from Asia to North America

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ABSTRACT

The constant market change and the critical role of the logistics process in the supply chain need to have special attention because it is an essential piece for the global business strategy. This paper presents an assessment of the processes of handling material from Asia suppliers to North America. The data utilized for the analysis is of 12 months of 2019, valuable input to support the proposal to the company to approve the changes to get a financial gain. The proposal aims to create a complete analysis starting on how the containers are loaded currently in Asia (floor loaded) and the complexity that this strategy creates for the whole supply chain. The analysis of the overall process aims how the proposed change (pallet loaded) will reduce demurrage cost annually (USD 147,000), lead time (from 6 days to 3 days), space utilization in the facility (reduce space by 6364 sqft/ft), reduce operational cost annually (USD 210,000), improve safety (Risk factor savings annually of USD 61,100), and on-time delivery to the customer (Increase 4%).

1. Introduction

In the current global supply chain footprint, one of the most critical parts is the transportation of goods from any place in the world to fulfill customer requirements. Companies are significant in maintaining competitive advantage from the competition, and the company needs to be prepared with flexibility and responsiveness to the dynamics of the customer demands [1].

Container loading is a pivotal function for operating supply chains efficiently, and underperformance results in unnecessary costs (e.g., cost of additional containers to be shipped) and in unsatisfactory customer service (e.g., violation of deadlines agreed to or set by clients). Thus, it is not surprising that container loading problems have been dealt with frequently in the operations research literature. It has been claimed, though, that the proposed approaches are of limited practical value since they do not pay enough attention to constraints encountered in practice [2].

Organizations must be capable of fast, radical changes, and those that aspire to be best must lead to changes [3]. Container shipping has changed the scale and scope of global freight distribution. By enabling a higher rate in freight distribution, it has opened up new global markets for export and import as a higher quantity of space could be traded with a similar, if not lower, amount of time and often at a lower cost. This rate is much more a

function of time than of speed as containerization mostly improved the function of transshipment [4].

The current customer changing needs force the supply chains to look for continuous improvement on the value-added on the different processes and create dynamic changes on how the goods are move through the chain [5].

The scope of the research is to determine the best containerization in Asia. Changing the way of containerization to create a faster supply chain reducing the safety stock needed for the waiting time in the ports to fill a floor loaded container and the overall improvement on reducing the extra cost that hits directly on the operating income of the company [6].

Part of the assessment comprised the current state of process from the point of origin Asia to the point of receipt in North America (Mexico), in that review the specific process that takes place in that part of the chain and creates a proposal for improvement that can be measured.

For the company case of study, the fast pace of customer demand is one of the essential value-added that is offered to the customer. For this reason, the supply chain needs to be fast, flexible, and dynamic to support what is being offered.

The company is focused on the wellbeing of the associates. The current container unloads process of a floor loaded container is

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very demanding and with a high risk of injury due to unloading by hand over 3000 to 4000 containers daily, that in the long run, can harm the associate's health, that in the final result of the project will be to eliminate this risk of injury, the impact of this is of USD 61,100 of saving on the risk factor.

2. Literature Review

The container system is slowly reaching maturity in a market environment where freight transportation has become the most volatile and costly component of many firms' supply chain and logistics operations. Managers must deal with delays in the transport system, with rising oil prices, complex security issues, and with labor and equipment shortages and trade imbalances. Each of these problems adds risk to the supply chain, and the problems are likely to get worse before they improve. Managers in the logistics industry, including the port and maritime industry, are spending more and more of their time handling freight transport missteps and crises. As such, reliability and capacity issues have emerged as critical factors next to pure cost considerations [1].

Empty container repositioning has been an on-going issue since the beginning of containerization. However, it has become more prominent in recent decades due to the rapid growth of the container shipping business and the regional difference in economic development. The critical factors that cause empty container movements, which include the trade imbalance, dynamic operations, uncertainties, size and type of equipment, lack of visibility and collaboration within the transport chain, and transport companies' operational and strategic practices [6].

Over the past decade, there has been a growing consensus concerning the strategic importance of integrating suppliers, manufacturers, and customers convincingly argued, the once narrow subject of logistics has become a broad topic that now spans the entire value system from suppliers to customers [5].

The first in the line of warehouse processes is the receiving of goods. This process does not take as much time as picking, which is shown onwards, but it is as relevant as any. Especially if incorrect put-away occurs and causes errors in further processing. The process of receiving can begin with the notice of the arrival of the goods. It permits the warehouse to prepare to schedule inbound operations, so there are no uncoordinated events. With the arrival, unloading begins after which units are put away with accurate documenting before [7].

Container loading problems can be interpreted as geometric assignment problems, in which small three-dimensional items (called cargo) have to be assigned (packed into) to three-dimensional; rectangular (cubic) large objects (called containers) such that a given objective function is optimized and two underlying geometric feasibility conditions hold, i.e. [2]:

- All small items lie entirely within the container
- The small items do not overlap.

A formal description of a solution to an assignment problem of this kind will be called a loading pattern.

According to the typology introduced in [8], one can distinguish between container loading problems, in which enough containers are available to accommodate all small items, and such

problems, in which only a subset of the small items can be packed since the availability of the containers is limited. Problems of the first kind are of the input (value) minimization type, those of the second type represent the output (value) maximization type.

Moreover, the changes in operations and processes of warehouses should cover every activity in warehousing [9] such as:

- Receiving: the process of unloading the incoming truck, identifying, registering, and sometimes repacking.
- Put away: moving the goods from the unloading dock to the storage area.
- Storage - in bulk or pick activities at the warehouse, affect goods in storage. For instance, the number of stocks must be counted to verify inventory quantities.
- Replenish If inventory levels of the pick storage drop to specific amounts, it is replenished with stocks from the bulk storage.

Leaning on a material-handling environment encompasses two main elements; value stream mapping to define the optimal future situation and analysis of the logistics flows used to move products in order to optimize the facility layout. Both practices aim to improve the operation continuously. Traditional warehouses should become cross-dock operations. Lean cross-docking operations should integrate principles as heijunka planning, advanced routing methods, and kanban. These principles would create flow in picking, packing, and replenishing while simultaneously reducing average order cycle time in [10].

Consider shipping priority in container loading, where high priority boxes must be loaded before those with low priority. They propose a multi-round partial beam search method that explicitly considers shipping priority when evaluating the potential of partial solutions to solve this problem. Since existing benchmark data for shipping priority covers only weakly different instances, they extend the benchmark data to strongly heterogeneous instances [11].

In accordance [12], the overall duration of the transport process, as well as the balance of the elements, differ depending on different factors, such as:

- Average distance cargo transport
- Localization of distribution points and cargo transportation conditions
- The capacity of the vehicle
- Technical speed of vehicle movement
- Technical vulnerabilities of cargo transport
- The level of mechanization degree of loading mechanisms construction
- Construction of highways surface and other

3. Research methodology

The research methodology for the study is described in Figure 1. The overall process of the research is to understand what is the problem that we have encountered; moreover, after that, it is the

process that needs to be worked on to create a solution that is in line with the expectations of the company in the study.

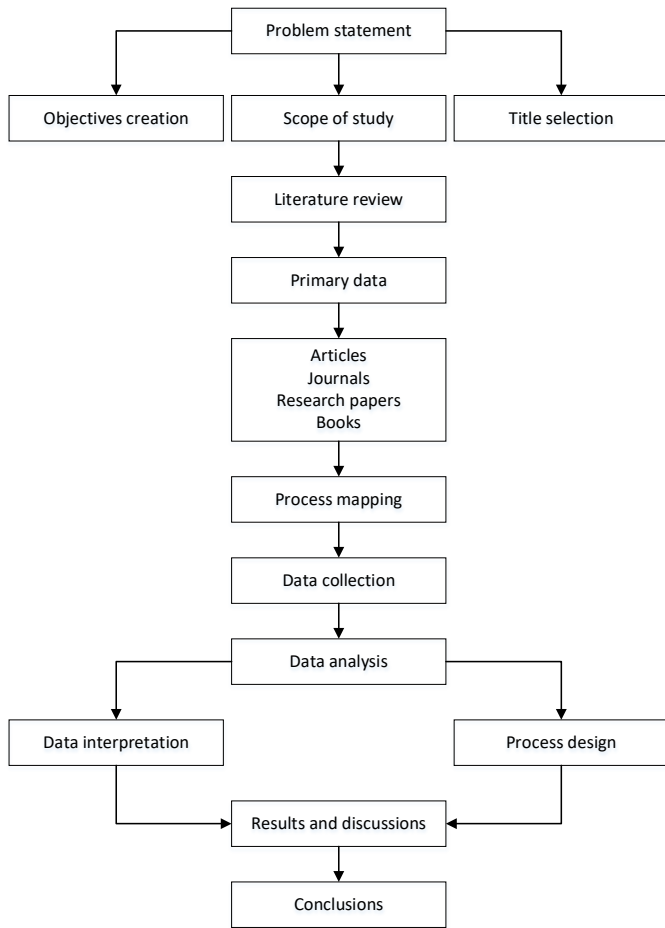


Figure 1: Research method for the study.

4. Case study

4.1. Problem statement

The company in the study is the leader on security products, with a distribution of goods to all the world, the manufacturing plant is in Mexico for finish good and most of the main components are made in the United States of America. The supply strategy for the make to stock business is 60% of the goods purchased to Asia suppliers, and the 40% is assembled in Mexico; on the make to order business, 100% of the products are made in Mexico with most of the components from U.S. suppliers, Mexico suppliers and very small from Asia suppliers.

By doing this study, the company is looking for the overall improvement on the lead time, create a lean supply chain from Asia to Mexico. Reducing the need for safety stock inventory that is not needed and the overall reduction of cost the effect the operating income, and by making this improvement, the company will improve on the customer service level and that, in the long run, will bring incremental sales and revenue Figure 2.

The overall market dynamics are forcing supply chains to change the current footprint dynamics to accommodate every changing customer requirement better. Regarding the current stage, much investment is put into creating a better logistic

network to support this. Moreover, the company found an opportunity to create a proposal by changing the way the containers are loaded in Asia.

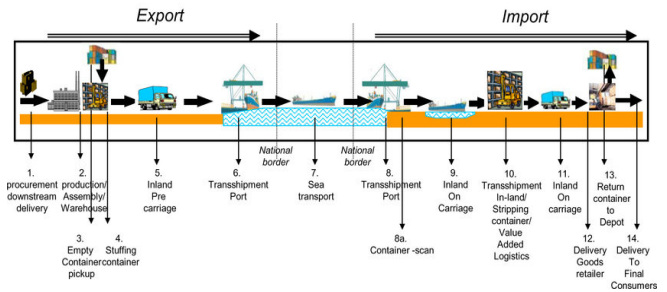


Figure 2: Overall ocean container flow.

In the current supply chain footprint of our Asia supplier, the company has a total of 38 suppliers that are located in mainland China, and seven are in other Asian countries (i.e., India, Vietnam, Philippines). Focusing on mainland China suppliers.

The scope of the project is to focus on the containers that are built-in mainland China that is close to the company suppliers in which the supplier ship to a consolidator in which they put cargo from different suppliers that are shipping to the same end-user. The ports utilized to ship material to the United States of America are:

- Yantian
- Hong Kong
- Shanghai
- Ningbo
- Keelung is out of Taiwan
- Shenzhen

After containers are built in China, they are moved to the freight forwarder cargo lines that will load the container to the boat to ship it out to Long Beach port to be unloaded.

The results of the demurrage cost USD 200.00 per day per container which is a delay that has been affecting the company due to the high cost per day because of not returning a container in the appropriate lead time.

The statistical data that was analyzed is from all the containers that arrived to the U.S., from Asia in 2019. Because of the COVID-19 pandemic, the data from 2020 is very different due to Asia suppliers delaying container flow. The company decided to use the 2019 data to obtain where the company was situated in the current state. Moreover, the lateness that the company has based and how long is it taking to unload the containers in the warehouse.

The total amount of containers that arrived in 2019 to the plan was 480 containers, from those, 344 are 40' size (equal to 72%) and 136 are 20' size (equal to 28%). From this data, the company needed to understand if there was a correlation between total boxes in the container and the pallets built per container. In Figure 3, a scatterplot of boxes quantity vs. pallet built for 40' container is presented and in Figure 4 is shown a scatterplot of box qty vs. pallet built for 20' container.

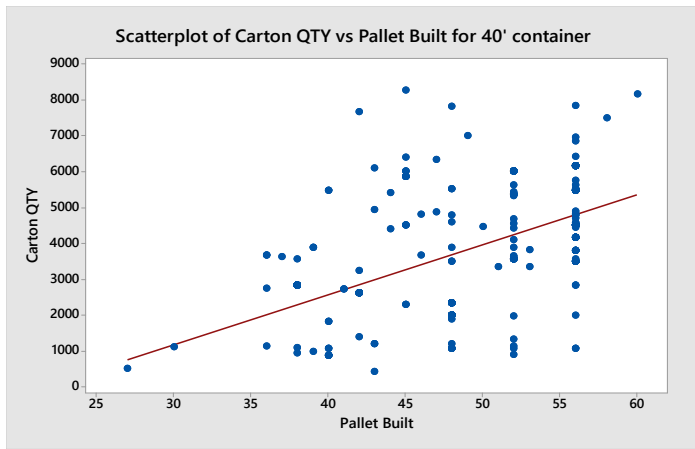


Figure 3: Scatterplot boxes qty vs. pallet built for 40' container.

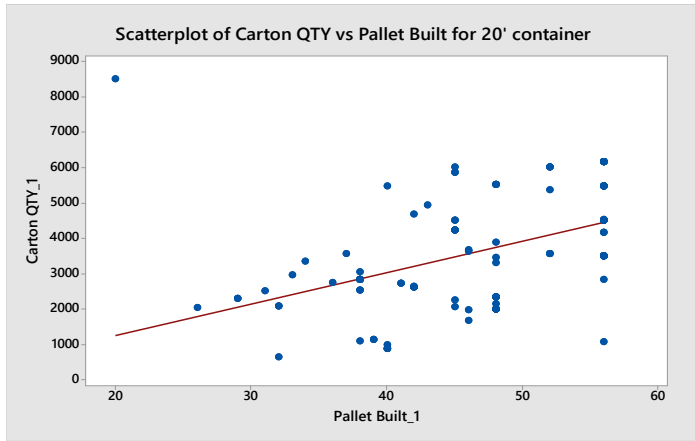


Figure 4: Scatterplot boxes qty vs. pallet built for 20' container.

As a result of the 40' container, the high-density population is between 45 to 55 pallets built per container. Furthermore, the 20' containers' population is between 40 to 50 pallets built. The plan is to eliminate the use of 20' containers and only use 40' ones to maximize utilization of the capacity of the container that is 5 to 15 more pallets than the 20' container. It is a quick example of how a floor loaded container arrives at the facility, see Figure 5. The correlation found in the analysis was that the company could eliminate the need for shipping in the 20' container, if the process is implemented of pallet loaded and changing to use only 40' containers due to the number of pallets that can be loaded.



These are the results analyzing the data in Table 1.

Table 1: Container boxes and pallet building.

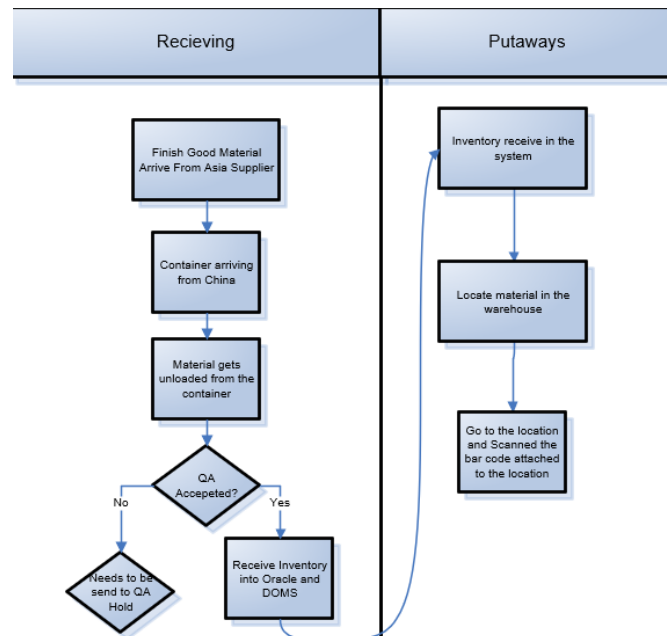
Container Length	The total quantity of boxes	Total Quantity of Pallet Built
20'	505,500	6,495
40'	1,364,734	17,214
Grand Total	1,870,234	23,709

Reviewing the results, they show the complexity of how the company has delays in unloading containers. The complexity of the process is that it is manual labor to unload the boxes from the container and then create pallets that will be received and then put-away in the warehouse. The manual process of unloading the containers has created an extra lead time of 3.06 days in the high season, and that is the issue of why the company has a high demurrage cost, affecting 240 containers every year, with those delays the company incurred in demurrage cost that affects the financial performance of the company due to an operational issue on how the container is loaded, how the container is unloaded and the receiving process of the goods.

4.2. Analyzing and creating the business model

For any continuous improvement project, it needs to define the current process map, to understand what are the areas of opportunity that are needed to focus on. This project is the actual process flow which has been focused on the receiving and put away part of the process, see Figure 6. the process map gave the company an overall perspective to analyze where it can focus resources to create a valuable proposition.

Following the current process flow, when the containers arrive from Asia, first the container arrive at Long Beach, after that it has to wait for its turn to be downloaded from the boat with a crane and be put into the inbound area, in that the transporter goes and picks up the container to bring it to the company yard, there it waits its turn to be crossed to Mexico to start the unloading process.



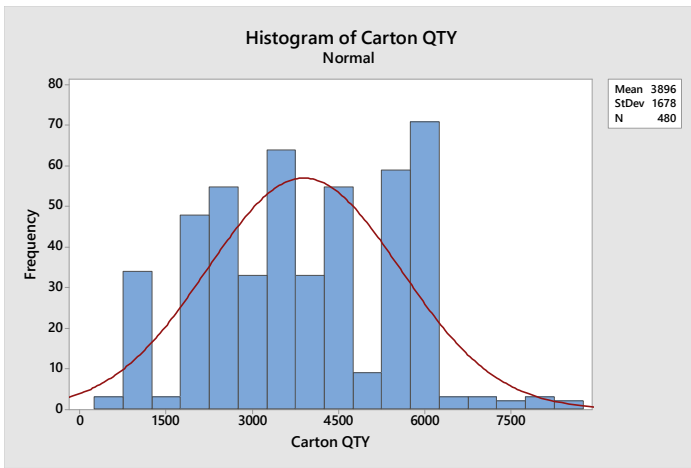


Figure 7: Histogram of box quantity.

In this part of the process is where we found the first issue. The complexity of how the containers are loaded in Asia (floor loaded) and the average amount of boxes per container affects the overall lead time to unload, delaying the unloading so the company occurs into demurrage.

On a yearly average, the company had 240 containers on which there was a delay of 1 day, and more to return the container to the supplier yard. This delay in the process has generated a loss of USD 147,200. By changing the process this cost can be eliminated.

In the data analysis, the average and the standard deviation per container on how many boxes and the pallet are represented in Figure 7 and Figure 8. The results obtained are that the average quantity of boxes in the container and the average pallet built from those boxes is equal to the number of complete pallets that fit inside a container, creating an opportunity in the process to change the current process of floor loaded to pallet loaded.

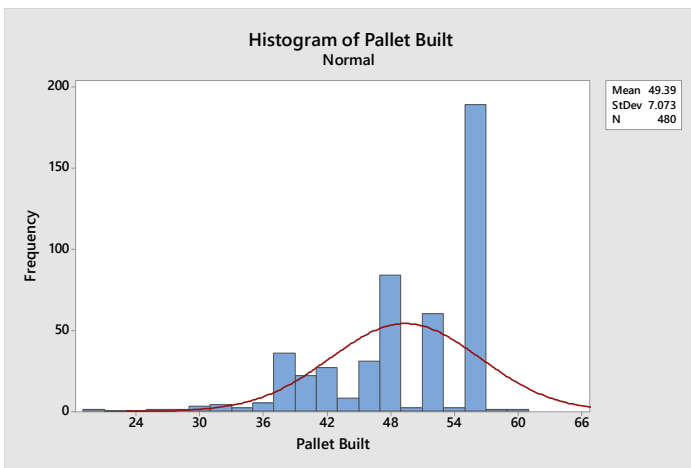
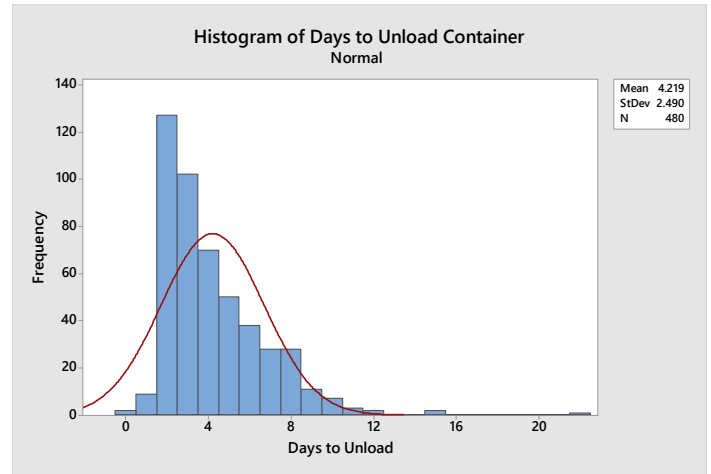


Figure 8: Histogram of pallet built.

The complexity of the process is outlined with the data of one year. On a yearly average per container, the company receives 3896 boxes per container and those equal to an average of 50 pallets per container. The study shifted to understand the lead time

that is taking to unload the containers from Asia, the lead time that the company has is three days to receive the container, unload, and return the container to the supplier yard, see Figure 9. In this histogram, the company is measuring the total lead time for a container to be unloaded.



There is an average of 4.2 days (this is taking the 480 containers, from which 240 were unloaded at or before the lead time of 3 days) to unload the container with a standard deviation of 2.49 days. The lead time that the company has is three days to return the container; this result creates an extra cost in the organization that is a demurrage cost in which for any extra day it takes for the company to ship the container back to the logistic cargo supplier, the cost is USD 200 per day for delay. The company needed to understand the lateness of the containers. Figure 10.

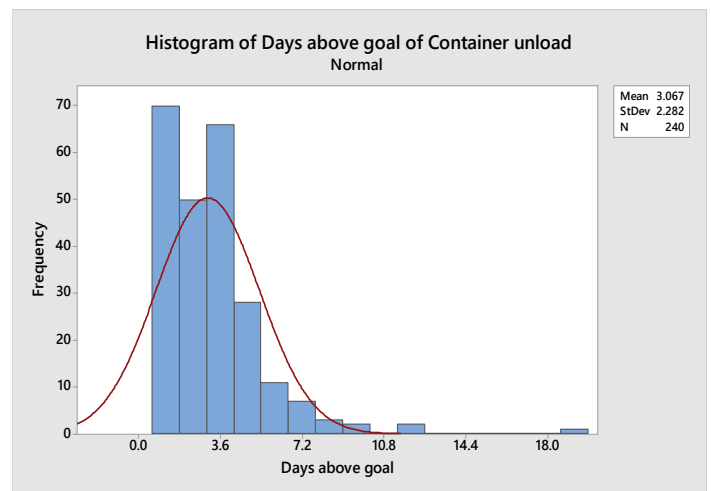


Figure 10: Histogram of days above the goal of container unload.

The result that was obtained (only 240 containers that were shipped out late back to the supplier yard) is that the days above the lead time on average is 3.06 days with a standard deviation of 2.28; with this, the company calculated an impact on the cost of USD 147,200 that affects the operating income, see in Table 2 cost due to demurrage.

Table 2: Cost due to demurrage.

Container Length	Cost due to demurrage	
20'	USD	45,600
40'	USD	101,600
Grand Total	USD	147,200

Based on the case study it's been determined that the company needs to work on improving the container loading in Asia. On the current process, the supplier can ship future P.O.s of material that are not needed yet, to fill up a container at the max on boxes and weight. This issue creates extra inventory that the company does not need; by changing the strategy, the company will eliminate the extra carryover inventory that is not needed and improve cash flow by not having inventory that is not needed due to an operation process. It will be reviewed to cut the need for those extra containers by reducing the safety stock level from 120 days of finish adequate supply to 90 days of safety stock. It will help to reduce the necessary containers between 60 to 90 that have an extra carryover of 30 extra days of safety stock. The significant impact is not having the correct inventory in the correct place to support customer demand, and the impact associated with that is customer fines because of out of stock that creates filling rate issues on the stores, on-time delivery because of shipping late, waiting for inventory to arrive and loss of sales due to cancellations.

Connecting this to the other warehouse process, in the unloading process, the company has two crews for the receiving process, each crew is of 7 associates, for a total of 14 associates, and one forklift driver that is the one that when the pallet is complete, he moves the material to a staging area for the quality team to audit each of the pallets that were made.

If the company improves the process of how the containers are loaded in Asia, there will be an immediate impact on the labor needed to unload a container, changing the way the container has been loaded in Asia from floor loaded to pallet loaded, improves the velocity in the process by eliminating the manual unloading box by box and improves the safety of the workforce by eliminating the manual labor of moving and unloading boxes.

The current labor of one crew to unload one container of 40' is between 3 to 4 hours depending on the number of boxes, the mix of SKU in the container, and the weight of each of the boxes. Each container has a different complexity inside of it. If the container is changed to a palletized container, one forklift driver can unload one container between 30 minutes to 60 minutes; in one day, one forklift driver can unload, taking the max time nine containers in one shift.

The cost of one receiving associate full loaded (salary + benefits) is around USD 15,000 per year; with this proposal, the reduction is for a total of 14 employs two unloading crews, each receiving associate earns USD 15,000 per year, with the reduction of the 14 associate the company can save on their operating cost

USD 210,000 per year when the proposed improvement is implemented.

Continuing to connect the dots of the analysis, and the company encounters another area of opportunity, floor space utilization for staging the building of the pallets. Moreover, in any industry, floor space is precious because staging and storing do not add value to the product, it adds cost. If there is an opportunity to save space, the company can save money and use that space for something that can add value to a product, for example, more production lines.

The total area that can be reutilized by adding more cells in an area of 86'x74' for a total of 6364 sqft/ft equals 10.5% of total production space, of the estimated cost of sqft/ft, taking all of the cost into consideration for a productive area is around \$48 x sqft/ft; this gives a saving or possible revenue of USD 305,472 that can be added for the justification of the project, see Figure 11.

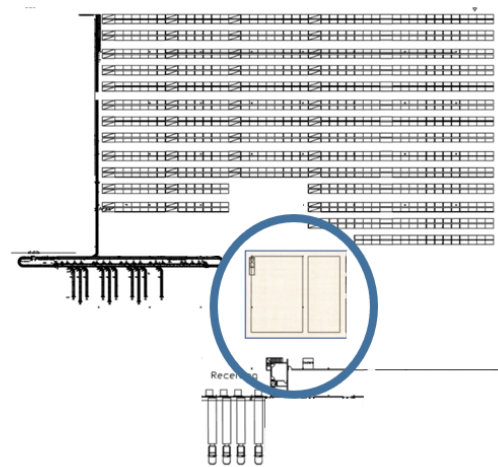


Figure 11: Finish good facility warehouse layout

5. Results and discussions

The purpose of this paper is to develop a proposal assessing the effectiveness of a change in the container operations loading process in Asia. As a result, the best solution found is to propose a change in the way the containers are loaded.

The improvement is changing from floor loaded container to pallet loaded container. The company has defined the pallet structure from Asia to maximize the pallets that can be loaded in the container. The proposal is to utilize only 40' containers and eliminate the use of 20' containers.

The interior dimensions of a container (in feet): 39' 6" long x 7' 9" wide x 7' 10" high, that is equal to 4,143,708 cubic/inches; with data, it can be calculated how many standard pallets the consolidator can load into the container, the standard size including the pallet will be 40"x48"x48, that will help the company load two lines of pallets double stack to have 40 pallets per container. To implement this, the engineering and the sourcing team will have to work with Asia for the supplier to have the pallet pattern and follow the new direction; that with this, the company will not have

to invest in more containers need base on the reduction due to safety stock not needed.

With this proposal, there is a potential saving in demurrage, labor, and space utilization. Another savings is the reduction of the risk factor on the unloading of the operation, due because it is a manual operation that can cause injury on the receiving operator, and because the human capital is the most crucial asset in the company, by eliminating the need of the manual force the company eliminates the risk of injury, the projected reduction of the risk factor is from 0.020597 to 0.020097 that generates to a yearly reduction on this factor of USD 61,100.

For this proposal to be implemented, it needs to have a united effort between several departments and key players to get the savings that have been identified.

For example, the packaging engineer needs to start working on standardizing the pallets and specific sizes to maximize the opportunity to double stack the container. After this activity is completed, the sourcing team will need to contact the supplier in Asia to give them the new packaging specifications, from which the supplier will need to start palletizing when they receive the new specifications. After that, the company will have a specific time frame in which it will continue to receive floor loaded containers, but when that ends, the process of unloading by pallet and auditing from quality and receive will have to change to create a more dynamic flow.

The total recurrent annual savings estimated in this project, not considering the potential inventory reduction is, with near to no investment is:

- Demurrage saving USD147,200
- Labor reduction of USD 210,000
- Space cost USD 305,472
- Risk factor reduction of USD 61,100
- Total savings USD 723,772

6. Conclusions

The case study helps the organization to identify current opportunities in the containerization process in Asia.

With the current change in the market dynamics, the company encounters an opportunity to reduce lead times. The market dynamic, based on customer needs in a faster pace to respond to demand. The pandemic of COVID-19 affected supply chains first, starting with Asia. Asia stop shipments for six weeks if it is considered that in 6 weeks there is not going to be any flow, that in a macro stage equals to 12 weeks without raw material or finish good; this pandemic created needs to improve and reduce time in the supply chain.

By focusing on creating a faster approach in the unloading of the container, there are several savings for the company. Reducing the labor or relocating labor in the area by 14 employees creates a reduction in the operating income of the company.

By changing one process, it impacts several other, for example, releasing pre-stage areas to create space for new manufacturing cells, which is a direct impact on having space utilized on value-added activities instead of staging inventory.

Overall, the proposal for the project is to change the way we have been doing the operation, by changing the process we can improve the overall efficiency of the operation.

In this time of new challenges, the companies need to think differently and have an open mind in creating a culture of change to create continuous improvement.

In this project, the approach is to work the different process that conforms the supply chain. The company is improving the warehouse activities from unloading containers, receiving material goods, and put away process by having a straighter forward operation. On the transportation side, it is improving the reduction in lead time to eliminating demurrage and having a faster return of empty containers to the supplier. In supply planning, the team needs to work with the system to have the correct supply strategy based on a dynamic and faster container supply chain, by having what we needed when we needed and overall, the company will have an improvement because it will save cost on the operating income and the customer service side, the performance on the service to the customer will improve by not delaying material to ship and to arrive at the company.

Conflict of Interest

The authors declare no conflict of interest.

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I am pleased to thank my teachers for giving us the push to think differently and to create new dynamics in our workplaces.

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Organizational Agility Assessment of a Moroccan Healthcare Organization in Times of COVID-19

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ABSTRACT

Since its appearance, COVID-19 has severely impacted the healthcare sector all over the world. The healthcare organizations should be agile in order to cope with this new health crisis. Indeed, organization agility was highly recommended as an essential basis for flexibility, innovation, speed, as well competitiveness. Different research provided different conceptual models suitable to evaluate the organization agility. In this sense, this paper presents an assessment model, which by defining different agile enablers, criteria and attributes, aims at identifying the least and the most suitable enablers influencing the healthcare organization agility. To realize it practically, this paper uses the fuzzy logic approach which provides the improvement directions for enhancing the organization agility. Subsequently, the data gathered from a Moroccan healthcare organization was substituted in this assessment model and the level and the suggestions improvement for agility were derived. In this way, the organization will integrate the successful combination of the agility enablers in this dynamic environment.

1. Introduction

The story of the pandemic “COVID-19” began in 2019 when the first case were identified from Wuhan, China [1]. Since its first appearance, COVID-19 has been receiving an increasing attention by academic and executive specialists and many researches have been developed on it in order to provide a general definition of the virus. In the beginning, COVID-19 has created a global healthcare crisis, and then it disrupted other sectors: economic, environmental and social [2]. But perhaps the most significant pressure was for the healthcare organizations which strengthened their medical system [3] in order to enhance their responsiveness, adaptability, flexibility, which explains the importance of agility implementation in the healthcare sector through the outbreaks of COVID 19.

Agility concept was presented as the effective exploration of different competitive bases by including the suitable resources and practices in order to cope with the changing environment [4, 5]. Later, different proposals of agility definitions have been derived and which presented a general consensus [5]: It means the organization capacity to react quickly [5]–[11] to the varied changes in market demand [8]–[11] in terms of cost, specification, quality, quantity and delivery [11, 12]. Despite being defined in different ways and from different perspectives, agility has sometimes been used interchangeably to refer to concepts such as

adaptability, flexibility, speed, intelligence or sharpness. In contrast to this point of view, several authors have expressed the difference between these concepts, which justifies our choice to use the word "Agility" many times in our paper.

In order to evaluate the agility of an organization [5], several approaches such as system approach [5, 13], graph theory [5, 14], multi-grade fuzzy logic [15], regression analysis [5, 16] and other artificial intelligence techniques, such as neural network [15], neuro-fuzzy [15], have been used [5, 13, 14, 16–19]. A main objective of this study is to help the healthcare organization to implement an easier and less complicated practical tool in order to evaluate their agility [11]. The above purpose suggests an assessment model in which we evaluated the enablers influencing the adoption of agility [15].

Our paper is organized as follows: In the next paragraph, we review previous researches related to agile enablers. By presenting the fuzzy logic approach, we presented the required steps to apply this methodology to a real case. Moreover, the results provided are discussed and the limits of the study and suggestions for future research are finally presented [11].

2. Literature review: Agile enablers

According to different conceptual models of agility presented in literature, companies can benefit from different enablers [11] in order to achieve agility. These enablers, also known as providers

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or levers [20], were introduced by Gunasekaran [21, 22] in order to identify the required features of the agile organization [20]. In his study, he identified seven agile enablers: virtual corporation formation tools/metrics, physically distributed teams and manufacturing, quick partnership formation, concurrent engineering, integrated information system, quick prototyping tools and E-commerce [22]. In 1999, Yusuf et al. [4] presented different enablers under ten groups: the introduction of new products, the formation of partnerships, continuous improvement, short conception/production of deadlines, decentralized decision-making, response to market requirements ...etc [20]. Later, Sharifi and his colleagues proposed four enablers from four different areas: organization, people, technology and innovation [9, 23]. Based on their sample, Tolf et al. identified five essentials enablers for an agile organization: transparent and transient inter-organizational links at all levels, market sensitivity and customer focus, management by support for self-organizing employees, organic structures and flexible human and resource capacity for timely delivery [24]. In their paper [25], Lin and his colleagues suggested four agility enablers: collaborative relationships, process integration, information integration and customer sensitivity [26]. Other enablers were identified by Eshlaghy et al., as organizational structure, virtual organization, information technology, organizational culture, leadership, team working, empowerment and improvement, motivation system and planning and evaluation performance [27].

From this literature review, we can notice that there is no single list of agility enablers [20] which is due to the varied requirements of each organization [28]. However, all the enablers should have some criteria and attributes that make them agile. For example, the criterion called “Organizational structure” should be flexible to accept changes, this means that the different attributes of the organizational structure should be easily adaptable [20], while promoting a fluid flow of information [15], communication [29] and knowledge [30], which makes it possible to accept the interchangeability of employees [15] and focus on teamwork [20, 27, 30, 31]. For the other criterion “Processes”, it should be flexible [20, 30], promote and concentrate on external environment developments [20, 30, 32]. According to Sherehiy et al. [30], human resource agility, as an enabler of the agile organization [20], should be flexible [33], multi-skilled [15, 33], adaptable, resilient [20, 30, 32], able to cooperate [15, 20, 30], take personal initiative and cope well with changes [20, 30, 32]. The technology enabler should also be flexible like other enablers, modular and easily scalable [20].

Summarizing the above literature, different enablers, as listed in Table 1, are chosen as necessary conditions for organizational agility [33]. Table 1 suggest an assessment model in which we defined, firstly, the agile enablers that should be implemented by organizations; secondly, for each enabler different agile criteria are listed and finally agile attributes are identified in order to achieve the required agile criteria [15].

Table 1: Organizational agility enablers (Adapted from [12, 15, 27, 29–34])

Agile enablers	Agile criteria	Agile attributes	
Management responsibility agility (E ₁)	Organizational structure (E ₁₁)	Flattened, horizontal organizational structure that promotes innovation, training and having an open information, communication and knowledge policy (E ₁₁₁)	
		Fluid information flow (E ₁₁₂)	
		Staff interchangeability (E ₁₁₃)	
		Collaborative and team work (E ₁₁₄)	
	Devolution of authority (E ₁₂)	Clear definition of staff responsibility and authority (E ₁₂₁)	
		Training to create self-managed and multi-functional teams (E ₁₂₂)	
		Decentralized decision-making, knowledge and control (E ₁₂₃)	
		Loyalty and commitment to a project or a group (E ₁₂₄)	
		Authority change when tasks change (E ₁₂₅)	
	Nature of management (E ₁₃)	Participative management style (E ₁₃₁)	
		Clearly known management purpose (E ₁₃₂)	
		Management participation and support (E ₁₃₃)	
		Motivation of profit associated with a humanitarian approach (E ₁₃₄)	
		Regular conduct of employer–employees meetings (E ₁₃₅)	
		Quick evaluation and implementation of employee suggestions (E ₁₃₆)	
	Manufacturing management agility (E ₂)	Patient response adoption (E ₂₁)	Dominance of the culture of continuous improvement (E ₂₁₁)
			Communication media to collect responses (E ₂₁₂)
			Incorporating patient feedback into services (E ₂₁₃)
Staff empowerment to resolve patient issues (E ₂₁₄)			
Efficient information system and technology (E ₂₁₅)			
Change in business and technical processes		Flexible business system (E ₂₂₁)	
		Application of business process reengineering to reinvent and reorganize the organization (E ₂₂₂)	

	(E ₂₂)	Positive employee attitude towards change, new ideas and technology (E ₂₂₃)
		Risk management (E ₂₂₄)
	Outsourcing (E ₂₃)	Adopting supply chain management concepts to improve the efficiency of outsourcing (E ₂₃₁)
		Exploitation of information technology (IT) in supply chain management (E ₂₃₂)
		Involvement of suppliers and different agents in product/service development (E ₂₃₃)
		Working with fewer qualified suppliers (E ₂₃₄)
	Processes sensing (E ₂₄)	Promoting and concentrating on external environment developments (E ₂₄₁)
	Processes responding (E ₂₅)	Reconfigurable process (E ₂₅₁)
		Scalable process (E ₂₅₂)
		Simple process to implement (E ₂₅₃)
	Concurrent engineering (E ₂₆)	Process design (E ₂₆₁)
		Intelligent Engineering Design Support System (E ₂₆₂)
		Integrated multidisciplinary teams of customers and suppliers (E ₂₆₃)
Continuous reengineering of the organization and business processes based on benchmarking (E ₂₆₄)		
Human resource agility (E ₃)	Employee status (E ₃₁)	Flexible employees to accept the adoption of new technologies (E ₃₁₁)
		Multi-skilled and flexible staff (E ₃₁₂)
		Implementation of job rotation system (E ₃₁₃)
		Education and training for all the existing and new employees (E ₃₁₄)
	Employee involvement (E ₃₂)	Employee cooperation (E ₃₂₁)
		Employee empowerment (E ₃₂₂)
	Human resource management practices (E ₃₃)	Entrepreneurial organizational culture (E ₃₃₁)
		Reward programs to encourage innovation and based on financial and non-financial measures (E ₃₃₂)
		Multi-skill training improving organizational agility (E ₃₃₃)
		Multi-functional, developed and trained employees (E ₃₃₄)
		Development of differentiation and diversity (E ₃₃₅)
	Human resources capacities (E ₃₄)	Anticipation of problems linked to change and resolution of these problems (E ₃₄₁)
		Personal initiative (E ₃₄₂)
		Interpersonal and cultural adaptability (E ₃₄₃)
		Resiliency (E ₃₄₄)
	Coordination (E ₃₅)	Personal, informal, goal-oriented and spontaneous coordination (E ₃₅₁)
		Network communication (E ₃₅₂)
		Management-employee cohesion (E ₃₅₃)
	Human knowledge and skills (E ₃₆)	Knowledge and skills management systems (E ₃₆₁)
		Protection of sensitive information (E ₃₆₂)
Knowledge acquisition from internal and external sources (E ₃₆₃)		
Technology agility (E ₄)	Manufacturing set-ups (E ₄₁)	Flexible manufacturing setups (E ₄₁₁)
		Less time to change machine settings (E ₄₁₂)
		Modernization of machines (E ₄₁₃)
		Usage of collapsible set-ups, Jigs and Fixtures (E ₄₁₄)
		Usage of automated tools (E ₄₁₅)
		Active policy to keep work areas clean and tidy (E ₄₁₆)
	Product life cycle (E ₄₂)	Specification of product life to the patient (E ₄₂₁)
		Company encourages patient to switch to new product (E ₄₂₂)
		Products superior field performance for a stipulated period with least maintenance cost (E ₄₂₃)
	Product service (E ₄₃)	Products designed for easy serviceability (E ₄₃₁)
		Products incorporated with a modular design (E ₄₃₂)

		Service centers well equipped with spares (E ₄₃₃)
		Minimum time required to execute the planning and to restore the defective product to its original performance (E ₄₃₄)
	Production methodology (E ₄₄)	Management's interest towards investment on flexible manufacturing system (FMS) concepts (E ₄₄₁)
		Application of Lean manufacturing principles for waste elimination (E ₄₄₂)
		Development of products whose components are all outsourced and assembled in-house (E ₄₄₃)
		IT application for better supplier management (E ₄₄₄)
	Manufacturing planning (E ₄₅)	Execution of short range planning (E ₄₅₁)
		Organization's procurement policy based on time schedule (E ₄₅₂)
		Strategic network in supply chain management to exercise zero inventory system (E ₄₅₃)
		Improved manufacturing technology (E ₄₅₄)
		Structured and flexible manufacturing processes (E ₄₅₅)
	IT integration (E ₄₆)	IT utilities incorporated with reengineered pattern of working (E ₄₆₁)
		Electronic commerce [27] (E ₄₆₂)
	Customization (E ₄₇)	Rapid introduction of new products/services (E ₄₇₁)
		Responding to changing market requirements (E ₄₇₂)
		Products with high added value (E ₄₇₃)
First-time correct design (E ₄₇₄)		
Manufacturing strategy agility (E ₅)	Status of quality (E ₅₁)	Products/services exceeding patient expectations (E ₅₁₁)
		Carrying out surveys/studies to guarantee the quality status (E ₅₁₂)
		Usage of total quality management tools (E ₅₁₃)
	Status of productivity (E ₅₂)	Improved productivity in all functions (E ₅₂₁)
		Reduction of non value-adding costs (E ₅₂₂)
		Quality is not infused at the cost of productivity (E ₅₂₃)
	Cost management (E ₅₃)	Costing and product pricing system focused on value-added and non-value-added activities (E ₅₃₁)
		Costing system enabling the evaluation of future resource consumption (E ₅₃₂)
		Product cost fixed according to the pricing of the customer (E ₅₃₃)
	Time management (E ₅₄)	Scheduled activities (E ₅₄₁)
		IT based communication system (E ₅₄₂)
		Adoption of time compression technologies (E ₅₄₃)

3. Fuzzy logic methodology to evaluate organizational agility

In order to enhance organizational agility in practice, the use of different methods and tools were recommended in literature [11, 23]. Focusing on methodological articles [11], the fuzzy logic approach has been used to assess the current agility level and identify the weaker attributes that need a particular attention to enhance the organizational agility. This approach is preferred over other methodologies because it can take the linguistic data as input, then convert linguistic expressions into corresponding fuzzy intervals and finally express the results back in linguistic terms with the help of Fuzzy Agility Index (FAI) [5].

Many studies in literature have used fuzzy logic to measure agility level of the healthcare organization (e.g. [5, 35]). Taking cues from these papers, this study uses this approach to evaluate the agility of a Moroccan healthcare organization.

4. Numerical illustration of fuzzy logic approach

4.1. About the healthcare organization

Our study has been done at a public hospital (referred as HealthOrg), located in Morocco and where patients can carry out

the diagnosis of COVID-19. In order to cope with the new dynamic environment, HealthOrg aims to strengthen its agility level. However, it found it difficult to identify enablers that influence its agility, in particular the weaker ones which need to be improved [15]. In this context, we aimed to evaluate the agility of HealthOrg.

Table 2 provides an illustration of different steps to apply the fuzzy logic approach [11].

Table 2: Steps required applying the fuzzy logic methodology (Adapted from [5, 32])

Steps
Identify a list of agile enablers that influence the organizational agility.
Define the linguistic variables for evaluating performance rating and importance weights of agile attributes.
Approximate the linguistic terms by the corresponding fuzzy intervals.
Calculate the FAI of the organization.
Match the FAI with the appropriate linguistic level.
Calculate Fuzzy Performance Importance Index (FPPI).

4.2. Fuzzy logic application

- Step1: Identification of agile enablers, criteria and attributes [32]: By identifying a list of five agile enablers from the literature [5], twenty-six criteria and ninety-eight attributes were identified (Table 1).
- Step 2: Definition of the linguistic variables for evaluating performance rating and importance weights of agile attributes [32]: Following this list, five experts (E1, E2,..., E5) from HealthOrg were asked to provide the weights in terms of linguistic variables ranging from “Very low (VL)” to “Very High (VH)” and ratings in terms of linguistic variables ranging from “Worst (W)” to “Excellent (E)” [5] (Table 3).

Table 3: Importance weight and performance rating of agile attributes

Agile attributes	Importance weight					Performance rating				
	E1	E2	E3	E4	E5	E1	E2	E3	E4	E5
E111	H	FH	M	H	FH	E	VG	VG	G	F
E112	H	M	FH	FH	H	P	P	F	G	G
E113	FH	H	FH	H	FH	VP	W	G	F	F
E114	H	M	H	FH	FH	E	G	G	F	F
E121	H	M	FH	M	FH	F	F	G	VG	VG
E122	H	FH	M	H	FH	P	F	P	G	F
E123	FH	H	FH	M	FH	W	W	P	F	P
E124	H	H	M	FH	H	W	W	VP	F	F
E125	M	H	H	FH	H	G	VG	E	E	G
E131	VH	H	H	VH	H	G	F	G	G	VG
E132	H	FH	H	FH	FH	E	E	G	F	E
E133	H	FH	H	FH	H	G	G	G	VG	G
E134	FH	M	FH	M	FH	F	G	F	F	G
E135	H	M	M	M	H	G	G	G	VG	F
E136	VH	H	H	VH	VH	VP	F	P	P	G
E137	H	FH	M	FH	H	W	F	G	F	G
E211	H	H	H	FH	H	G	VG	G	F	F
E212	FH	M	FH	FH	M	W	W	F	G	VP
E213	FH	FH	FH	FH	FH	VP	P	P	F	P
E214	VH	H	H	VH	H	F	G	E	VG	E
E215	H	FH	H	FH	FH	VP	P	W	F	F
E221	FL	M	FL	FL	M	VG	F	E	F	G
E222	H	FH	H	M	FH	W	VP	G	E	G
E223	H	M	M	FH	H	VP	F	F	W	E
E224	FH	H	H	H	FH	F	G	E	VG	G
E231	VH	H	VH	H	H	F	F	G	F	VG
E232	H	M	FH	H	FH	VP	P	G	F	W
E233	H	H	H	H	H	F	W	VP	F	G
E234	FH	H	M	FH	FH	E	VG	F	G	G
E241	H	M	FH	FH	FH	VP	F	G	G	F
E251	H	FH	M	H	M	F	VG	VG	G	VG
E252	FH	FH	FH	FH	FH	VP	VG	F	G	F
E253	FH	M	FH	FH	M	W	W	VP	F	VP
E261	H	FH	H	FH	M	G	F	G	VG	E
E262	H	M	FH	H	H	W	W	G	F	G
E263	FH	M	H	FH	FH	VP	P	W	P	F
E264	H	FH	H	FH	M	G	F	P	VP	G
E311	FH	FH	H	FH	H	P	W	F	G	P
E312	H	H	H	H	H	W	W	F	F	P
E313	VH	H	VH	VH	H	F	G	P	P	P
E314	FH	H	FH	M	FH	E	VG	G	E	F
E321	H	H	H	H	H	E	E	VG	F	F
E322	FH	M	H	H	H	P	F	F	G	VG
E331	H	FH	H	H	M	E	VG	G	F	G
E332	H	H	H	H	H	E	F	G	F	F
E333	H	M	M	M	M	W	W	F	G	F
E334	FH	FH	H	H	FH	W	P	VP	G	F
E335	H	FH	FH	H	H	E	E	E	G	E

E341	H	M	FH	M	H	VP	P	F	G	F
E342	H	FH	FH	FH	M	F	G	P	F	G
E343	H	FH	H	FH	M	F	E	VG	G	F
E344	H	FH	FH	H	H	G	F	F	E	G
E351	H	H	FH	H	M	VP	F	F	F	F
E352	FH	M	M	FH	FH	E	G	G	F	F
E353	H	FH	H	FH	FH	G	E	F	F	VG
E361	M	M	M	FH	FH	W	W	W	F	P
E362	H	M	FH	FH	H	E	E	E	E	VG
E363	H	FH	H	H	H	E	VG	F	P	F
E411	M	H	M	M	FH	VG	G	F	E	E
E412	FH	FH	M	M	H	W	G	P	F	F
E413	H	M	M	M	FH	G	F	G	E	F
E414	FH	H	H	H	H	G	F	F	F	VG
E415	M	H	FH	H	H	E	G	F	P	VP
E416	FH	H	M	H	FH	W	VP	P	VP	F
E421	H	VH	H	H	H	E	F	G	E	VG
E422	FH	FH	FH	M	H	E	E	G	G	G
E423	H	FH	M	M	FH	E	VG	F	G	G
E431	H	H	FH	H	FH	G	G	VG	E	E
E432	FL	FL	L	VL	M	E	VG	G	VG	E
E433	FL	M	FH	H	FH	G	F	E	E	VG
E434	M	FH	FH	H	VH	VP	P	F	VG	VG
E441	FH	VH	M	FH	VH	E	VG	VG	VG	G
E442	H	M	H	FH	H	G	F	VG	E	VP
E443	FL	H	VH	H	FH	G	F	VP	G	F
E444	VH	H	H	FH	VH	G	E	F	VG	F
E451	VH	VH	H	H	FH	W	VP	F	G	F
E452	VH	VH	H	VH	H	W	W	G	F	F
E453	FH	VH	FH	VH	M	VP	P	G	VG	F
E454	VH	VH	H	FH	FH	G	F	F	VP	P
E455	M	H	VH	H	H	E	VG	G	VG	F
E461	FH	FL	FL	FH	FH	G	G	F	F	F
E462	FH	M	FH	FH	H	VG	E	E	F	G
E471	H	H	FH	H	H	F	F	G	VG	VG
E472	FL	FH	FH	L	FH	E	E	E	VG	G
E473	H	H	FH	FH	H	G	E	VG	F	F
E474	VH	M	VH	H	VH	W	VP	F	G	E
E511	FH	FL	FL	M	FH	F	F	G	F	F
E512	FH	FH	FH	FH	H	E	VP	E	F	G
E513	H	H	M	H	H	E	E	E	E	E
E521	H	FH	VH	H	H	VP	G	E	G	G
E522	VH	M	VH	H	VH	VP	P	P	W	G
E523	H	VH	FH	FL	FL	E	VG	G	E	E
E531	M	M	FH	H	FL	G	E	F	G	F
E532	H	FL	H	M	H	F	F	VG	F	G
E533	M	M	M	M	M	F	F	F	G	G
E541	M	H	FL	M	M	VG	E	F	G	G
E542	H	H	FH	FH	H	G	F	F	F	VG
E543	M	H	M	VL	VL	G	F	F	F	VP

- Step 3: Approximation of the linguistic terms by the corresponding fuzzy intervals [32]: These linguistic variables were approximated by fuzzy intervals [5] chosen from literature [5, 25] and presented in Table 4.

Table 4: Linguistic variables and fuzzy numbers for weighting and rating of agility (Adapted from [25])

Importance Weight		Performance Rating	
Linguistic variable	Fuzzy number	Linguistic variable	Fuzzy number
Very Low (VL)	(0, 0.05, 0.15)	Worst (W)	(0, 0.5, 1.5)
Low (L)	(0.1, 0.2, 0.3)	Very Poor (VP)	(1, 2, 3)
Fairly Low (FL)	(0.2, 0.35, 0.5)	Poor (P)	(2, 3.5, 5)
Medium (M)	(0.3, 0.5, 0.7)	Fair (F)	(3, 5, 7)
Fairly High (FH)	(0.5, 0.65, 0.8)	Good (G)	(5, 6.5, 8)
High (H)	(0.7, 0.8, 0.9)	Very Good (VG)	(7, 8, 9)
Very High (VH)	(0.85, 0.95, 1.0)	Excellent (E)	(8.5, 9.5, 10)

To calculate the average fuzzy weight and performance rating of each attribute [5], the literature recommended using average operation method [5, 27].

Example: Average fuzzy weight of the attribute $E_{111} = [H+FH+M+H+FH]/5 = (0.7, 0.8, 0.9)/5, (0.5, 0.65, 0.8)/5, (0.3, 0.5, 0.7)/5, (0.7, 0.8, 0.9)/5, (0.5, 0.65, 0.8)/5 = (0.54, 0.68, 0.82)$

Example: Average fuzzy performance rating of the attribute $E_{111} = [E+VG+VG+G+F]/5 = (8.5, 9.5, 10)/5, (7, 8, 9)/5, (7, 8, 9)/5, (5, 6.5, 8)/5, (3, 5, 7)/5 = (6.1, 7.4, 8.6)$

The following step consists of calculating the rating of each criterion [5]. An example of this calculation for the criterion E_{11} is shown below.

Example: Rating of the criterion

$$E_{11} = \frac{\sum_{k=1}^{k=4} (\text{Average fuzzy performance rating} \otimes \text{Average fuzzy weight})}{\sum_{k=1}^{k=4} \text{Average fuzzy weight}}$$

$$= [(6.1, 7.4, 8.6) \otimes (0.54, 0.68, 0.82) \oplus (3.4, 5.0, 6.6) \otimes (0.54, 0.68, 0.82) \oplus (2.4, 3.8, 5.3) \otimes (0.58, 0.71, 0.84) \oplus (4.9, 6.5, 8.0) \otimes (0.54, 0.68, 0.82)] / [(0.54, 0.68, 0.82) \oplus (0.54, 0.68, 0.82) \oplus (0.58, 0.71, 0.84) \oplus (0.54, 0.68, 0.82)] = (4.17, 5.65, 7.11)$$

By using R language, fuzzy calculations are presented in Table 5.

Table 5: Fuzzy index of agile criteria rating

Agile criteria	Agile attributes	Average fuzzy performance rating	Average fuzzy weight	Criteria rating
E ₁₁	E ₁₁₁	(6.1, 7.4, 8.6)	(0.54, 0.68, 0.82)	(4.17, 5.65, 7.11)
	E ₁₁₂	(3.4, 5.0, 6.6)	(0.54, 0.68, 0.82)	
	E ₁₁₃	(2.4, 3.8, 5.3)	(0.58, 0.71, 0.84)	
	E ₁₁₄	(4.9, 6.5, 8.0)	(0.54, 0.68, 0.82)	
E ₁₂	E ₁₂₁	(5.0, 6.5, 8.0)	(0.46, 0.62, 0.78)	(3.52, 4.88, 6.28)
	E ₁₂₂	(3.0, 4.7, 6.4)	(0.54, 0.68, 0.82)	
	E ₁₂₃	(1.4, 2.6, 4.0)	(0.50, 0.65, 0.80)	
	E ₁₂₄	(1.4, 2.6, 4.0)	(0.58, 0.71, 0.84)	
E ₁₃	E ₁₂₅	(6.8, 8.0, 9.0)	(0.58, 0.71, 0.84)	(4.49, 5.99, 7.47)
	E ₁₃₁	(5.0, 6.5, 8.0)	(0.76, 0.86, 0.94)	
	E ₁₃₂	(6.7, 8.0, 9.0)	(0.58, 0.71, 0.84)	
	E ₁₃₃	(5.4, 6.8, 8.2)	(0.62, 0.74, 0.86)	
	E ₁₃₄	(3.8, 5.6, 7.4)	(0.42, 0.59, 0.76)	
	E ₁₃₅	(5.0, 6.5, 8.0)	(0.46, 0.62, 0.78)	
	E ₁₃₆	(2.6, 4.1, 5.6)	(0.79, 0.89, 0.96)	
E ₂₁	E ₁₃₇	(3.2, 4.7, 6.3)	(0.54, 0.68, 0.82)	(3.66, 4.93, 6.23)
	E ₂₁₁	(4.6, 6.2, 7.8)	(0.66, 0.77, 0.88)	
	E ₂₁₂	(1.8, 2.9, 4.2)	(0.42, 0.59, 0.76)	
	E ₂₁₃	(2.0, 3.5, 5.0)	(0.50, 0.65, 0.80)	
	E ₂₁₄	(6.4, 7.7, 8.8)	(0.76, 0.86, 0.94)	
	E ₂₁₅	(1.8, 3.2, 4.7)	(0.58, 0.71, 0.84)	
E ₂₂	E ₂₂₁	(5.3, 6.8, 8.2)	(0.24, 0.41, 0.58)	(4.45, 5.77, 7.04)
	E ₂₂₂	(3.9, 5.0, 6.1)	(0.54, 0.68, 0.82)	
	E ₂₂₃	(3.1, 4.4, 5.7)	(0.50, 0.65, 0.80)	
	E ₂₂₄	(5.7, 7.1, 8.4)	(0.62, 0.74, 0.86)	
E ₂₃	E ₂₂₄	(5.7, 7.1, 8.4)	(0.62, 0.74, 0.86)	(3.56, 5.05, 6.55)
	E ₂₃₁	(4.2, 5.9, 7.6)	(0.76, 0.86, 0.94)	
	E ₂₃₂	(2.2, 3.5, 4.9)	(0.54, 0.68, 0.82)	
	E ₂₃₃	(2.4, 3.8, 5.3)	(0.7, 0.8, 0.9)	
E ₂₄	E ₂₃₄	(5.7, 7.1, 8.4)	(0.50, 0.65, 0.80)	(3.4, 5.0, 6.6)
	E ₂₄₁	(3.4, 5.0, 6.6)	(0.50, 0.65, 0.80)	
E ₂₅	E ₂₅₁	(5.8, 7.1, 8.4)	(0.50, 0.65, 0.80)	(3.68, 4.89, 6.18)
	E ₂₅₂	(3.8, 5.3, 6.8)	(0.50, 0.65, 0.80)	
	E ₂₅₃	(1.0, 2.0, 3.2)	(0.42, 0.59, 0.76)	
E ₂₆	E ₂₆₁	(5.7, 7.1, 8.4)	(0.54, 0.68, 0.82)	

E ₃₁	E ₂₆₂	(2.6, 3.8, 5.2)	(0.58, 0.71, 0.84)	(3.29, 4.63, 6.03)
	E ₂₆₃	(1.6, 2.9, 4.3)	(0.50, 0.65, 0.80)	
	E ₂₆₄	(3.2, 4.7, 6.2)	(0.54, 0.68, 0.82)	
E ₃₂	E ₃₁₁	(2.4, 3.8, 5.3)	(0.58, 0.71, 0.84)	(3.08, 4.57, 6.06)
	E ₃₁₂	(1.6, 2.9, 4.4)	(0.7, 0.8, 0.9)	
	E ₃₁₃	(2.8, 4.4, 6.0)	(0.79, 0.89, 0.96)	
	E ₃₁₄	(6.4, 7.7, 8.8)	(0.50, 0.65, 0.80)	
E ₃₃	E ₃₂₁	(6.0, 7.4, 8.6)	(0.7, 0.8, 0.9)	(5.09, 6.55, 7.92)
	E ₃₂₂	(4.0, 5.6, 7.2)	(0.58, 0.71, 0.84)	
	E ₃₃₁	(5.7, 7.1, 8.4)	(0.58, 0.71, 0.84)	
	E ₃₃₂	(4.5, 6.2, 7.8)	(0.7, 0.8, 0.9)	
	E ₃₃₃	(2.2, 3.5, 5.0)	(0.38, 0.56, 0.74)	
E ₃₄	E ₃₃₄	(2.2, 3.5, 4.9)	(0.58, 0.71, 0.84)	(4.69, 5.97, 7.21)
	E ₃₃₅	(7.8, 8.9, 9.6)	(0.62, 0.74, 0.86)	
	E ₃₄₁	(2.8, 4.4, 6.0)	(0.50, 0.65, 0.80)	
	E ₃₄₂	(3.6, 5.3, 7.0)	(0.50, 0.65, 0.80)	
E ₃₅	E ₃₄₃	(5.3, 6.8, 8.2)	(0.54, 0.68, 0.82)	(4.21, 5.79, 7.32)
	E ₃₄₄	(4.9, 6.5, 8.0)	(0.62, 0.74, 0.86)	
	E ₃₅₁	(2.6, 4.4, 6.2)	(0.58, 0.71, 0.84)	
E ₃₆	E ₃₅₂	(4.9, 6.5, 8.0)	(0.42, 0.59, 0.76)	(4.20, 5.86, 7.45)
	E ₃₅₃	(5.3, 6.8, 8.2)	(0.58, 0.71, 0.84)	
	E ₃₆₁	(1.0, 2.0, 3.3)	(0.38, 0.56, 0.74)	
	E ₃₆₂	(8.2, 9.2, 9.8)	(0.54, 0.68, 0.82)	
E ₄₁	E ₃₆₃	(4.7, 6.2, 7.6)	(0.66, 0.77, 0.88)	(5.01, 6.04, 7.03)
	E ₄₁₁	(6.4, 7.7, 8.8)	(0.42, 0.59, 0.76)	
	E ₄₁₂	(2.6, 4.1, 5.7)	(0.46, 0.62, 0.78)	
	E ₄₁₃	(4.9, 6.5, 8.0)	(0.42, 0.59, 0.76)	
	E ₄₁₄	(4.2, 5.9, 7.6)	(0.66, 0.77, 0.88)	
	E ₄₁₅	(3.9, 5.3, 6.6)	(0.58, 0.71, 0.84)	
E ₄₂	E ₄₁₆	(1.4, 2.6, 3.9)	(0.54, 0.68, 0.82)	(3.81, 5.30, 6.74)
	E ₄₂₁	(6.4, 7.7, 8.8)	(0.73, 0.83, 0.92)	
	E ₄₂₂	(6.4, 7.7, 8.8)	(0.50, 0.65, 0.80)	
E ₄₃	E ₄₂₃	(5.7, 7.1, 8.4)	(0.46, 0.62, 0.78)	(6.21, 7.52, 8.67)
	E ₄₃₁	(6.8, 8.0, 9.0)	(0.62, 0.74, 0.86)	
	E ₄₃₂	(7.2, 8.3, 9.2)	(0.16, 0.29, 0.43)	
	E ₄₃₃	(6.4, 7.7, 8.8)	(0.44, 0.59, 0.74)	
E ₄₄	E ₄₃₄	(4.0, 5.3, 6.6)	(0.57, 0.71, 0.84)	(5.84, 7.14, 8.27)
	E ₄₄₁	(6.9, 8.0, 9.0)	(0.60, 0.74, 0.86)	
	E ₄₄₂	(4.9, 6.2, 7.4)	(0.58, 0.71, 0.84)	
	E ₄₄₃	(3.4, 5.0, 6.6)	(0.59, 0.71, 0.82)	
E ₄₅	E ₄₄₄	(5.3, 6.8, 8.2)	(0.72, 0.83, 0.92)	(5.14, 6.53, 7.82)
	E ₄₅₁	(2.4, 3.8, 5.3)	(0.72, 0.83, 0.92)	
	E ₄₅₂	(2.2, 3.5, 5.0)	(0.79, 0.89, 0.96)	
	E ₄₅₃	(3.6, 5.0, 6.4)	(0.60, 0.74, 0.86)	
	E ₄₅₄	(2.8, 4.4, 6.0)	(0.68, 0.80, 0.90)	
E ₄₆	E ₄₅₅	(6.1, 7.4, 8.6)	(0.65, 0.77, 0.88)	(3.34, 4.76, 6.23)
	E ₄₆₁	(3.8, 5.6, 7.4)	(0.38, 0.53, 0.68)	
	E ₄₆₂	(6.4, 7.7, 8.8)	(0.50, 0.65, 0.80)	
E ₄₇	E ₄₆₃	(5.0, 6.5, 8.0)	(0.66, 0.77, 0.88)	(5.28, 6.76, 8.16)
	E ₄₇₁	(5.0, 6.5, 8.0)	(0.66, 0.77, 0.88)	
	E ₄₇₂	(7.5, 8.6, 9.4)	(0.36, 0.50, 0.64)	
	E ₄₇₃	(5.3, 6.8, 8.2)	(0.62, 0.74, 0.86)	
E ₅₁	E ₄₇₄	(3.5, 4.7, 5.9)	(0.71, 0.83, 0.92)	(5.01, 6.42, 7.74)
	E ₅₁₁	(3.4, 5.3, 7.2)	(0.34, 0.50, 0.66)	
	E ₅₁₂	(5.2, 6.5, 7.6)	(0.54, 0.68, 0.82)	
E ₅₂	E ₅₁₃	(8.5, 9.5, 10.0)	(0.62, 0.74, 0.86)	(6.16, 7.34, 8.37)
	E ₅₂₁	(4.9, 6.2, 7.4)	(0.69, 0.80, 0.90)	
E ₅₃	E ₅₂₂	(2.0, 3.2, 4.5)	(0.71, 0.83, 0.92)	(4.48, 5.75, 6.93)
	E ₅₂₃	(7.5, 8.6, 9.4)	(0.49, 0.62, 0.74)	
	E ₅₃₁	(4.9, 6.5, 8.0)	(0.40, 0.56, 0.72)	
E ₅₄	E ₅₃₂	(4.2, 5.9, 7.6)	(0.52, 0.65, 0.78)	(4.33, 6.01, 7.67)
	E ₅₃₃	(3.8, 5.6, 7.4)	(0.3, 0.5, 0.7)	
	E ₅₄₁	(5.7, 7.1, 8.4)	(0.36, 0.53, 0.70)	
	E ₅₄₂	(4.2, 5.9, 7.6)	(0.62, 0.74, 0.86)	
	E ₅₄₃	(3.0, 4.7, 6.4)	(0.26, 0.38, 0.52)	(4.38, 6.01, 7.57)

In order to calculate the rating of each enabler, we firstly aggregate the five experts' weights and ratings, by using median operation [25], and then we carry out the same calculation as that of the criteria rating (Table 6). An example of the rating of the enabler E₁ is shown below.

Example: Rating of the enabler

$$E_1 = \frac{\sum_{j=1}^{j=3} (\text{Criteria rating} \otimes \text{Fuzzy importance weight of the agile criteria})}{\sum_{j=1}^{j=3} \text{Fuzzy importance weight of the agile criteria}}$$

$$= [(4.17, 5.65, 7.11) \otimes (0.5, 0.65, 0.8) \oplus (3.52, 4.88, 6.28) \otimes (0.5, 0.65, 0.8) \oplus (4.49, 5.99, 7.47) \otimes (0.5, 0.65, 0.8)] / [(0.5, 0.65, 0.8) \oplus (0.5, 0.65, 0.8) \oplus (0.5, 0.65, 0.8)] = (5.14, 6.55, 7.86)$$

Table 6: Fuzzy index of agile enabler rating

Agile enablers	Agile criteria	Criteria rating	Fuzzy importance weight of the agile criteria	Enabler rating	Fuzzy importance weight of the agile enablers
E ₁	E ₁₁	(4.17, 5.65, 7.11)	(0.5, 0.65, 0.8)	(5.14, 6.55, 7.86)	(0.5, 0.65, 0.8)
	E ₁₂	(3.52, 4.88, 6.28)	(0.5, 0.65, 0.8)		
	E ₁₃	(4.49, 5.99, 7.47)	(0.5, 0.65, 0.8)		
E ₂	E ₂₁	(3.66, 4.93, 6.23)	(0.5, 0.65, 0.8)	(3.67, 5.04, 6.44)	(0.5, 0.65, 0.8)
	E ₂₂	(4.45, 5.77, 7.04)	(0.5, 0.65, 0.8)		
	E ₂₃	(3.56, 5.05, 6.55)	(0.7, 0.8, 0.9)		
	E ₂₄	(3.4, 5.0, 6.6)	(0.5, 0.65, 0.8)		
	E ₂₅	(3.68, 4.89, 6.18)	(0.5, 0.65, 0.8)		
	E ₂₆	(3.29, 4.63, 6.03)	(0.5, 0.65, 0.8)		
E ₃	E ₃₁	(3.08, 4.57, 6.06)	(0.7, 0.8, 0.9)	(4.36, 5.79, 7.16)	(0.7, 0.8, 0.9)
	E ₃₂	(5.09, 6.55, 7.92)	(0.7, 0.8, 0.9)		
	E ₃₃	(4.69, 5.97, 7.21)	(0.7, 0.8, 0.9)		
	E ₃₄	(4.21, 5.79, 7.32)	(0.5, 0.65, 0.8)		
	E ₃₅	(4.20, 5.86, 7.45)	(0.5, 0.65, 0.8)		
	E ₃₆	(5.01, 6.04, 7.03)	(0.5, 0.65, 0.8)		
E ₄	E ₄₁	(3.81, 5.30, 6.74)	(0.5, 0.65, 0.8)	(4.88, 6.31, 7.64)	(0.5, 0.65, 0.8)
	E ₄₂	(6.21, 7.52, 8.67)	(0.5, 0.65, 0.8)		
	E ₄₃	(5.84, 7.14, 8.27)	(0.5, 0.65, 0.8)		
	E ₄₄	(5.14, 6.53, 7.82)	(0.7, 0.8, 0.9)		
	E ₄₅	(3.34, 4.76, 6.23)	(0.7, 0.8, 0.9)		
	E ₄₆	(5.28, 6.76, 8.16)	(0.5, 0.65, 0.8)		
	E ₄₇	(5.01, 6.42, 7.74)	(0.7, 0.8, 0.9)		
E ₅	E ₅₁	(6.16, 7.34, 8.37)	(0.5, 0.65, 0.8)	(4.90, 6.28, 7.61)	(0.5, 0.65, 0.8)
	E ₅₂	(4.48, 5.75, 6.93)	(0.7, 0.8, 0.9)		
	E ₅₃	(4.33, 6.01, 7.67)	(0.3, 0.5, 0.7)		
	E ₅₄	(4.38, 6.01, 7.57)	(0.3, 0.5, 0.7)		

- Step 4: Calculation of the FAI of HealthOrg: We carry out the same calculation as that of the enabler rating [32].

$$FAI = \frac{\sum_{i=1}^{i=5} (\text{Enabler rating} \otimes \text{Fuzzy importance weight of the agile enablers})}{\sum_{i=1}^{i=5} \text{Fuzzy importance weight of the agile enablers}}$$

$$= [(5.14, 6.55, 7.86) \otimes (0.5, 0.65, 0.8) \oplus (3.67, 5.04, 6.44) \otimes (0.5, 0.65, 0.8) \oplus (4.36, 5.79, 7.16) \otimes (0.7, 0.8, 0.9) \oplus (4.88, 6.31, 7.64) \otimes (0.5, 0.65, 0.8) \oplus (4.90, 6.28, 7.61) \otimes (0.5, 0.65, 0.8)] / [(0.5, 0.65, 0.8) \oplus (0.5, 0.65, 0.8) \oplus (0.7, 0.8, 0.9) \oplus (0.5, 0.65, 0.8) \oplus (0.5, 0.65, 0.8)] = (4.57, 5.98, 7.34)$$

The overall agility of HealthOrg is (4.57, 5.98, 7.34).

- Step 5: Matching the FAI with the appropriate linguistic level [32]: After determining the FAI of the organization, we converted it into linguistic terms. To do this, we used the Euclidean distance method in which we seek to obtain the minimum distance between FAI and the linguistic level (Table 8). Table 7 presents the linguistic terms of different agility levels and their fuzzy intervals [5].

Table 7: Fuzzy values of agility levels (Adapted from [25])

Level of agility	Fuzzy intervals
Slowly Agile	(0, 1.5, 3)
Fairly Agile	(1.5, 3, 4.5)
Agile	(3.5, 5, 6.5)
Very Agile	(5.5, 7, 8.5)
Extremely Agile	(7, 8.5, 10)

Table 8: Agility level of HealthOrg

FAI for HealthOrg	(4.57, 5.98, 7.34)
D (FAI, Slowly Agile)	$\{(4.57-0)^2 + (5.98-1.5)^2 + (7.34-3)^2\}^{1/2} = 7.78$
D (FAI, Fairly Agile)	$\{(4.57-1.5)^2 + (5.98-3)^2 + (7.34-4.5)^2\}^{1/2} = 5.13$
D (FAI, Agile)	$\{(4.57-3.5)^2 + (5.98-5.0)^2 + (7.34-6.5)^2\}^{1/2} = 1.67$
D (FAI, Very Agile)	$\{(4.57-5.5)^2 + (5.98-7)^2 + (7.34-8.5)^2\}^{1/2} = 1.80$
D (FAI, Extremely Agile)	$\{(4.57-7)^2 + (5.98-8.5)^2 + (7.34-10)^2\}^{1/2} = 4.40$

The minimum distance between FAI and the level of agility is that obtained with the “Agile” level. Then, HealthOrg is considered as an agile enterprise.

- Step 6: Fuzzy performance importance index (FPII) calculation: Although HealthOrg is agile; some attributes weakened its agility during COVID-19 era. In order to identify them, we calculate FPII and the ranking score for each agile attribute (Table 9) [5]. An example of it for E₁₁₁ is calculated as:

FPII₁₁₁ = [(1, 1, 1) – Average fuzzy weight of E₁₁₁] ⊗ Average fuzzy performance rating of

$$E_{111} = [(1, 1, 1) - (0.54, 0.68, 0.82)] \otimes (6.1, 7.4, 8.6) = (2.81, 2.37, 1.55)$$

$$\text{Ranking score of } E_{111} = (2.81 + 4 \times 2.37 + 1.55) / 6 = 2.31$$

Table 9: FPII and ranking score of agile attributes

Agile Attributes	Average fuzzy weight	Fuzzy performance average rating	FPII	Ranking score
E ₁₁₁	(0.54, 0.68, 0.82)	(6.1, 7.4, 8.6)	(2.81, 2.37, 1.55)	2.31
E ₁₁₂	(0.54, 0.68, 0.82)	(3.4, 5.0, 6.6)	(1.56, 1.60, 1.19)	1.52
E ₁₁₃	(0.58, 0.71, 0.84)	(2.4, 3.8, 5.3)	(1.01, 1.10, 0.85)	1.04
E ₁₁₄	(0.54, 0.68, 0.82)	(4.9, 6.5, 8.0)	(2.25, 2.08, 1.44)	2.00
E ₁₂₁	(0.46, 0.62, 0.78)	(5.0, 6.5, 8.0)	(2.70, 2.47, 1.76)	2.39
E ₁₂₂	(0.54, 0.68, 0.82)	(3.0, 4.7, 6.4)	(1.38, 1.50, 1.15)	1.42
E ₁₂₃	(0.50, 0.65, 0.80)	(1.4, 2.6, 4.0)	(0.70, 0.91, 0.80)	0.86
E ₁₂₄	(0.58, 0.71, 0.84)	(1.4, 2.6, 4.0)	(0.59, 0.75, 0.64)	0.70
E ₁₂₅	(0.58, 0.71, 0.84)	(6.8, 8.0, 9.0)	(2.86, 2.32, 1.44)	2.26
E ₁₃₁	(0.76, 0.86, 0.94)	(5.0, 6.5, 8.0)	(1.20, 0.91, 0.48)	0.89
E ₁₃₂	(0.58, 0.71, 0.84)	(6.7, 8.0, 9.0)	(2.81, 2.32, 1.44)	2.25
E ₁₃₃	(0.62, 0.74, 0.86)	(5.4, 6.8, 8.2)	(2.05, 1.77, 1.15)	1.71
E ₁₃₄	(0.42, 0.59, 0.76)	(3.8, 5.6, 7.4)	(2.20, 2.30, 1.78)	2.20
E ₁₃₅	(0.46, 0.62, 0.78)	(5.0, 6.5, 8.0)	(2.70, 2.47, 1.76)	2.39
E ₁₃₆	(0.79, 0.89, 0.96)	(2.6, 4.1, 5.6)	(0.55, 0.45, 0.22)	0.43
E ₁₃₇	(0.54, 0.68, 0.82)	(3.2, 4.7, 6.3)	(1.47, 1.50, 1.13)	1.43
E ₂₁₁	(0.66, 0.77, 0.88)	(4.6, 6.2, 7.8)	(1.56, 1.43, 0.94)	1.37
E ₂₁₂	(0.42, 0.59, 0.76)	(1.8, 2.9, 4.2)	(1.04, 1.19, 1.01)	1.13
E ₂₁₃	(0.50, 0.65, 0.80)	(2.0, 3.5, 5.0)	(1.00, 1.22, 1.00)	1.15
E ₂₁₄	(0.76, 0.86, 0.94)	(6.4, 7.7, 8.8)	(1.54, 1.08, 0.53)	1.06
E ₂₁₅	(0.58, 0.71, 0.84)	(1.8, 3.2, 4.7)	(0.76, 0.93, 0.75)	0.87
E ₂₂₁	(0.24, 0.41, 0.58)	(5.3, 6.8, 8.2)	(4.03, 4.01, 3.44)	3.92
E ₂₂₂	(0.54, 0.68, 0.82)	(3.9, 5.0, 6.1)	(1.79, 1.60, 1.10)	1.55

E223	(0.50, 0.65, 0.80)	(3.1, 4.4, 5.7)	(1.55, 1.54, 1.14)	1.47
E224	(0.62, 0.74, 0.86)	(5.7, 7.1, 8.4)	(2.17, 1.85, 1.18)	1.79
E231	(0.76, 0.86, 0.94)	(4.2, 5.9, 7.6)	(1.01, 0.83, 0.46)	0.80
E232	(0.54, 0.68, 0.82)	(2.2, 3.5, 4.9)	(1.01, 1.12, 0.88)	1.06
E233	(0.7, 0.8, 0.9)	(2.4, 3.8, 5.3)	(0.72, 0.76, 0.53)	0.71
E234	(0.50, 0.65, 0.80)	(5.7, 7.1, 8.4)	(2.85, 2.48, 1.68)	2.41
E241	(0.50, 0.65, 0.80)	(3.4, 5.0, 6.6)	(1.70, 1.75, 1.32)	1.67
E251	(0.50, 0.65, 0.80)	(5.8, 7.1, 8.4)	(2.90, 2.48, 1.68)	2.42
E252	(0.50, 0.65, 0.80)	(3.8, 5.3, 6.8)	(1.90, 1.85, 1.36)	1.78
E253	(0.42, 0.59, 0.76)	(1.0, 2.0, 3.2)	(0.58, 0.82, 0.77)	0.77
E261	(0.54, 0.68, 0.82)	(5.7, 7.1, 8.4)	(2.62, 2.27, 1.51)	2.20
E262	(0.58, 0.71, 0.84)	(2.6, 3.8, 5.2)	(1.09, 1.10, 0.83)	1.05
E263	(0.50, 0.65, 0.80)	(1.6, 2.9, 4.3)	(0.80, 1.01, 0.86)	0.95
E264	(0.54, 0.68, 0.82)	(3.2, 4.7, 6.2)	(1.47, 1.50, 1.12)	1.43
E311	(0.58, 0.71, 0.84)	(2.4, 3.8, 5.3)	(1.01, 1.10, 0.85)	1.04
E312	(0.7, 0.8, 0.9)	(1.6, 2.9, 4.4)	(0.48, 0.58, 0.44)	0.54
E313	(0.79, 0.89, 0.96)	(2.8, 4.4, 6.0)	(0.59, 0.48, 0.24)	0.46
E314	(0.50, 0.65, 0.80)	(6.4, 7.7, 8.8)	(3.20, 2.69, 1.76)	2.62
E321	(0.7, 0.8, 0.9)	(6.0, 7.4, 8.6)	(1.80, 1.48, 0.86)	1.43
E322	(0.58, 0.71, 0.84)	(4.0, 5.6, 7.2)	(1.68, 1.62, 1.15)	1.55
E331	(0.58, 0.71, 0.84)	(5.7, 7.1, 8.4)	(2.39, 2.06, 1.34)	1.99
E332	(0.7, 0.8, 0.9)	(4.5, 6.2, 7.8)	(1.35, 1.24, 0.78)	1.18
E333	(0.38, 0.56, 0.74)	(2.2, 3.5, 5.0)	(1.36, 1.54, 1.30)	1.47
E334	(0.58, 0.71, 0.84)	(2.2, 3.5, 4.9)	(0.92, 1.01, 0.78)	0.96
E335	(0.62, 0.74, 0.86)	(7.8, 8.9, 9.6)	(2.96, 2.31, 1.34)	2.26
E341	(0.50, 0.65, 0.80)	(2.8, 4.4, 6.0)	(1.40, 1.54, 1.20)	1.46
E342	(0.50, 0.65, 0.80)	(3.6, 5.3, 7.0)	(1.80, 1.85, 1.40)	1.77
E343	(0.54, 0.68, 0.82)	(5.3, 6.8, 8.2)	(2.44, 2.18, 1.48)	2.11
E344	(0.62, 0.74, 0.86)	(4.9, 6.5, 8.0)	(1.86, 1.69, 1.12)	1.62
E351	(0.58, 0.71, 0.84)	(2.6, 4.4, 6.2)	(1.09, 1.28, 0.99)	1.20
E352	(0.42, 0.59, 0.76)	(4.9, 6.5, 8.0)	(2.84, 2.66, 1.92)	2.57
E353	(0.58, 0.71, 0.84)	(5.3, 6.8, 8.2)	(2.23, 1.97, 1.31)	1.90
E361	(0.38, 0.56, 0.74)	(1.0, 2.0, 3.3)	(0.62, 0.88, 0.86)	0.83
E362	(0.54, 0.68, 0.82)	(8.2, 9.2, 9.8)	(3.77, 2.94, 1.76)	2.88
E363	(0.66, 0.77, 0.88)	(4.7, 6.2, 7.6)	(1.60, 1.43, 0.91)	1.37
E411	(0.42, 0.59, 0.76)	(6.4, 7.7, 8.8)	(3.71, 3.16, 2.11)	3.08
E412	(0.46, 0.62, 0.78)	(2.6, 4.1, 5.7)	(1.40, 1.56, 1.25)	1.48
E413	(0.42, 0.59, 0.76)	(4.9, 6.5, 8.0)	(2.84, 2.66, 1.92)	2.57
E414	(0.66, 0.77, 0.88)	(4.2, 5.9, 7.6)	(1.43, 1.36, 0.91)	1.30
E415	(0.58, 0.71, 0.84)	(3.9, 5.3, 6.6)	(1.64, 1.54, 1.06)	1.48
E416	(0.54, 0.68, 0.82)	(1.4, 2.6, 3.9)	(0.64, 0.83, 0.70)	0.78
E421	(0.73, 0.83, 0.92)	(6.4, 7.7, 8.8)	(1.73, 1.31, 0.70)	1.28
E422	(0.50, 0.65, 0.80)	(6.4, 7.7, 8.8)	(3.20, 2.69, 1.76)	2.62
E423	(0.46, 0.62, 0.78)	(5.7, 7.1, 8.4)	(3.08, 2.70, 1.85)	2.62
E431	(0.62, 0.74, 0.86)	(6.8, 8.0, 9.0)	(2.58, 2.08, 1.26)	2.03
E432	(0.16, 0.29, 0.43)	(7.2, 8.3, 9.2)	(6.05, 5.89, 5.24)	5.81
E433	(0.44, 0.59, 0.74)	(6.4, 7.7, 8.8)	(3.58, 3.16, 2.29)	3.08
E434	(0.57, 0.71, 0.84)	(4.0, 5.3, 6.6)	(1.72, 1.54, 1.06)	1.49
E441	(0.60, 0.74, 0.86)	(6.9, 8.0, 9.0)	(2.76, 2.08, 1.26)	2.06
E442	(0.58, 0.71, 0.84)	(4.9, 6.2, 7.4)	(2.06, 1.80, 1.18)	1.74
E443	(0.59, 0.71, 0.82)	(3.4, 5.0, 6.6)	(1.39, 1.45, 1.19)	1.40
E444	(0.72, 0.83, 0.92)	(5.3, 6.8, 8.2)	(1.48, 1.16, 0.66)	1.13
E451	(0.72, 0.83, 0.92)	(2.4, 3.8, 5.3)	(0.67, 0.65, 0.42)	0.61
E452	(0.79, 0.89, 0.96)	(2.2, 3.5, 5.0)	(0.46, 0.38, 0.20)	0.36
E453	(0.60, 0.74, 0.86)	(3.6, 5.0, 6.4)	(1.44, 1.30, 0.90)	1.26
E454	(0.68, 0.80, 0.90)	(2.8, 4.4, 6.0)	(0.90, 0.88, 0.60)	0.84
E455	(0.65, 0.77, 0.88)	(6.1, 7.4, 8.6)	(2.13, 1.70, 1.03)	1.66
E461	(0.38, 0.53, 0.68)	(3.8, 5.6, 7.4)	(2.36, 2.63, 2.37)	2.54
E462	(0.50, 0.65, 0.80)	(6.4, 7.7, 8.8)	(3.20, 2.69, 1.76)	2.62
E471	(0.66, 0.77, 0.88)	(5.0, 6.5, 8.0)	(1.70, 1.49, 0.96)	1.44
E472	(0.36, 0.50, 0.64)	(7.5, 8.6, 9.4)	(4.80, 4.30, 3.38)	4.23
E473	(0.62, 0.74, 0.86)	(5.3, 6.8, 8.2)	(2.01, 1.77, 1.15)	1.71
E474	(0.71, 0.83, 0.92)	(3.5, 4.7, 5.9)	(1.01, 0.80, 0.47)	0.78
E511	(0.34, 0.50, 0.66)	(3.4, 5.3, 7.2)	(2.24, 2.65, 2.45)	2.55
E512	(0.54, 0.68, 0.82)	(5.2, 6.5, 7.6)	(2.39, 2.08, 1.37)	2.01
E513	(0.62, 0.74, 0.86)	(8.5, 9.5, 10.0)	(3.23, 2.47, 1.40)	2.42
E521	(0.69, 0.80, 0.90)	(4.9, 6.2, 7.4)	(1.52, 1.24, 0.74)	1.20
E522	(0.71, 0.83, 0.92)	(2.0, 3.2, 4.5)	(0.58, 0.54, 0.36)	0.52
E523	(0.49, 0.62, 0.74)	(7.5, 8.6, 9.4)	(3.82, 3.27, 2.44)	3.22
E531	(0.40, 0.56, 0.72)	(4.9, 6.5, 8.0)	(2.94, 2.86, 2.24)	2.77
E532	(0.52, 0.65, 0.78)	(4.2, 5.9, 7.6)	(2.02, 2.06, 1.67)	1.99

E533	(0.3, 0.5, 0.7)	(3.8, 5.6, 7.4)	(2.66, 2.80, 2.22)	2.68
E541	(0.36, 0.53, 0.70)	(5.7, 7.1, 8.4)	(3.65, 3.34, 2.52)	3.25
E542	(0.62, 0.74, 0.86)	(4.2, 5.9, 7.6)	(1.60, 1.53, 1.06)	1.46
E543	(0.26, 0.38, 0.52)	(3.0, 4.7, 6.4)	(2.22, 2.91, 3.07)	2.82

Based on the five experts' experience, scale 1.1 was considered as the threshold which distinguishes the weaker attributes than the other ones. Table 10 showed these attributes and some suggestions to improve them [5].

Table 10: Weaker agile attributes and improvement proposals

Weak agile attribute	References	Improvement proposals
<ul style="list-style-type: none"> Staff interchangeability Multi-skilled and flexible staff Implementation of job rotation system 	[15, 33]	Prepare employees to participate in the implementation of job rotation system
<ul style="list-style-type: none"> Flexible employees to accept the adoption of new technologies Multi-functional, developed and trained employees 	[15, 29]	Develop a flexible working environment for employees
<ul style="list-style-type: none"> Decentralized decision-making, knowledge and control Knowledge and skills management systems Staff empowerment to resolve patient issues 	[15, 29, 30, 31, 33]	Give authority to different level employees which contributes to improved their knowledge
<ul style="list-style-type: none"> Loyalty and commitment to a project or a group Participative management style Quick evaluation and implementation of employee suggestions Involvement of suppliers and different agents in product/service development 	[15, 29, 30]	Remove barriers to facilitate the participation of different employees and suppliers
<ul style="list-style-type: none"> Efficient information system and technology Exploitation of information technology (IT) in supply chain management 	[15, 27, 29, 30, 32, 33]	Link information systems to technology
<ul style="list-style-type: none"> Adopting supply chain management concepts to improve the efficiency of outsourcing Simple process to implement Intelligent Engineering Design Support System Active policy to keep work areas clean and tidy Execution of short range planning Company's procurement policy based on time schedule Improved manufacturing technology First-time correct design Reduction of non value-adding costs 		Use advanced technologies and production methods

5. Conclusion

This study evaluated organization agility of a public hospital in Morocco in times of COVID-19. The enablers influencing agility were studied, as were the agile criteria and attributes. After a literature review, an assessment model was presented and tested via the fuzzy logic approach. Empirical results showed that HealthOrg is agile. The COVID-19 outbreak has revealed how different enablers can influence the hospital agility. It has also shown how some agile enablers need to be enhanced in order to increase the healthcare organization agility.

This article offers initial empirical exploration on how Moroccan healthcare organizations cope with the COVID-19 crisis. It allows identifying the required changes to improve the agility of the organization. There will be increasing improvement for hospitals in technology and human resources departments; COVID-19 has demonstrated their importance in making the healthcare organization extremely agile.

Despite the above benefits for using the assessment model, there is some limitation: this model does not take into account the different agile drivers and capacities which must be aligned with the agile enablers. Also, the organizational agility assessment has been done for a single healthcare organization; however future research should replicate the assessment model in other organizations, in public and private sector. Also, it is highly recommended to compare the results obtained in times of COVID-19 with those provided by previous studies. Moreover, further practical suggestions for healthcare sector through COVID 19 outbreaks should be provided.

Conflict of Interest

The authors declare no conflict of interest.

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Inventory Management Practices during COVID 19 Pandemic to Maintain Liquidity Increasing Customer Service level in an Industrial Products Company in Mexico

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ABSTRACT

This work presents the development and improvement obtained by implementing inventory managing practices during the COVID 19 pandemic in a Mexican company, a leader in the industrial sector to overcome the effects on the Company's economies due to constrained market to maintain liquidity and preserve employment by increasing customer service level ensuring the availability of the finished product and improving the delivery time in the distribution center, from the receipt of the customer's order, order picking, shipment preparation, invoicing and final delivery to the customer. The areas involved are Commercial, Demand and Materials Planning, Purchasing, Manufacturing, Logistics, and Operations of the Distribution Center. The deployment process considered an ABC study, analysis of the historical demand, product inventory coverage days, analysis of the lead time components of the distribution center, to implement a minimum and maximum inventory control policy for the product portfolio A and manufacture products classified as B and C on a make to order basis, an audit was performed of its distribution center, to identify opportunities for improvement in their processes to reduce the time of delivery to the customer.

The Company was not in compliance with the level of customer service with an 89% performance due to the low availability of the finished product inventory, affecting the customer's delivery time in the distribution center with a time of 5 hours versus the goal of 90 minutes per event.

The implementation of the improvement achieved an increase in the level of service up to 5% starting the fourth quarter of 2019, the savings in inventory optimization at an annual base represented USD 530,785.00 (Five hundred thirty thousand seven hundred eighty-five dollars), and the Company has implemented this good practice nationwide in its other Manufacturing Plants and Distribution Centers as part of the strategic corporate policy deployment.

1. Introduction

The value chain is all actions to make a product to flow from the raw material to the customer's hands. Within the value chain, the primary processes include the transformation of the product, inbound logistics that is the delivery of suppliers of the raw material to a warehouse of the manufacturing Company, the logistics of operations whose purpose is the proper administration of the raw material in the transformation process to ensure the availability of raw material inventory or inventory in process in the work centers and finally the outbound logistics from the storage, distribution and perfect delivery of the finished product to the end customer [1].

The secondary processes in a value chain are the ones that give support to the primary processes for the transformation of the product. The timeline determines the response time of the value chain, and the flow of information in the value chain is essential because it includes the release of the sales estimate, placement of the customer order, release of the purchase orders and manufacturing orders to the delivery of the product to the end customer [1].

The efficiency and optimization of the distribution center's functions is a priority for the achievement of the goal of perfect delivery to the customer and inventory availability assurance to ensure the desired service level [2].

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This case study's scope is a company of 100% Mexican capital, market leader, is dedicated to the production and marketing of industrial products located in Mexico with ten manufacturing plants and three Distribution Centers with 800 employees.

This case study helps the Company to face COVID 19 pandemic with a constrained market to contain the economic effects of the pandemic that we are facing helping to preserve employment as much as possible and provide liquidity to create the conditions for the recovery of economic growth by ensuring the availability of the inventory of its products to meet the level of delivery service on time and improve the delivery time to the customer in the distribution center through an audit in the distribution center, establish a baseline of product inventory coverage days, analysis of the lead time components of the distribution center, value chain mapping, ABC classification of finished products, inventory control implementation with the maximum and minimum methodology, production balancing, measurement of customer's delivery time as days of inventory coverage in the distribution center.

Masaaki Imai, in his work, "Kaizen, The Key to Japanese Competitiveness," mentions that Japanese companies follow a defined strategic planning scheme; the administration develops and communicates the rules of the game: transparent processes, that is, with a standard procedure for Operation. It translates into top management shall first establish policies and procedures for all critical operations, then communicate and ensure that they are understood by all levels [3].

The rest of the research work consists of describing the case study, theoretical framework, and research methodology as its conclusions and results obtained.

2. Literature Review

According to the customer's perspective, the value chain's purpose is to determine which activities are value-added and non-value-added [4]. All activity that transforms the product should be understood as an added value; in contrast, all the activities that do not transform the product are no value-added. They are known as waste: Reworks, defects, unnecessary movements, inventories, waiting times, overproduction, unnecessary space, and transportation. This waste shall be eliminated to improve the value chain [5].

A distribution center is a vital component of the value chain for any company to achieve perfect delivery to the product customer as to the quantity, time, price, quality, and correct information.

The distribution center functions include receipt, inspection, storage, picking, preparation of shipment, dispatch, consolidation of orders, and final delivery to the customer. The efficiency of these activities is critical to ensure speed and optimize the flow of the product to reduce the response time and operating costs, from receipt of the customer's order to delivery, to send the products with the correct specification, quality, price with proper documentation to the customer. Always searching for continuous improvement to reduce waste as mentioned earlier and add only value in the supply chain.

The correct management of the distribution center supports the strategic objectives of the Company: Generate more sales, profit margin, cash flow, stability in the jobs satisfying customer demand with the correct level of service.

Therefore, storage and distribution activities for the product should be regarded as a vital component of the Company's strategic planning for it to be coupled with the expectations raised in the business plan [6].

The management of the Company must consider several factors to maintain optimal inventory levels, such as the financial liquidity of the Company, sales behavior such as seasonality, reliability, and availability of suppliers, available financial resources. An adequate level of inventory reduces the potential risks of lost sales due to the lack of inventory availability as well as an increase in the cash flow of the Company, such as the release of warehouse capacity [7].

It is strategic for the companies to achieve a high level of customer service with a minimum level of inventory by implementing the Lean Pull Replenishment methodology by having product's supermarkets for the products that represent 80% of the Company's revenues which inventory is replenished based on the consumer's signal at the time of consumption and made to order for those products that represent the other 20% of the Company's revenue. The Lean Pull Replenishment methodology should be coupled with the Process Capability analysis to reduce variation in processes and determine the processing capabilities of the Company through the commitment of the delivery date of the customer's order [8].

Inventory in the lean philosophy is viewed as a waste given that it impacts the cash flow of the Company when it is not in the correct amount; besides, the Company requires an expense to manage it, at the same time, it hides problems such as downtime of machinery, long periods of changeover of products, quality problems, lack of reliability of suppliers' performance among others. Therefore, it is essential to focus on reducing the longest process lead time and reduce inventory. It is vital to take into consideration synchronization between processes with a correct balanced production plan as well as reduce the change over time between products for each of the processes and always work with small batch sizes and avoid overproduction [9].

In the implementation of a continuous flow, the reduction of equipment change over times is vital, which consequently translates into smaller lot sizes aligned with a *KanBan* signaling system with an adequate plant layout allowing to achieve improvements in the reduction of manufacturing delivery times, thereby reducing work in process and finished goods inventories, eliminating unnecessary movements of materials resulting in having the correct level of inventory to meet customer demand and thus increase the customer service level [10].

It is essential to align the demand planning by reducing the variation of the demand estimate and leveling the demand, establishing EOQ to determine the optimum lot size to produce to minimize the ordering and logistic costs of maintaining the inventory, also optimizing equipment change over times allows reducing the number of Kanban cards which results in a reduction of storage space such as the transport of materials by creating a

continuous flow in the value chain and making timely deliveries to the customer [11].

Within the investigation of inventory management, the optimization strategy stands out; the correct coordination of prices and inventory management technology is vital. Many companies begin to improve logistics by applying inventory control technology to reduce costs. The opportunity lies in ensuring having enough inventory to meet demand by minimizing inventory costs in the right place and time [12].

Any improvement in inventory performance has an impact on the quality of the product as well as the financial performance of the Company, so management must pay attention to proper inventory management. Companies without sufficient financial liquidity to obtain better financial performance can improve product quality by improving inventory management [13].

The correct inventory management practices have a direct impact on working capital, production, and the level of customer service and sales. Goods inventory management practices include having the correct levels of raw material and in-process inventory to ensure the continuous flow of supply to production, to avoid stoppages of the production line, to anticipate the correct prices of materials, ensure the correct levels of inventory of finished product to complete customer orders, follow the customer's demand to increase the level of service provided to the same [14].

The ABC Inventory Classification usually considers the annual volume multiplied times the ordered price in a descending manner classified into three categories A, B, and C. According to the ABC classification, the same service level is assigned for each part number according to the classification. Regularly, the articles generate the most considerable profit and are considered higher levels of service. To classify each of the part numbers, a new approach that takes into account four parameters is proposed: the cost of having a shortage times the rate of demand, divided into the cost of maintaining the inventory (purchase price) times the amount to be ordered for each of the articles; the result is sorted in descending order and is classified on ABC, which considers three classes: 50%, 30% and 20%, where A must have the highest level of service, followed by B and C [15].

Once certain products classified as type A, for the calculation of finished product inventory level, known as supermarket Figure 1, the following formula is considered [16]:

Average daily demand x Replacement delivery period		Stock for the cycle
+	Demand Variation % (stock for the cycle)	Buffer stock
+	Security Factor % (stock for the cycle + buffer stock)	Security stock
=		Supermarket stock

Figure 1: Approach to the calculation of the supermarket inventory level

The supermarket inventory is equal to the stock for the cycle (it is the average demand of each product classified type A, which considers the replenishment delivery time. Replenish time is the period elapsed from the date the order is received, manufactured,

and made available at the warehouse) plus buffer stock (which is the amount of each product to be placed to cover any supply variation, such as quality defects, equipment stoppages, personnel missing, raw materials shortage). This supermarket shall be revised daily to ensure finished product availability to comply with service level upon any variation in demand or supply.

Inventory management with a maximum and minimum policy established on this case study for the industrial products industry has also been applied as the policy to health services, which have considered the importance of ensuring the supply of medicine, as well as a level of safety stock inventory to have continuity in the service in the event of supply shortages. By having a correct level of service and reducing delivery times, the decrease in inventory level is favored. The factors contributing to a shortage in medication shall be known, and evaluation is to be made from the demand pattern and all processes of the value chain intervening up to the delivery of the medication [17].

3. Problem Statement

The Company is committed to a quality management system that seeks to continuously improve profitability, customer satisfaction, internal processes, and staff development through the fulfillment of quality objectives and has considered strengthening its continuous improvement process in the distribution center located on the main plant solving the next opportunity for improvement: Position the correct level of finished product inventory under A classification, to increase the level of service to 95% as the preparation of shipment is interrupted due to the shortage of finished products for direct sale to or transferred to other manufacturing plants of the Company, having to reschedule shipments impacting the Company's sales, improve response time in the distribution center from the receipt of the finished product, collection of the product according to the customer's order, preparation of shipment, invoicing and clearance to 90 minutes.

Change management for continuous improvement as outlined in his Theory of Constraints (TOC) concepts and principles for improving companies' performance by focusing on some restrictions in the system. These influence points are system restrictions [18] [19].

4. Methodology

It is necessary to validate if the processes are oriented to serving the customer and achieve a high standard of service level to understand the value chain's baseline of performance. For this purpose, a mapping of the value chain is performed, which is a tool of lean manufacturing that is carried out by product family which outlines the value chain, customers, primary and secondary processes, suppliers, flows of information, and timeline, to display the waste, non-value-added activities and take actions to eliminate them. First, the map of the value chain in current status is carried out to identify the waste, which is transportation, inventory, movements, waiting, over-processing, overproduction, and defects; improvement events known as Kaizen are proposed to eliminate waste and streamline the value chain and therefore map the ideal state [2].

ABC analysis for inventory management is a method of inventory classification to book value (cost or acquisition) of the materials stored that considers the use of the article by its book value, classified from highest to lowest [20].

The principle of ABC analysis in inventory management applies:

- 1) In the classification of inventory items, based on their relative importance.
- 2) By setting different administrative controls for different classifications of materials and setting different degrees of control according to each classification's different ranges.

The criterion of classification should reflect the difficulty of controlling an article and the impact of this on the cost and in profit.

The ABC analysis determines the importance of an article in the Company's inventory. To perform this classification, companies could consider some of these no limitation criteria:

- 1) The annual transaction volume of an article (valued monetarily).
- 2) Shortages of material used in the production of an article.
- 3) Delivery time.
- 4) Storage requirements of an article.
- 5) Risk of theft.
- 6) Useful life.
- 7) Cost of a shortage of inventory, among other criteria.

The criterion used in this case study for the ABC classification is the volume of sales valued monetarily considering the last six months of current sales.

For classified items A, inventory control of maximum and minimum inventory method is implemented, which is a system specially developed to achieve up-to-date warehouses control and achieve optimal inventory; it sets the maximum and minimum levels of stock for each product, as shown below:

Definition of Variables:

\bar{X} = Average sales in three months.

T_{Info} = Time since the manufacturing plant receives the request from the distribution center.

T_{mfg} = time to manufacture considers the days the manufacturing plant requires to produce the finished product.

$T_{transit}$ = time in transit from the plant warehouse to the distribution center.

$Var.T_{transit}$: Time the shipment may be delayed from the main plant warehouse to the distribution center.

$Frec.Emb$: Shipment frequency. Several days between each shipment.

$Var.Dem.$ = Demand variation in days needed as additional coverage in the event of any demand fluctuation.

Equations for the calculation of maximum and minimum inventory:

The minimum inventory is calculated based on the average daily demand times the replenish lead time [16].

$$Min.Inventory = \bar{X} * (T_{Info} + T_{mfg} + T_{transit} + Var.T_{transit} + Frec.Emb) \tag{1}$$

The maximum inventory is calculated based on the average daily demand times the replenish lead time in days plus the variation of the demand in days to have additional coverage for any demand fluctuation [16].

$$Max.Inventory = \bar{X} * (T_{Info} + T_{mfg} + T_{transit} + Var.T_{transit} + Frec.Emb + Var.Dem) \tag{2}$$

$$Optimal\ inventory = \frac{(Min\ Inventory + Max\ Inventory)}{2} \tag{3}$$

The reorder point is the point when the inventory drops to a certain level, an order for a predetermined amount to replenish the inventory within the supplier's time of delivery is placed. This type of system can be used effectively for articles with independent demand. The reorder point is established to cover the average use within the delivery time plus variation in demand or variation in delivery time. The inventory to absorb this variation is known as safety stock. The amount of variation to cover depends on the level of customer service desired [20].

The safety stock (SS) required is a function of the random variation in demand during the estimated period, the desired level of customer service, and the radius of the delivery time during the estimated period.

$$SS = z s \sqrt{LT} \tag{4}$$

Where SS is the safety stock in a warehouse, z is the level of service sought for the Company represented by the value of the area under the curve, s is the standard deviation of the product demanded in the warehouse per unit of time.

Once inventory levels are set, next is the leveling of manufacturing within a period. It allows avoiding fluctuations to make the consumption of raw material, labor, and production capacity more predictable, ensuring finished product availability, minimizing inventory, working capital, and lead time throughout the value chain [16].

For this proposal, it is transcendent to determine the control condition of the process before the proposed improvements, as well as the determination of process capability indexes before the improvements and the associated sigma level thereof, to have transcendent measurements

To establish the central distribution center's baseline of performance, the Auditing Warehouse Performance, Ohio: Ackerman Publications checklist was applied [21].

Table 1: Summary of results of the Audit Central Distribution Center

AREA	WEIGHT	RANK	MAX RANK	GAP
External	0.05	0.117		
Internal	0.05	0.126		
Warehouse IT systems	0.1	0.3	0.4	0.1

Mechanical handling equipment	0.1	0.264	0.4	0.136
Contingency planning	0.05	0.067		
Inbound operation	0.1	0.211	0.49	0.278
Put-away and storage	0.05	0.14		
Stock control	0.15	0.417	0.6	0.183
Picking	0.05	0.15		
Dispatch	0.15	0.48	0.72	0.24
Staff and housekeeping	0.05	0.123		
Warehouse - performance management	0.05	0.1		
Legislative & Health and Safety requirements	0.05	0.154		
Overall Warehouse Rating		2.648	3.585	

1	2	3	4	0
No	Poor	Good	Excellent	N/A

Overall, the general grade of DC was 2.648, which indicates performance with an opportunity for improvement. When considering the ascribed areas as the most important in the auditing process, the maximum range was calculated. It denotes three areas with an opportunity for significant improvement:

- 1) Inbound Operation with a gap of 0.278.
- 2) Dispatch with a gap of 0.240.
- 3) Stock Control with a gap of 0.183.

If efforts are focused on these three areas, then a potential score of 3.459 can be reached to be close to excellence with a rating of 4.

Hence, the efforts will be focused on the following processes:

- a) Receipt, Preparation of the Shipping Order & Inventory Control. It interrupts the shipment's preparation flow due to finished goods and raw material shortage in the main warehouse, which causes reschedule shipments to the distribution centers based on the promised delivery date of production and suppliers. Evaluate the option to implement a pre-shipment activity and implement a performance metric of hours of preparation and loading of the shipment.
- b) Dispatching requires a shipment schedule to increase flexibility associated with sales to customers based on available resources as workforce, space, and equipment.
- c) One of the audit opportunities is the lack of KPI's to monitor CD's performance. Customer's delivery time, one of the top priorities identified by the commercial area, currently is 5 hours, being the goal of an average time of 90 minutes.

- d) In the stock control process, the opportunity is detected to implement an inventory control to guarantee the inventory's availability due to the constant interruption in the picking process due to finished goods inventory shortage compromising the shipment program and impacting the customer service level.

Associated with the delivery of the finished product to the customer, transformation processes were evaluated to understand the flow of the value chain of the Company, from suppliers, production processes, distribution and final delivery of customer, as well as the activities that provide service to primary processes, which involves the creation of the customer order, the administration area authorizes the order, the ordered product inventory is booked, delivery of documents to logistics, processing the loading order, delivery of documents to the loading area, loading of order and delivery of documents to the customer. Value stream mapping is a tool to achieve competitiveness in any company's value chain, highlighting the inefficiencies of processes such as areas for improvement [22].

The value stream map of the current state indicates:

- The model is pushed and does not have a sales estimate from the commercial area.
- Orders flow into the commercial area, and there is no supermarket of the finished product to shorten the delivery time to the customer and act as a buffer to absorb changes in demand.
- The production plan is made based on the demonstrated demand, and a production signal is sent to production based on a weekly production plan that applies to each of the work centers, which takes into account proven capacity and labor requirements.
- Material planning is done based on an MRP that explodes customer requirements to validate inventory position and release the production orders.
- The suppliers do not estimate the future requirement of the raw materials, so they react based on the monthly supply signal sent by the purchasing department.

ABC analysis was performed, Table 2, which considered the sale of each Distribution Center (DC) for each of the finished products by book value, based on manufacturing and sorted from highest to lowest. The Company's approach resides in 52 catalogs in Central Distribution Center, 18 catalogs in Distribution Center in City one, and 21 catalogs in City two Distribution Center, as it is shown below:

Table 2: ABC Classification

DC Central		
ABC	Total Catalogs	%Sales Value
A	52	80
B	68	15
C	207	5

DC City 1		
ABC	Total Catalogs	%Sales Value

A	18	80
B	31	15
C	58	5

DC City 2

ABC	Total Catalogs	%Sales Value
A	21	80
B	26	15
C	68	5

When reviewing the inventory's coverage in the days of the finished goods classified as type A, there is an average inventory coverage of 27 days, compared against the Company's goal of 14 inventory days. The following Table 3 shows a summary of coverage in the inventory days before the implementation of the improvement:

Table 3: Coverage in days and distribution as a percentage of the value of inventory catalogs classified as Type A

DC Central

DOS	Number of Finished Goods	% of Inventory Value
0 Days	7	3%
From 1 to 14 days	12	7%
From 15 to 22 days	13	53%
From 23 to 30 days	6	17%
Greater than 30 days	12	20%
Total	50	100%

DC City 1

DOS	Number of Finished Goods	% of Inventory Value
0 Days	1	0%
From 1 to 14 days	8	57%
From 15 to 22 days	2	18%
From 23 to 30 days	3	9%
Greater than 30 days	4	16%
Total	18	100%

DC City 2

DOS	Number of Finished Goods	% of Inventory Value
0 Days	2	0%
From 1 to 14 days	10	43%
From 15 to 22 days	4	19%
From 23 to 30 days	3	33%
Greater than 30 days	2	5%
Total	21	100%

Next, the state of statistical process control regarding the original process is shown and the capability index, Z level, and associated sigma [23].

A prerequisite to determine the status of control of a process is to validate that the data analyzed corresponds to a standard distribution. Figure 2, which can be validated and with the value $p=0.191$, is higher than the level of type I error or $\alpha=0.05$.

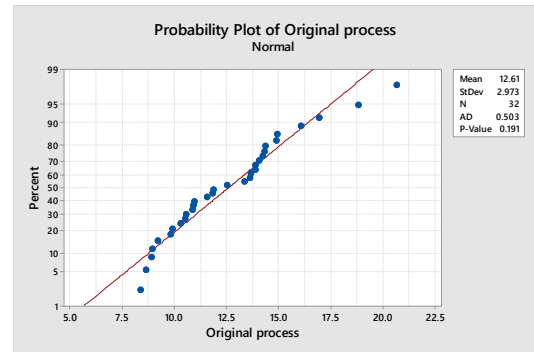


Figure 2: Normal Probability Graph

In Figure 3, it can be noticed that the process is out of statistical control due to several measuring points, which are outside control limits, which are associated with sources of variation attributable to the conditions of the current process [23].

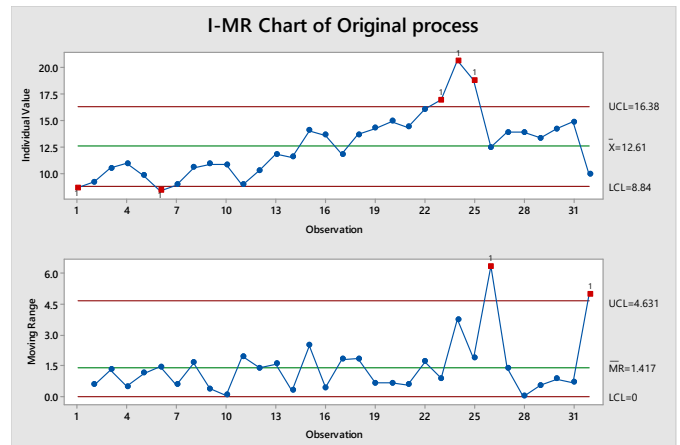


Figure 3: Control Chart for Individual Values and Mobile Range of the original process

Figure 4 shows the capability process analysis report for the original process. The cpk index establishes the actual process capability to meet specifications to consider that a process is adequate; the value must be higher than 1.25 [23]. the current cpk value of the process is 0.37, so the process under current conditions cannot meet specifications and requires serious intervention to restructure its activities and operation controls. The Z level of the process is 1.11, which is reflected in the sigma level = 2.61, the sigma level of a process is determined by the value of the Z + 1.5 level associated with the general standard deviation of the process. It should be noted that the lower specification limit is considered suitable; hence efforts will be concentrated on the upper specification limit [23].

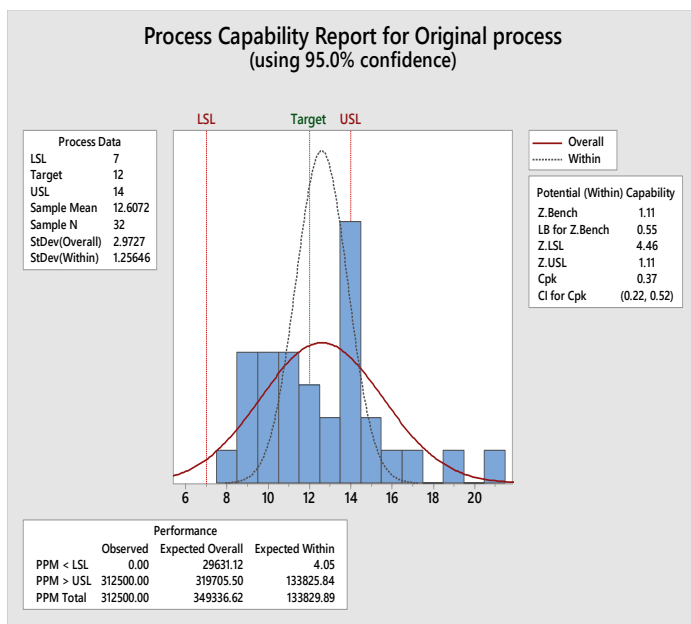


Figure 4: Process Capability report for the original process

The graph of the performance of the process shown in Figure 5 allows observing the fraction of the process that fails to comply with the established specifications. It can be seen in the area under the curve that exceeds the upper control limit.

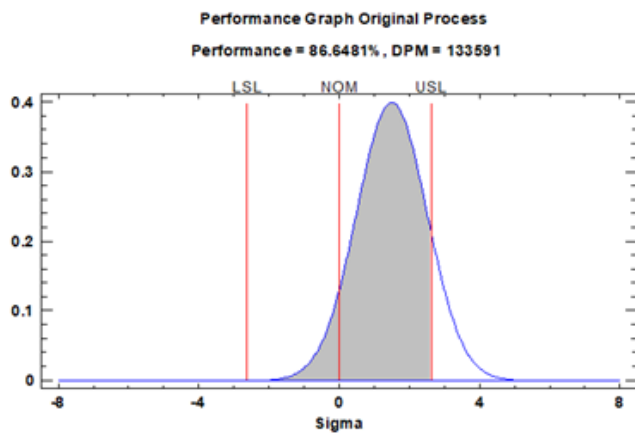


Figure 5: Performance Graph for the original process.

In the six sigma calculator associated with the process Table 4, the values obtained are the Z value of 1.11, Defects Per Million (DPM) of 133,519, Percentage of Defects 13.3, Yield of 86.64% with a process capability (Cpk) of 0.37, and a sigma quality level (SQL) of 2.6 [23].

Table 4: Six Sigma Calculator
Entry: Value-Z = 1.11
Change in sigma = 1.5
Equivalent values

Table of Contents	Value
Value-Z	1.11
DPM	133519
Defects	13.3519
Performance	86.6481
Cpk	0.37
SQL	2.61

5. Issues, Controversies and Problems

Based on the audit, other opportunities were identified and then raised to the Company:

- 1) Improve the receiving flow of raw materials and finished product, since the schedule for the reception of raw material as complementary products for sale is interspersed with the hours of shipment preparation, which generates a conflict of space in the yard and rescheduling of shipments of the finished product.
- 2) Review the flow of finished products from other manufacturing plants to ensure the availability of inventory in the central distribution center, positioning a supermarket to facilitate the consolidation of shipments.
- 3) Streamline the work used in the Operation of the process put away (pre-stowage to the final location of the finished product) combined with the efforts of picking Operation for the shipment of the product and create a standardized work for the truck loading process.

6. Research Methodology

In the implementation of the improvement of the customer service level to guarantee the availability of the finished product and improve the delivery time in the distribution center, the following results were obtained:

- 1) **Audit in the central distribution center** to detect improvement opportunities, where the detail of such is presented in the analysis of Table 1.
- 2) **The ABC classification** was performed to determine the items that represent 80% of the sales valued, to focus on the control of inventory presented in Table 2.
- 3) **The analysis of the coverage of inventory of finished product catalogs**, Table 3, classified as type A, indicates that seven catalogs of finished product do not have inventory for sale, only twelve catalogs are within the target set by the Company of fourteen days of inventory, and the rest of the twenty-nine catalogs are above the goal of fourteen days of inventory. Only 7% of the total monetary value of the stock is located within the established goal of inventory coverage.
- 4) **Lead Time Component Analysis**
 - a) **Information Lead Time:** Time from the moment the manufacturing facility receives the request for inventory replenishment from the distribution center supermarket.
 - b) **Manufacturing Lead Time:** Considers the days that require the manufacturing facility to produce the finished product, plus the quarantine time.
 - c) **In Transit Lead Time:** Time in transit from the warehouse of the manufacturing facility to the distribution centers.
 - d) **In Transit Lead Time Variation:** Time that can delay the shipment from the warehouse manufacturing facility to the distribution center due to external factors such as climate, holidays, transport breakdown, among others.
 - e) **Frequency of Shipments:** Considers the period in days between each shipment.
 - f) **Variation of Demand:** Days of daily inventory coverage regarding the daily sales average to cover any variation in demand required by the final customer.

- g) Variation of Supply: Daily coverage based on average daily production to cover any variation in the supply as quality defects, equipment stoppage, lack of personnel, shortage of raw material.

The evaluation of lead time's components for the manufacturing facility is considered in the following Table 5:

Table 5: Manufacturing Lead Time Components

Manufacturing Lead Time Components	Days
Information Lead Time	2
Manufacturing Lead Time	1
Quarantine Lead Time	7
Supply Variation	10

For the case of a distribution center, the lead time components are shown in the following Table 6:

Table 6: Lead Time Components for the Distribution Centers

DC Central Lead Time Components	Days
Information Lead Time	2
Manufacturing Lead Time	7
In Transit Lead Time	0
In Transit Variation	0
Shipment Frequency	1
Demand Variation	7

DC City 1 Lead Time Components	Days
Information Lead Time	2
Manufacturing Lead Time	7
In Transit Lead Time	1
In Transit Variation	0
Shipment Frequency	3
Demand Variation	3

DC City 2 Lead Time Components	Days
Information Lead Time	2
Manufacturing Lead Time	7
In Transit Lead Time	1
In Transit Variation	0
Shipment Frequency	3
Demand Variation	2

DC Central Lead Time Components	Days
Information Lead Time	2
Manufacturing Lead Time	7
In Transit Lead Time	0
In Transit Variation	0
Shipment Frequency	1
Demand Variation	7

5) Inventories Planning for the distribution centers and manufacturing facility

The sales estimate horizon is three months (current month plus two months based on the historical demand), the demand is analyzed based on the current sales and sales estimate provided by the commercial area Table 7 for calculations of supermarkets to position each of them in the distribution centers.

Table 7: Demand for each Distribution Center

Central Distribution Center

Catalog	Aug 19	Sep 19	Oct 19	Nov 19	Dec 19	
8750	286	92	138	272	227	
6890	271	219	210	169	150	
5151	78	170	61	162	94	

Central Distribution Center

Catalog	Jan 20	Feb 20	Mar 20	Apr 20	May 20	Jun 20
8750	307	307	314	215	205	205
6890	260	313	282	215	200	200
5151	18	62	59	60	50	50

City 1 Distribution Center

Catalog	Aug 19	Sep 19	Oct 19	Nov 19	Dec 19	
8750	2	8	23	6	7	
6890	19	139	119	197	140	
5151	58	28	155	140	100	

City 1 Distribution Center

Catalog	Jan 20	Feb 20	Mar 20	Apr 20	May 20	Jun 20
8750	2	1	0	13	13	9
6890	230	211	293	171	140	128
5151	177	88	126	92	43	43

City 2 Distribution Center

Catalog	Aug 19	Sep 19	Oct 19	Nov 19	Dec 19	Catalog
8750	53	25	6	39	52	8750
6890	8	60	24	21	6	6890
5151	26	24	8	34	19	5151

City 2 Distribution Center

Catalog	Jan 20	Feb 20	Mar 20	Apr 20	May 20	Jun 20
8750	64	35	61	63	67	63
6890	2	6	6	12	12	12
5151	16	18	16	25	29	25

The daily requirement sale is calculated as well the reorder point as the maximum, optimum, and minimum of inventory of finished product Table 8, for each of the distribution centers of the Company, which consider the lead time components.

Table 8: Supermarket Positioning Distribution Center

DC Central

Catalog	ROP	Inventory	MIN	IDEAL	MAX
8750	171	247	96	139	182
6890	166	231	93	135	177
5151	16	49	9	14	19

DC City 1

Catalog	ROP	Inventory	MIN	IDEAL	MAX
8750	17	4	6	13	20
6890	147	76	52	113	173
5151	51	35	24	43	63

DC City 2

Catalog	ROP	Inventory	MIN	IDEAL	MAX
8750	35	18	12	26	41
6890	17	27	6	13	20
5151	9	25	5	8	11

In the manufacturing facility, the production plan Table 9 is analyzed to implement the supermarket and act as a buffer before any variation of supply to ensure the availability of the product. The production plan considers the distribution centers' net requirement, less the positioned inventory on the facility to calculate the requirement to produce.

Table 9: Production Plan - Manufacturing Facility

Catalog	Aug 19	Sep 19	Oct 19	Nov 19	Dec 19	
8750	456	332	338	100	325	
6890	549	542	467	320	360	
5151	38	286	65	241	229	

Catalog	Jan 20	Feb 20	Mar 20	Apr 20	May 20	Jun 20
8750	430	323	450	449	408	400
6890	580	493	584	599	469	457
5151	128	59	191	235	65	65

Determines the supermarket Table 10 for the production area that considers the maximum and minimum inventory policy:

Table 10: Supermarket Manufacturing Facility.

Catalog	ROP	Inventory	MIN	IDEAL	MAX
8750	154	130	154	170	185
6890	212	230	170	212	255
5151	19	25	10	22	34

6) Visual Management of the Inventory of Distribution Centers

The current inventory of finished products is compared against the maximum, optimum, and minimum inventory to maintain visual management. Green indicates that it is within the maximum level and optimum inventory; this is the ideal position. Yellow between the optimum and minimum levels requires planning to place a manufacturing order to replenish the inventory to its position. Red requires expediting the production order, given that the current inventory is below the minimum level with a possible negative impact on the service level. When the current position is

blue, it is above the maximum allowed level, and action is required to balance the inventory levels to those approved. It is essential to run this report daily since it is the tool that manages the release, issuance, and establishment of priorities of the manufacturing orders to production and the valuation of the position of inventory in units. This report is required per the manufacturing facility and distribution center.

7) Planning Horizons

Once the supermarket was positioned in the Distribution Center and manufacturing facility, the following was agreed with the Commercial area:

The sales estimate horizon is three months (current month plus two months based on the historical demand), delivery takes place between 3 - 4 days business days of the month, and formed on the following and the basis of the planning zones:

- *Fixed Zone:* Consists of the time required upon releasing the production order and until the product is available for sale. The horizon is of 14 days with zero percentage of variation. This planning zone is conformed of labor, materials, and burden.
- *Firm Zone:* This zone considers, from the moment the purchase order is placed to the suppliers, considers the longest lead time of the resource, either materials, tools, and/or equipment, as labor in compromising the production requirements. The time horizon is 20 days; the variation percentage of the sale estimated is +/- 20%. In this horizon, planning involves materials and any other resource required to be contracted as labor and/or equipment.
- *Planning Zone:* Consists of the horizon when no resource for production is committed; therefore, the percentage of variation is open.

8) Delivery Time to Customer Service

The delivery time to the customer is essential as part of the flexibility offered by the Company, to meet the immediate need for what was agreed with the Commercial area, the following delivery times according to the ABC classification of the finished product:

- *Family Products A:* Delivery time is the time upon the receipt of the order, preparation, shipment, and invoicing; this delivery time is of 90 minutes for the external customer; in the case of an internal customer as the Distribution Centers located in other cities, it must be considered two days upon the receipt of the inventory replenishment requirement, preparation of shipment and billing plus the in-transit time. If demand variation consumes the inventory available in the supermarket, the planning area should coordinate the managing of materials and resource capacity with Production and Purchasing; consideration should be given to the delivery to customers and communicate to the commercial area the best delivery commitment to customer's order. In coordination with planning, the Commercial area shall manage the priorities of the inventory allocation until the inventory is regularized in the supermarket according to the maximum and minimum levels of inventories approved. Production should communicate the plan to recover inventory to approved levels.

- *Family Products B:* These finished goods products are not supplied within the calculation of the maximum and minimum inventory. It is a product that is managed to make an order basis. Delivery Time is seven days. The way to schedule this finished product to production is FIFO (Customer's First orders entered are the first to be scheduled for production).
- *Family Products C:* This is a new product with a particular design in which the delivery time is variable according to the project's timeline.

Based on the month's production requirement, the production requirement is planned in Table 11, 30% in week 1, 30% in week 2, 20% in week 3, and 20% in Week 4; this production balance enables demand confrontation since 60% of the sale occurs in the last two weeks of the month, which makes the labor requirement planning Table 12 as the materials requirements more predictable, for inventory positioning of raw materials in supermarkets, this enables better visibility of the requirement to the consumption of raw materials to suppliers and increase the flexibility of the productive capacity, especially when they are manufacturing make to order products for special projects for which demand is random.

9) **Production Balance**

Table 11: Monthly Balanced Production Plan

Catalog	Mont hly Prod. Req"	Pro d. Req Wk 1	Pro d. Req Wk 2	Pro d. Req Wk 3	Pro d. Req Wk 4	Hr. Req Proce ss 1 Wk1	Hr. Req Proce ss 2 Wk1	Hr. Req Proce ss 1 Wk2	Hr. Req Proce ss 2 Wk2	Hr. Req Proce ss 1 Wk3	Hr. Req Proce ss 2 Wk3	Hr. Req Proce ss 1 Wk4	Hr. Req Proce ss 2 Wk4
Product 1	493	148	148	99	99	166	243	166	243	111	162	111	162
Product 2	323	97	97	65	65	109	159	109	159	73	106	73	106
Product 3	59	18	18	12	12	8	16	8	16	5	11	5	11
Product 4	0	0	0	0	0	0	0	0	0	0	0	0	0
Product 5	232	70	70	46	46	63	63	63	63	42	42	42	42
Product 6	0	0	0	0	0	0	0	0	0	0	0	0	0
Product 7	145	44	44	29	29	49	71	49	71	33	48	33	48
Product 8	430	129	129	86	86	145	212	145	212	97	141	97	141
Product 9	1	0	0	0	0	1	3	1	3	1	2	1	2
Product 10	57	17	17	11	11	19	51	19	51	13	34	13	34
Product 11	40	12	12	8	8	14	36	14	36	9	24	9	24
Product 12	151	45	45	30	30	27	20	27	20	18	14	18	14
Product 13	241	72	72	48	48	43	33	43	33	29	22	29	22
Product 14	78	23	23	16	16	14	11	14	11	9	7	9	7
Product 15	372	112	112	74	74	67	50	67	50	45	33	45	33
Product 16	300	90	90	60	60	54	41	54	41	36	27	36	27
Product 17	109	33	33	22	22	20	15	20	15	13	10	13	10
Product 18	92	28	28	18	18	25	83	25	83	17	55	17	55
Product 19	165	50	50	33	33	22	22	22	22	15	15	15	15
Product 20	218	65	65	44	44	0	75	0	75	0	50	0	50
Product 21	1089	327	327	218	218	0	399	0	399	0	266	0	266
Wk Req. hrs.						540.1	762.9	540.1	762.9	360.0	508.6	360.0	508.6
Daily Req. hrs.						90.0	127.2	90.0	127.2	60.0	84.8	60.0	84.8

Table 12: Labor Weekly Requirement

Labor Weekly Requirement								
	Week 1		Week 2		Week 3		Week 4	
	Process 1	Process 2	Process 1	Process 2	Process 1	Process 2	Process 1	Process 2
Product Family 1	9.7	14.1	9.7	14.1	6.5	9.4	6.5	9.4
Product Family 2	7.8	11.2	7.8	11.2	5.2	7.4	5.2	7.4
Product Family 3	1.7	1.8	1.7	1.8	1.1	1.2	1.1	1.2
Product Family 4	0.9	1.8	0.9	1.8	0.6	1.2	0.6	1.2

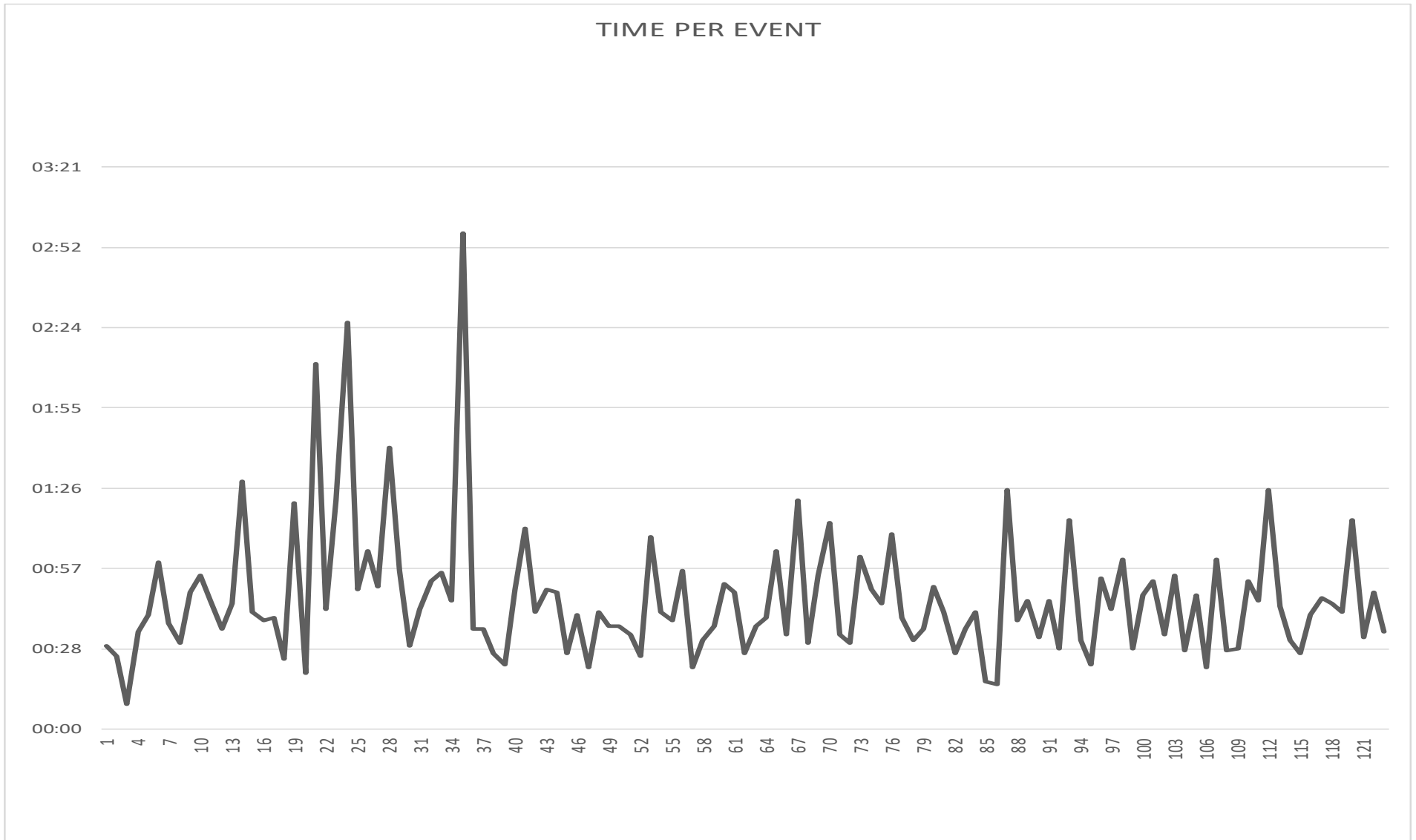


Figure 6: Customer delivery Time per event.

10) Customer delivery Time

The customer delivery time Figure 6 is measured from the moment the customer order is created, the administration area authorizes the order, the ordered product inventory is booked, delivery of documents to logistics, processing the loading order, delivery of documents to the loading area, loading of order and delivery of documents to the customer.

Registers an average customer delivery time of 46 minutes below the goal of 90 minutes, which encourages the customer to be recurrent customers considering the availability of inventory to cover their requirements with a short delivery time.

11) Process Capability and Six Sigma

Through the implementation of the proposed improvements, the process is in statistical control, as well as in the assessment of capability indexes, the level of cpk increased from 0.37 to 0.86, the associated z level moved from 1.11 to 2.59, and the sigma level moved from 2.61 to 4.09 with a decrease of defects per million of 133,519 to 4,798.83. It should be noted that an optimum level is not yet achieved. However, this represents a strategic impact and the opportunity to deploy additional improvements to arrive at an ideal level of six sigma, that is to say, with only 3.4 ppm of failure. It can be observed in Figure 7 that the associated data with the subsequent measurements to improvements come from a normal distribution with a p value=0.407, which is higher than the value $\alpha=0.05$ [23].

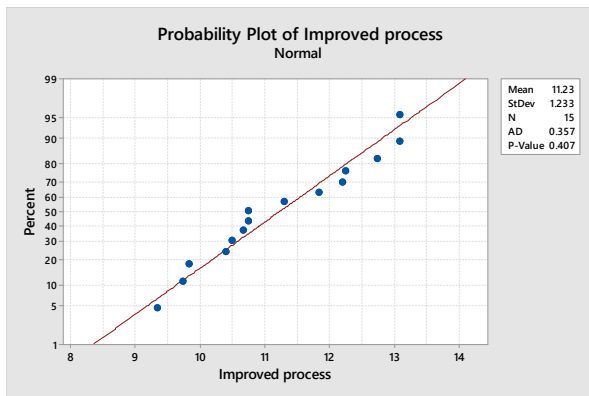


Figure 7: Probability Plot of Improved Process

Figure 8 shows the process under statistical control without points outside the control limits without any anomaly trends.

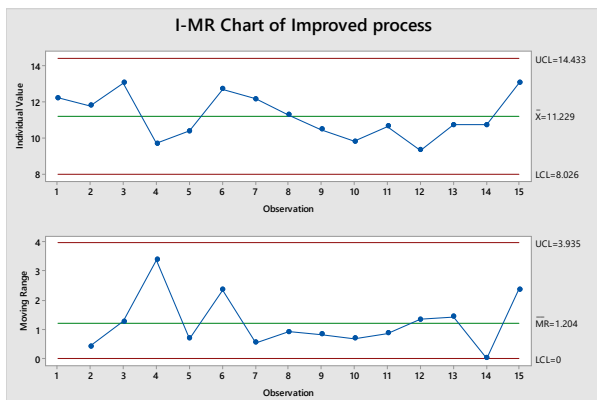


Figure 8: Graph of Individual Values and Mobile Range for the Improved Process

Figure 9 shows the process capability analysis report in which it is possible can see the improvements obtained with a Cpk index of 0.86; although it is not the optimal state of the process represents a significant improvement.

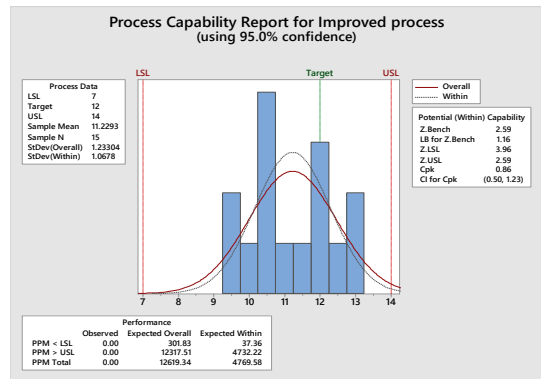


Figure 9: Process Capability Report for Improved process

Figure 10 shows the improvement in performance in which there is a significant reduction in the fraction of the probability distribution outside the upper limit of the specification.

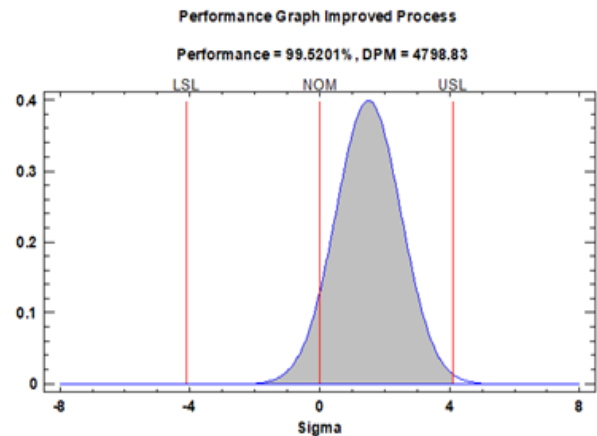


Figure 10: Performance Graph Improved Process

Table 13 shows the values obtained in the six-sigma calculator associated with the improved process the Z value of 2.59, Defects Per Million (DPM) of 4,798.33, Percentage of Defects 0.47, Yield of 99.52% with a process capability (Cpk) of 0.86, and a sigma quality level of (SQL) 4.09.

Table 13: Six Sigma Calculator
Entry: Value-Z = 2.59, Change in sigma = 1.5
Equivalent values

Table of Contents	Value
Value-Z	2.59
DPM	4798.83
Defects	0.479883
Performance	99.5201
Cpk	0.863333
SQL	4.09

12) Pull System

The Commercial area estimates the monthly sales to determine the maximum and minimum level of finished product inventory. A pull system is implemented, the customer's orders are supplied directly from the CD's finished good product supermarket. The

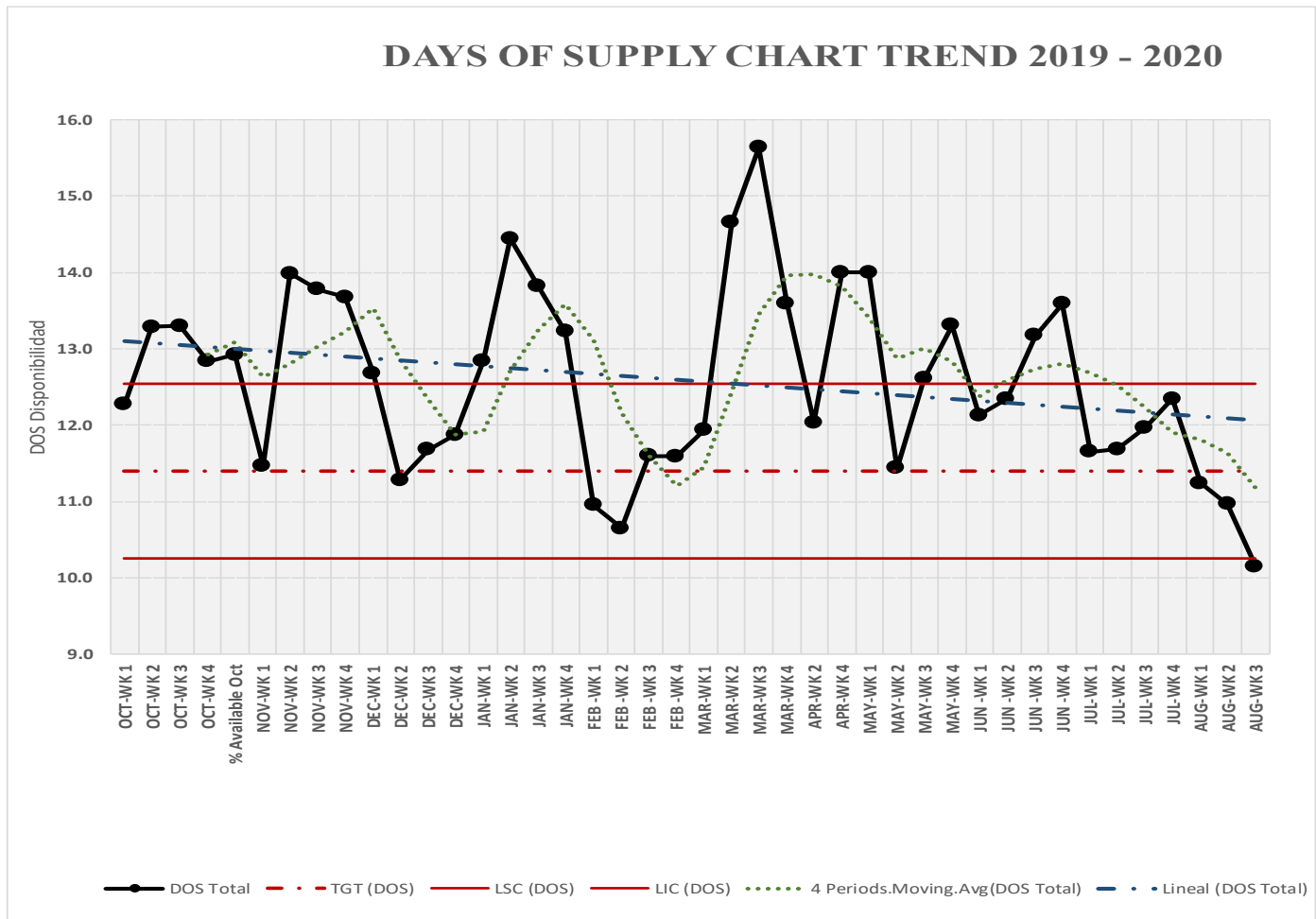


Figure 11: Days of Supply Finished Goods Inventory

consumption of the supermarket inventory generates a manufacturing order for production to replenish the finished product supermarket. As the supermarket's raw materials are consumed when producing the manufacturing orders, the purchasing requisitions of raw material are released to the purchasing department to generate the purchase orders for the suppliers and thus guarantee the replenishment in the raw's materials supermarket.

13) Days of Supply Finished Goods Inventory

The trend chart of days of supply Figure 11 shows a favorable trend in days of coverage, having a supply of twelve days of inventory against a goal of 14 days.

7. Results and Conclusions

During the COVID 19 pandemic, the Company has been operated with a Pull system, in which supermarkets were positioned in Central, City 1, and City 2 distribution centers for finished products classified A; The inventory is managed with a maximum, and minimum policy, based on customer consumption, the supply signal to the manufacturing plant is triggered to replenish and position the inventory in the distribution centers.

Based on the inventory consumption for the supermarket of the manufacturing plant, the manufacturing orders are released to replenish the inventory in the supermarket of the plant, which has generated a reduction of the inventory to a coverage of 12 days before starting the improvement in the process, the catalogs classified type A had a 27-day average coverage, against the Company's goal of 14 days of inventory. The service level, the baseline of performance 89% guaranteeing inventory availability, exceeds expectations with a 98% service level. An average customer delivery time of 46 minutes is recorded below the 90-minute goal, which encourages the customer to be a recurring customer considering inventory availability to meet their requirements with lead time delivery. The savings in inventory optimization on an annual basis represented USD 530,785. (Five hundred thirty thousand seven hundred eighty-five dollars) helping the Company to gain liquidity and to create the conditions for the recovery of economic growth, and helping to preserve employment as much as possible in a constrained market. Through the implementation of the proposed improvements, the process is under statistical control, the process capability (Cpk) is increased from 0.37 to 0.86, and the level six sigma (SQL) is increased from 2.61 to 4.09, reducing the percentage of defects to

13.3 to 0.47. An additional benefit is that the Company implemented the methodology nationwide in its other Manufacturing Plants and Distribution Centers. This methodology supports the acceptable practices that the Company is implementing in search of continuous improvement as part of the strategic framework to fulfill the strategic objectives based on the business vision.

Conflict of Interest

The authors declare no conflict of interest.

Acknowledgment

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COVID-19 Crises: Global Economic Shocks vs Pakistan Economic Shocks

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Behavioral economics

ABSTRACT

This paper documents, information about the current outbreak of Corona virus and its multidimensional effects witnessed worldwide. The objective of the study is to disseminate information to policymakers, government and the general public, to facilitate the efforts for fighting against the contagious virus and aims to contribute to the economic and social welfare. Though the data changes rapidly by every passing minute, yet the current scenario may be analyzed to evaluate the present situation for a fruitful outcome. Hence, the discussion may be useful for all the stakeholders (government, policymakers and the public) for their reference. Various studies previously observed that widespread contagious diseases have a severe impact on the economy. It is observed that the faster and wider the outbreak of disease, the higher and severer the influence on the economies. The economies face shrinkage of income, revenue, earnings, while health expenditure increases for hospitals, medical kits, ventilators, uniforms, masks, gloves, medicines and other medical equipment. Therefore, it has a two-pronged adversely hitting effect on economies to manage the imbalance in the budget and fiscal matters. Another unfortunate situation is when the high populated country is poor too. The world has realized the effects of the different contagious viruses in the different times in history. Nevertheless, the virulence and the severity of the COVID-19 is far greater than the previous viral breakouts. We, in this research attempt to highlight the multidimensional effects of COVID-19 and create some possibilities how to deal and fight with this cruel and invisible enemy.

1. Introduction

Where there are many advantages of globalization, there are disadvantages attributed to it, as well. What we are facing currently in the shape of contagious viral breakout worldwide is one such example. Therefore, one should not think that the disaster that happens in one country would not affect the other. Everything is affected because of the social interaction and shared economies around the globe. Education, skills, tourism, business and human resource mobilization are major factors which create a cause for connecting the people and making the world a global village.

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What we are facing currently in the shape of contagious viral breakout worldwide is one such example. Therefore, one should not think that the disaster that happens in one country would not affect the other. Everything is affected because of the social interaction and shared economies around the globe. Education, skills, tourism, business and human resource mobilization are major factors which create a cause for connecting the people and making the world a global village.

In this connection whenever the good comes to one country, it reaches to other also by imports, social attitudes or demonstration effect. Accordingly, when evil occurs in one country, the same comes to the rest of the world. Today we the habitants of this global village are facing the same evil occurrence in the shape of

the novel coronavirus. It is only due to the interconnection of the countries of the whole world called global village. This strengthens the concept that everything has its pros and cons on its side.

Similarly, where the globalization has shared knowledge, expertise, technical skills and productive output of resources among countries, it shares bad events there too, which weakens the ability of workforce as being witnessed today as an aftermath of COVID-19 outbreak. Resultantly, cause deaths and morbidity in human resource globally. According to [1] “*In a strongly connected and integrated world, the impacts of the disease beyond mortality (those who die) and morbidity (those who are unable to work for some time) have become apparent since the outbreak*”. They further elaborate that due to the novel coronavirus, a panic is created between business and consumers. That has created market anomalies and slanted consumption patterns. International financial markets and global stock indices have plunged in the response of changing world conditions.

Moreover, the intensity of loss increases when the country is underdeveloped like Pakistan. The socio-economic effects of COVID-19 are dispersed with greater force across developing countries and their emerging markets. Such increasing effect has directly hit their income adversely. The loss of employment creates declining GDP, national income GNP and per capita income leading to the rise in poverty. As in 2019 more than 25% of the population lived below the poverty line and more than 29.5% of the population considered poor and depends on agriculture. Such a component of the population is expected to reach 40%, according to the World Bank report (see Figure 1). The graph shows the Poverty Headcount Ratio since 2001 to 2020f (forecast). “Poverty Headcount Ratio”:

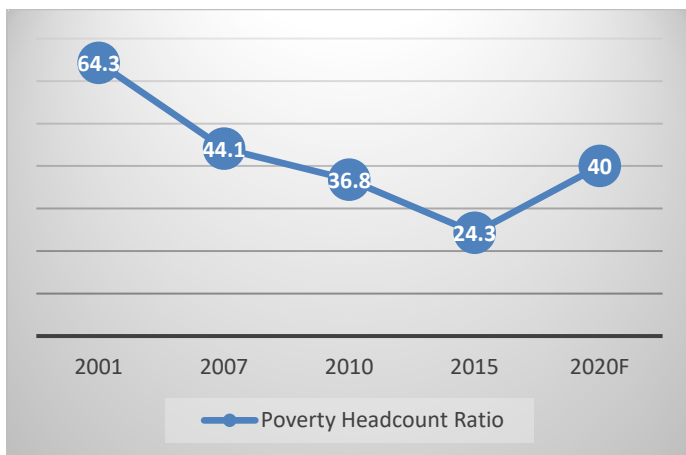


Figure.1 Poverty headcount ratio (Source: World Bank)

Pakistan’s per capita income is already lower. The average per capita income is estimated at 1250 USD. Such a lower income rate cannot even fulfil the basic needs of people. Higher unemployment rates around six per cent, according to “Trading Economics, global macro models and analysts expectations”¹. Most of the labor force comprising of daily wage and temporary employment under the informal sector, worried about their bread and butter. The industry is not as strong as in developed countries.

¹<https://tradingeconomics.com/pakistan/unemployment-rate>
www.astesj.com

Pakistan relies heavily on the imports for most technical products, automobiles, machinery and oil. Similarly, exports are more important for these developing countries whose foreign exchange is not at a satisfactory level, rather indebted to international institutions heavily and chronically. In this backdrop, the outbreak of COVID-19 is a big disaster for Pakistan threatening all spheres including its crippling economy.

Here the research question arises, due to COVID-19 what aspects of the economy of the world and Pakistan, in particular, are affected? To what extent the world is experiencing psychological and socioeconomic shocks? And how far their impact would be seen?

Therefore, our objective is to evaluate and analyze the effects of this epidemic COVID-19 on the world and Pakistan economy. To what extent, particularly psychological, social and economic hits the globe is facing currently. In this study, we try to focus on the emerging threats jeopardies and vulnerabilities in the world economy that may be considered. The economic costs of viral outbreaks were different in the past as compared with the current worldwide spread of viral disease. The economic cost is directly proportionate with the rise of the virus; rather the cost has a multiplying impact for the least developed economies. Deaths and illness or morbidity further create chaos in multi spheres. It also sprouts the disability and uncertainty at the workplace in future.

The paper is structured further as below; section 2 provides some previous studies on the pandemic. Section 3 briefs the method to articulate the study while section 4 discusses and analyses the different economic shocks worldwide and in Pakistan by highlighting its different aspects. Section 5 concludes the paper and section 6 suggests some recommendations on the issue.

2. Previous studies on pandemics

The economy cannot be separated from the health of the population as the human resource is the major factor of production. Therefore, the health of people and economies go together either grow/flourish or weaken/collapse. A lot of research is conducted on the issue that has found that the health of the population is closely concerned with economic welfare and economic growth [2-9]. Other studies on SARS, including [10] for Taiwan, [11] for China and [12] for Hong Kong also elaborate the worse situation of the affected regions. These studies directly or indirectly can be connected to this current issue, however the effects higher than the historical contagious diseases. We can also comprehend that the health of people and the health of the economy are directly connected.

In the 20th century, the historical breakouts of epidemics that world witnessed are: “*Spanish Influenza of 1918, Asian flu of 1957 and the Hong Kong flu of 1968. In the 21st century, outbreaks are NIHI in 2009 (‘bird flu’), Severe Acute Respiratory Syndrome (SARS) in 2002, Middle East Respiratory Syndrome (MERS) in 2012, and Ebola which peaked in 2013-14*” [13]. All these pandemics spread panic in the regions when they broke out and infected population at large scale by health and economic depressions. For example, in 2003 by the breakout of SARS, the economic problems increased. There was a huge reduction in the demand or consumption and the cost of operating a business which increased the uncertainties and risk premium. The spread

of disease crossed borders, according to the interaction of the host country's exposure and predisposition to the disease. Similarly, [14], describes that AIDS/HIV affects the economy. Government, business and households suffer through changing labor supply, labor efficiency, growing cost of business and confining investment in training of staff by firms, increased health care expenditure by supporting disabled people and orphan children due to AIDS in public sectors.

The researchers elaborate that despite a low level of health damage, mortality rate and the small number of deaths the world suffered a lot in terms of economic loss. The global cost witnessed that it is not only specific to the countries affected adversely [15]. Conversely, the impact of COVID-19 is far more than the formerly experienced contagions because this is not the story of a few countries, rather the disaster of the whole world consisting around 200 countries. This epidemic impact on the health of people and the economy is much more than World War I and World War II. These wars did not infect 200 countries all around. The unexpected and sudden blow-out of coronavirus has put the entire world into the shock. According to [15] "*The fear of 1918-19 Spanish influenza, the deadliest plague in history, with its extreme severity and gravity of clinical symptoms, is still present in the research and general community*". Likewise, at the start of breakout people think that COVID-19 has the same level of fear as the other former contagious diseases. On the contrary, the COVID-19 has infected at greater extent by multi spheres all over the world. Plenty of research is available about previously highly infectious observed diseases of epidemic for which no vaccine prepared yet. All that literature providing experience from these aforementioned epidemics can be informative to some extent how to think and deal regarding COVID-19 for implications [16].

However, this time the invisible enemy COVID-19 has played far beyond the previous epidemics did. According to CEPR Press, 2020, the number of people affected by the COVID-19 is much greater than the SARS cases. Hence, due to the fear of novel coronavirus, countries have started lockdown. Lockdown is creating a gap in the world level economy. The contagious virus is going to be affected so badly that countries went for lockdown and curfew.

To see the global situation, John Cochrane in the chapter of eBook indicates some bold queries about lockdown mechanism. That there will not be any disaster if a short pause is given to economize for a certain period for the sake of public health and socioeconomic prosperity. For this, there should be a systemic way and constructive approach in implementing it properly and completely. The researcher displays worry about huge financial issues even for firms' disbursements or payments of debts, mortgage, salaries, wages, rents, utilities. Subsequently, when the business shuts during lockdown under demand shock, how can household and firms manage their fixed costs? This fear is felt and John Cochrane writes that it is possible to occur economic shocks like bankruptcies, insolvencies as well as inability to pay the bills. Lockdown situation will prolong across economic fluctuations as happened in 2001 and 2008.

The great influence of the COVID-19 on the economy has been started due to the prolonged worldwide shut down. What repercussions the world is observing the matter of attention and focus so that some way out could be found to cope with this perilous condition.

3. Methodology

In this study, our objective is "to evaluate and analyze the effects of this epidemic COVID-19 on the world and Pakistan economic shocks and what particular psychological, social and economic hits the globe is facing currently". Therefore the methodology we used is mostly through collecting secondary data by desk research we referred published reports and statistics by different sources ranging from national and international surveys, reviews and publications [17]. For that purpose, we conducted desktop research, accordingly. We also reviewed and referred to the research papers on the subject. In this study, we have analyzed the current pandemic situation and discussed its multi sphere effects on economic factors during the occurrence of the pandemic situation. We evaluated the world economic shocks as well as Pakistan economic shocks being faced by the masses.

4. Analysis and discussion on the multi sphere, economic shocks

4.1. Global economic shocks

As the first attack of COVID-19 in China, the second-largest economy behind US 1/3 of world manufacturer and world's largest exporter shut down after viral breakout. According to Statista expected report 2019, China's GDP contributes to 19.24% of the global total in 2019 and 19.72% in 2020; the same is expecting 21.39% in 2024. Despite that China's economic effect is widely noticed and spread globally.[18], in the ebook of CEPR Press, mention that the Chinese economy showed a sluggish pattern in the 1st quarter of 2020. While looking at the global economic situation and economic contribution, China stands high by contribution in global GDP by 17%, in world trade by 9%, in global tourism by 9.3% and in global demand by 40% which leaves not a positive impression and influence to the other countries. This does not affect china only, but also the supply and demand of the rest of the country.

However, it is observed that the World GDP is condensed up to 0.75%, by this the impact on world GDP growth is being around half a present point in 2020. The reason for this decline is due to the initial curtailment in the demand in China. Thus China's international trade has significantly declined by around 1.4% in the 1st half of and 0.9% in the whole year of 2020. China's cross border linkage is strong with other countries through commodity exporters of Japan, Korea, East and South-East Asian countries ranging from the supply chain, tourism and other travel-based services. All other countries of America, Europe, Middle East and Asia are growing seriously infected day by day. Therefore, the whole world is facing isolation and lockdown due to which all economic activities are stagnant. All together the countries affected over 70% of global GDP in terms of PPP. Thus, the big economies of the world are infected by this invisible enemy at their worst. The world's GDP trend of various countries since 2017 -2020 can be seen in the table 1.

According to [19]. "Taking just the US, China, Japan, Germany, Britain, France, and Italy, they account for 60% of world supply and demand (GDP), 65% of world manufacturing, and 41% of world manufacturing exports". Due to a strong supply chain in the regional dimension, China, Japan, Korea at hard-hitting and this shock of the supply chain will be extended to whole Asia. According to an estimate, the global GDP has

declined by 1.75% in the latter half of 2020, whereas it is to be declined around 1.5% in the full-year GDP growth impact in 2020. Global trade is, decreasing approximately by 3.75% in 2020, hammering exports in all economies.

The global panic of COVID-19 has created unprecedented uncertainty to a level which caused a massive reduction in oil prices, resulted by declining of investment in China and the rest of the world. IEA further foresees the global oil demand falling by “435,000 barrels per day when compared at the year-on-year basis. The current quarter compared with the corresponding period of last year reveals that the world has witnessed the highest shrinkage in the economy of the decade. It is expected further that the global oil demand will further touch to the low by “365,000 barrels per day”. It is said to be the worst behavior of demand since 2011. Consequently, “OPEC plus countries consider the reduction in oil production of 600,000 barrels a day as an emergency measure on the top of the 1.7 million barrels a day already pledged” [20]. This declining scenario is observed only from the direct effect of shrinkage of demand-supply side. However, the impact of the risk and future uncertainty is yet to cripple in slow the days to come.

Furthermore, the financial sector and the global stock markets have witnessed crashed down situations all over the world. Stock exchanges are experiencing a decline in market capitalization on an hourly basis. European stock indices, American stock markets witnessed worst drops since March 20, 2020. Financial crunch and stock market of developing countries would lead their economies into a hazard. Puts it: “*Developing economies in East Asia and the Pacific (EAP), recovering from a trade war and struggling with a viral disease, now face the prospect of a global financial shock and recession. Given the unprecedented nature of the economic shock to each country, and the fact that it is also affecting all other countries in the region and beyond, an exceptional policy response is needed*”. Hence, having more than 70% of the poor population in developing countries is more vulnerable to the situation. The production has declined and so the employment level due to the shutter down and bans imposed for halting the outbreak of this pandemic. The low-grade staff or daily wage labor is burdening the economy in two ways. From one side they are unproductive whereas from the other side the governments have to arrange their bread.

4.2 Multidimensional hits of COVID-19

COVID-19 has created chaos and hitting in multi spheres globally. The effect of this contagious virus is discussed below along with the decoration of the graphical presentation.

4.3 Demographic hits

The rampant and contagious coronavirus has created a global emergency. The demographic change has occurred dramatically. It has hit the health of people in millions across the world. The figures of infected people change quickly in minutes all over the world. The reasons are all other kinds of flu viruses do not transmit faster, the way it transmits from one person to another. Its mortality rate is 2% to 3%, which is greater than other viruses.

Thus, what people have faced already is terrible. Increasing deaths or mortality rates, illness and morbidity by damaging health have created a big demographic change in the world.

According to [21] who runs preparedness efforts for NYC Health and Hospitals, said: “This particular virus seems like it is highly transmissible, I think that it is certainly plausible that 40–70% of the world’s population could become infected with coronavirus disease, but a large number of cases are (expected to be) mild.”

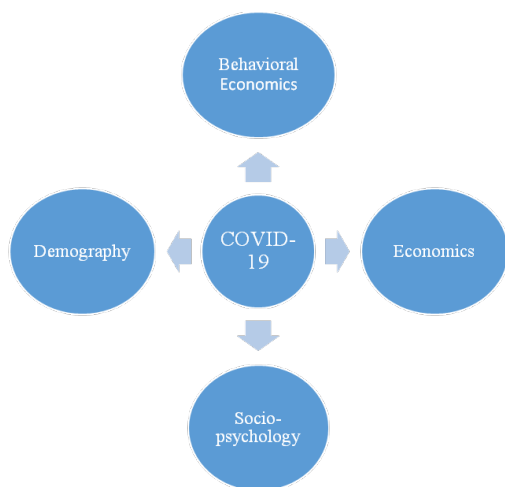
4.4 Economic hit:

The novel coronavirus is witnessed as contagious economically as it is medically. The economy is suffering and gets a double hit in the following ways:

1. From one side “**revenue reduction**”: Coronavirus affects all type of enterprises specifically service sector and small & medium enterprises (SMEs). All forms of business organizations such as manufacturing, trade and service organizations are facing curtailment of operational activities. Millions of formal as well as informal employment and self-employment are affected. The business loss occurred as services have been curtailed globally. Transport being limited and even restricted among countries has further slowed down global economic activities. It has further minimized the consumption of oil and other fuels. Resultantly, Oil & petrol companies face revenue loss. The lockdowns resulted in low production, which has reduced the local and global trade. As the world economies also depend on international trade, which has dented the economies world over. Confined economic activities have resulted in revenue kerbing. For example, hotel booking cancellation, restaurants, marriage halls supermarkets, casinos, bars, pubs, saloons, and parlours shut down, limited supply chain, banned exports and imports, worldwide airline cancellation, and restricted tourism, all have affected the revenue generation and ultimately the economies of the world. Hence the loss of tax collection would also occur and the Governments would bear this burden on the exchequer. The fiscal and monetary policies, depending on government revenue collection, have witnessed major policy shifts. It ultimately shows a big economic depression for all economies.
2. From the other side “**expenditure extension**” For the national security purpose, huge expenditure is set for this battle to fight by purchasing expensive medical equipment in huge number. Every country is engaged in making budgets for vaccines, medicines, ventilators, isolation centres, hospitals and other medical apparatus. Addition to that spending on research and science in this particular direction to prepare apparatus, vaccines and medicines, as well as other health care expenditure, would be a severe problem for poor countries. Thus, revenue reduction and extending expenditure for poor economies is a big challenge. Because the loss of human lives and economies by COVID-19 is greater than the world witnessed before.

Table 1: Economic situation of the world

Real GDP (% change from previous years)	(% difference from January 2020 forecasts)						
	2017	2018	2019	2020f	2021f	2020f	2021f
World	3.3	3.0	2.4	-5.2	4.2	-7.7	1.6
Advanced economies	2.5	2.1	1.6	-7.0	3.9	-8.4	2.4
United States	2.4	2.9	2.3	-6.1	4.0	-7.9	2.3
Euro Area	2.5	1.9	1.2	-9.1	4.5	-10.1	3.2
Japan	2.2	0.3	0.7	-6.1	2.5	-6.8	1.9
Emerging market and developing economies	4.5	4.3	3.5	-2.5	4.6	-6.6	0.3
Commodity-exporting EMDEs	2.2	2.1	1.5	-4.8	3.1	-7.4	0.2
Other EMDEs	6.1	5.7	4.8	-1.1	5.5	-6.2	0.3
Other EMDEs excluding China	5.4	4.8	3.2	-3.8	3.5	-7.6	-0.8
East Asia and Pacific	6.5	6.3	5.9	0.5	6.6	-5.2	1.0
China	6.8	6.6	6.1	1.0	6.9	-4.9	1.1
Indonesia	5.1	5.2	5.0	0.0	4.8	-5.1	-0.4
Thailand	4.1	4.2	2.4	-5.0	4.1	-7.7	1.3
Europe and Central Asia	4.1	3.3	2.2	-4.7	3.6	-7.3	0.7
Russia	1.8	2.5	1.3	-6.0	2.7	-7.6	0.9
Turkey	7.5	2.8	0.9	-3.8	5.0	-6.8	1.0
Poland	4.9	5.3	4.1	-4.2	2.8	-7.8	-0.5
Latin America and the Caribbean	1.9	1.7	0.8	-7.2	2.8	-9.0	0.4
Brazil	1.3	1.3	1.1	-8.0	2.2	-10.0	-0.3
Mexico	2.1	2.2	-0.3	-7.5	3.0	-8.7	1.2
Argentina	2.7	-2.5	-2.2	-7.3	2.1	-6.0	0.7
Middle East and North Africa	1.1	0.9	-0.2	-4.2	2.3	-6.6	-0.4
Saudi Arabia	-0.7	2.4	0.3	-2.8	2.5	-5.7	0.3
Iran	3.8	-4.7	-8.2	-5.3	2.1	-5.3	1.1
Egypt	4.2	5.3	5.6	3.0	2.1	-2.8	-3.9
South Asia	6.5	6.5	4.7	-2.7	2.8	-8.2	-3.1
India	7.0	6.1	4.2	-3.2	3.1	-9.0	-3.0
Pakistan	5.2	5.5	1.9	-2.6	-0.2	-5.0	-3.2
Bangladesh	7.3	7.9	8.2	1.6	1.0	-5.6	-6.3
Sub-Saharan Africa	2.6	2.6	2.2	-2.8	3.1	-5.8	0.0
Nigeria	0.8	1.9	2.2	-3.2	1.7	-5.3	-0.4
South Africa	1.4	0.8	0.2	-7.1	2.9	-8.0	1.6
Angola	-0.1	-2.0	-0.9	-4.0	3.1	-5.5	0.7
Memorandum items							
Real GDP							
High-income countries	2.4	2.2	1.7	-6.8	3.8	-8.3	2.3
Developing countries	4.8	4.4	3.7	-2.4	4.7	-6.7	0.2
Low-income countries	5.4	5.8	5.0	1.0	4.6	-4.4	-0.9
BRICS	5.3	5.3	4.7	-1.7	5.3	-6.6	0.4
World (2010 PPP weights)*	3.9	3.6	2.9	-4.1	4.3	-7.3	1.0
World trade volume*	5.9	4.0	0.8	-13.4	5.3	-15.3	2.8
Commodity prices*							
Oil prices	23.3	29.4	-10.2	-47.9	18.8	-42.5	16.9
Non-energy commodity price index	5.5	1.8	-4.2	-5.9	3.0	-6.0	1.3



4.5 Socio-psychological hit:

The socio-psychological effect of coronavirus is felt greater than ever in the history of viruses' breakouts at different times in the world before. Intensifying fears of a global recession also circulate in Governments, business communities and the general public of all countries. Panic has created a deep impression on the psychology of people. There is a challenge for doctors, nurses, police and army while dealing with patients, salute to them. The uncertainty of the future and risk of lives has created a great depression all over the world. People are suffering from depression in quarantine and isolation. Indeed, such pandemics spread a lot of fear and panic so that people cannot perform at their normal level. As the same effect was noticed in 1918 on the breakout of Spanish influenza and World Health Organization estimates a bigger number of people some more than 300 million people were suffering from stress and depression worldwide and becomes the leading cause of disability in human. Also, [22] describes that the invisible and lethal situation of virus creates not only the biological issue, but also a psychological pressure like a terrorism threat which leaves long-lasting consequences. However, due to COVID-19 in 2020, the extent of depression is far more than ever expected. [23] also opine the same by describing that a large proportion of the masses will observe the risk of pandemic whereas the risk of death will not be equal.

Due to physical and psychological distress in patients either they lose their appetite temporarily before and even after treatment because they face the traumatic situation and see the death closely or relish the meal when they get back to normality. Patients become reluctant, doubtful, angry, exhausted, regretted in stress. Therefore, they need support with greater zeal.

4.6 Behavioral economics

The economy is also affected by the various behaviors/psychological reactions of different stakeholders through high/low demand and high/low supply shocks and other reasons. For example: The investment decision of investors in fluctuating certain/uncertain conditions, by the consumer behavior in varying situations such as high/low-risk taking, healthy/unhealthy conditions, fear of injury, infection, fear of death, fear of loss, due to precaution, government instructions, quarantine, lockdown, curfew and other various reasons. In the

result, demand curtails and suppliers also hold the production according to limitations in orders and apply wait and watch policy. Labor force is prone to be infected with such pandemic diseases. The contagious disease affects labor from many aspects, e.g. infections, disability and deaths. Therefore, from the human resource side the production process slows down and employment rate reduces, hence supply curtails. Every economic indicator becomes vulnerable.

During the attack of COVID-19 hand washing, hygiene, diet, clean environment, mask and gloves wearing is projected. Likewise, by changing behavior, goods and services change. Manufacturing takes place in that connection.

On the other hand, people in quarantine can save much living cost, no social interaction/ gathering, no tour or outing cost, no hotel, restaurant, travel, parlor and theatre/cinema cost, overall precautionary steps to reduce the viral effect too. As [24] expresses the quarantining period is social isolation and disintegrate from the period, which results in the social pressure and psychological down. Similarly, [25] state that undertaking hygiene measures are not a big deal because it minimizes the possibility of contagion, which is very favorable for healthy economic and social conditions.

From the experience of these cruel epidemics, if the world population adopts some hygiene based behaviors and make them their habit to keep themselves safe and secure would reduce the transmissions and decrease the economic cost. Likewise, [26] emphasize the habit formation for desirable behaviors during the pandemic outbreaks. Subsequently, these behaviors offset the cost of contagious outbreaks exerting positive health effects and decrease the risk of viruses like COVID-19. Contagious diseases and behavioral economics have progressed recently for developing the change in behavior and understanding the nature of outbreaks. Scientists and policy makers can coordinate between the two approaches which can lead to reducing the speed of transmission of contagious and overall loss [27].

1. Pakistan economic shock

Pakistan being a developing country is already suffering from multiple socioeconomic problems. The outbreak of COVID-19 has dragged the poor country into more multifarious issues, to deal with.

Unfortunately, like global stock markets, freaking out Pakistan stock exchange faces curbing of the investment and production. The decrease in employment/ labor force is hitting the capital formation and production badly. Lockdown and restricted movement are disturbing channelization of raw material and finished goods. Plunging demand and sapping supply due to lock down and transportation restrictions has created a gap between suppliers and consumers. Limited movement of agricultural and industrial goods (raw material and finished goods) and nominal exploitation or uses of natural resources are increasing problem by narrowing economic activities. It also has slowed down the Investment process. This situation is responsible for the lower performance of the economy as a whole which leads to upsurge overall poverty This growing gap in the economy has created a big challenge for developing countries like Pakistan around the world.

Furthermore, Pakistan's economy is crumbling because of overall system shut down. For example, reduction in capital formation, production, revenue, trade imbalance and the health

care, safety due to COVID-19 related extra medical expenditure has further burdened limited resources of the crippling economy of the country. Pakistan can face the estimated economic loss of Rs1.3tr initially due to coronavirus according to the news report. However, in this current situation, Pakistan may take some advantage of the lower oil prices dropped worldwide.

However, she would face the adverse impact of lower exports and necessary imports /tariffs. Lower imports would lead to scarcity of goods. Because unlike China and America or any other developed country, Pakistan is unable to manufacture all products locally. America and other developed countries are trying to produce goods locally but no poor country is at this level of economic strength.

Consistently, the news Pakistan reports that “we cannot afford to practice such lockouts given that we can face a massive revenue shortfall as our resources are limited and the economy is collapsing. The FBR estimates show that the lockdown of Karachi is going to cause major revenue losses which, if persisted till June 2020, then the tax losses would go up to Rs380 billion”. Equally, according to the present federal secretary commerce “the exports might face loss in the range of \$2 to \$4 billion as export orders had got cancelled. Pakistan’s textile export sector relies on China for the bulk of its capital goods inputs, so there will be an impact if there is a protracted closedown of the Chinese economy. The imports would be reduced in the shape of declining POL prices as well as in quantity. Pakistan imported 80 billion barrels of POL products and keeping in view the low-ever prices in the international market in the last two decades, the import bill would shrink harming the FBR’s collection and petroleum levy might also be reduced if the consumption decreased because of the possible lockdown in different parts of the country”².

Therefore, a complete lockdown situation may not be in favor of Pakistan. Pakistan being a poor country does not afford complete shutdown. The worrisome situation is 70% of the population depends on agriculture or earning by working on the sites. Moreover, the Pakistan economy is too weak to bear the burden arising in the result of stagnating and no production. Pakistan can lose from multi spheres what contributes to the GDP. For example, Pakistan’s GDP growth in 2017-18 was recorded as 5.5%, in 2018-19 was 1.9%, in 2019 to the first quarter of 2020 was -2.6% and in 2020 till the first quarter of 2021 is reported as -0.2%. We can notice a visible decline in GDP by these statistics. According to the estimation of the Planning Commission, the level of Pakistan GDP is Rs. 44trillion and 1/4th stood at the amount of Rs. 11 trillion. Thus the loss by the outbreak of COVID-19 is predicted to occur at least 10% means Rs1.1 trillion in the last Q of April-June. Some common macroeconomic indicators are given below with the comparison of the two years 2019 and 2020.

Furthermore, in Pakistan, the decreasing interest rate can play a role in lifting exports and other businesses. Still, it is criticized by economists that interest rates are not decreased at a satisfactory level. The interest rate has been decreased by 11%, according to the situation through the monetary policy of SBP. This is also a fact that the inflation rate in Pakistan has fluctuated widely over the years since 1984 and onwards (see appendix A). Nonetheless, this time as compared to 2019 which is 7.74% reached at 13.25%

in 2020 at that level of worry indicating the surging of prices more in the future along with a loss of labor especially daily wages and poor people working at lower levels. The increasing prices of routine products like sugar and wheat have created many problems for the lower and middle class to cope with the situation. Realizing the sensitivity of the time, producers in Pakistan must stop hoarding edible products in such critical time to let feed poor cheaply. Otherwise, all this leads to the short supply and rising inflation even more thus people may face starving at a greater level. To understand this reality a figure provided by SBP highlights the inflation rates of Pakistan in the global context (See the appendix B).

Table 2 Economic indicators of Pakistan

Economic indicators of Pakistan	2018-19	2019-20
GDP growth	1.9%	-2.6%
GDP per capita	\$1,482 (nominal)	\$1,244 (nominal)
Inflation rate	6.74%	11.12%
Interest rate	12.25% as of June-19	13.25% - 7.00%
Exchange rate USD	PKR 160.00	PKR 167.40
Unemployment rate	4.45%	6.2%
Poverty rate	29.5%	40.0% forecasted

How could poor and emerging economies be in the current scenario of the COVID-19 viral shock? Which has put even developed countries in greater trouble. Hence, the economy of Pakistan is not self-sufficient to deal with it without intensifying losses. If we compare Pakistan with the pandemic host country China and other regional countries, we can analyze much difference. China is the biggest economy and thus could do what they needed. Despite that, they face an economic loss substantially. Currently, China has started reviving her economy. Chinese factories are working and manufacturing the medical equipment for local and international market supply. Through producing and providing medical equipment and supplying widely to various countries in the world China is creating and reviving jobs too. Contrariwise Pakistan’s economy is more delicate to bear a huge loss. Pakistan is not self-sufficient economically therefore badly affected in terms of GDP, GNP, production, employment and per capita income. Consequently, the common man is living a miserable life and poverty increased badly. Besides, in Pakistan, most of the illiterate and unaware population does not understand the situation properly, they are afraid of everything even from quarantine and treatment. Though many of the infected people reacted wisely and recovered yet others lost their lives. The role of doctors and army/police is important many of front fighters in this regards lost their lives while providing treatment and dealing with infected crowds.

Similarly, COVID-19 outbreak drastically hit all over the Asian region. The manufacturing, service and trade activities are badly affected in the Asian region, including Pakistan. The disturbing trade led to exchange rate depreciation. Inflation along with demand and supply shocks in the whole region is alarming.

²Malik A. Rehman. (2020, March 26) Pak economy under dark shadow of coronavirus vs deep economic crisis. The News International.

The epidemic has distressed financial markets, especially capital markets (equity/bond markets) in the region. The drop in the stock exchanges in the whole region is exerting an adverse effect on the regional economic indicators (See appendix c).

5. Conclusion

In this paper, we discussed the outbreak of pandemic COVID-19 and its effects on the global economy as well as the Pakistan economy. We evaluate that along with the strong demographic losses of the contagious virus, the economic losses are also jeopardizing the world in its full capacity. We can judge the channel of globalization as the source of spreading any good or bad worldwide. The blessings of globalization in the shape of trade, business, employment, education, tourism and socialization we have been shared since long. However, we cannot avoid the curses of globalization in the shape of contagious, diseases and other disasters too. For example, the world witnessed the historical contagious diseases time to time in the past and this time the widespread of novel coronavirus is also the result of globalization. Thus, we can conclude that the greater the extent to which the world is becoming a global village by increasing mobilization means and ways the higher the blessing or curses are shared around the globe. We analyzed the multidimensional economic shocks worldwide. For example Demographic hits, socio-psychological hit and Economic hits from the revenue and expenditure side as well as demand and supply side. We also discuss how behavioral economies are important in the result of changing behaviors of people. Almost all the countries are observing losses in their business activities and every sector of industries tumbling in their revenue. Capital markets are shrinking their activities. The stock markets/ equity markets got hard hit so declining their performance around the globe. Apart from that, we elaborate that developing countries like Pakistan are suffering more from the repercussions of a cruel pandemic that poverty is getting even more strength. The process of economic development weakens further by the deteriorating performance of all socioeconomic indicators. We conclude that the Governments, policy makers and stakeholders along with realization must take soothing measures to uplift the dropped down economy and try to support markets with high/low supply and high/low demand creating imbalances from both sides of demand and supply in markets for different commodities.

5.1. Recommendations

In this critical time, the role of Government is very important to fight the battle against the microscopic enemy. [28], describes that the intensity of financial losses will be a responsibility of governments to control.

Government's expenditure on health care is inevitable to control the transmission and treatment of infected people. Government and the public must work hard and go together in this fight by moving forward and think of each other collectively and do not leave anyone behind.

The government may compromise for the production of luxury goods but the core sectors, which relates to basic needs, i.e. utility services, food, health and construction should not be compromised by the total lockdown. However, in the operating factories, applying SOPs is essential to provide health care.

Moreover, by deploying the teams of doctors to check employees frequently will ensure smooth sailing during these troubled times. Significant Business organizations should be given relaxation on their fixed costs, inject liquidity, where ever needed to sustain the pressure of abrupt breakout and sudden downfall.

Isolation centers and temporary hospitals should be created in sufficient number. According to the situation, retired doctors may be called in case of need. Increase the doctors and nurses by calling final- year-medical students and house jobholders. Meanwhile, foreign degree holders may be called by waving their PMDC exams. Special training may be given to new nurses and doctors. Sufficient stock of medical kits, uniforms of doctors and patients, ventilators, drugs and other clinical apparatus should be arranged.

Support the labour force and daily wages people who lost their jobs or income and health. They may be compensated through government by free treatment and distribution of food/groceries where necessary.

Extraordinary cleaning programs should be started. More importantly, behavioural change, social attitude, values, norms, and changing lifestyle is highly required in Pakistan. More and frequent awareness programs are needed and teams may be organized for public awareness.

Spend a handsome amount for research and development to improve scientific research and preparing vaccine and medicine and/or other necessary equipment against the contagious virus. Create multiple teams for this highly demanding cause and make plans to work hard to face the crises efficiently.

The government may take measures to protect the people residing in foreign countries by providing support to them and make sure of their safety by the country's embassies.

Many foreign returned people are unknowingly scattered in different regions of the country and they are mixed up with masses thus unnoticed. Government and public try their best together to detect and testify them and their connected circle to reduce transmissions.

The government may review fiscal and monetary policies frequently, according to the situation.

Compliance with Ethical Standards:

It is to confirm that principles of ethical and professional conduct have been carefully followed and the following statements are to ensure the mandatory requirements of the journal.

a. Funding: It is to mention here that there is no sponsorship received from any institution nor any institution is requested for the funding.

b. Ethical approval: The Editors reserve the right to reject manuscripts that do not comply with the above-mentioned guidelines. The author will be held responsible for false statements or failure to fulfil the above-mentioned guidelines.

c. Informed consent: It is to ensure here that the research work does not involve human participation nor research on animals is involved.

d. Conflict of the statement: On behalf of all authors, the corresponding author states that there is no conflict of interest involved, neither financial nor non-financial.

Conflict of Interest

The authors declare no conflict of interest.

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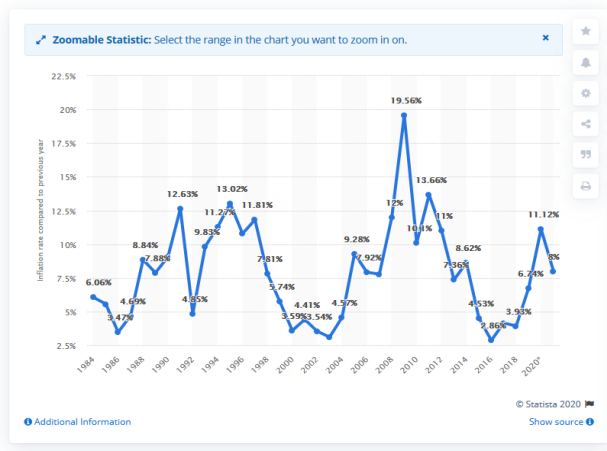
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Appendices

Appendix A Pakistan's inflation 1984 -2021

Pakistan: Inflation rate from 1984 to 2021 (compared to the previous year)

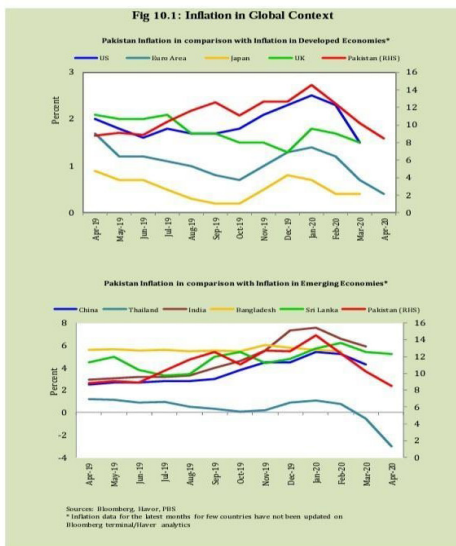


Appendix B: Pakistan's Inflation to the global context

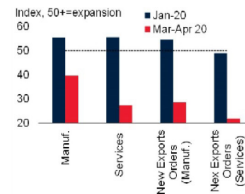
State Bank of Pakistan

10. Inflation in Global Context

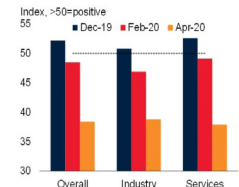
In global context, Pakistan witnessed highest inflation not only in comparison with developed economies but also with emerging economies (See figure 10.1).



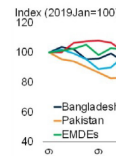
Appendix C:



A. India: Purchasing managers' indexes



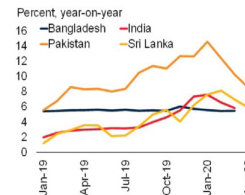
B. Pakistan: Business confidence survey



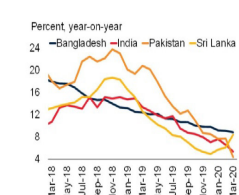
C. Equity indices SAR



D. Exchange rates



E. Inflation



F. Private sector credit growth

An Empirical Comparison of Different Two-Factor Models in the Context of Portfolio Optimisation

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ABSTRACT

The crisis linked to the COVID-19 and the uncertainty it generates in the unprecedented health, societal, economic and financial fields have had a strong impact on the stock markets. Indeed, in such a climate of very high uncertainty, it is to be expected that the excessive stock market price movements will continue, with both declines and technical rebounds, and that the resulting volatility will remain particularly high. In order to cope with this crisis, investors and portfolio managers must mobilize all portfolio selection strategies. In particular, portfolio management and construction are based on the concepts of return and risk. This couple has been at the center of all the concerns of managers and investors in portfolio optimization issues since the introduction of the mean-variance model by Markowitz. However, many studies have proposed different measures of risk to overcome the drawbacks of variance. The objective of this paper is to present and compare the portfolio compositions and performance of four different portfolio optimization models using different risk measures, including variance, Mean Absolute Deviation, Gini coefficient and Lower Partial Moments (LPM). The results of this study show that the Mean-Lower Partial Moments (MLPM) model outperforms other models. The Mean-Lower Partial Moments (MLPM) model is suitable for investors during the crisis period (COVID-19) in the Moroccan financial market.

1 Introduction

During a financial crisis, it is crucial for investors and portfolio managers to implement the best portfolio selection model that takes into account investors' risk and return preferences. Several studies have evaluated and compared different portfolio management strategies according to their return and risk characteristics. The portfolios are made up of financial assets such as shares, bonds, credits, and options. A fundamental question in the management of asset portfolios is the choice of valid investment objectives. In the context of risk, individuals make decisions based on two fundamental parameters (return and risk).

Return¹ and risk² are two associated concepts in finance. Indeed, in the case of an investment in a risky financial asset, an investor will

demand a higher return or a lower risk and investment decisions boil down to finding an optimal compromise between return and risk. So an investor who wishes to improve the return on his portfolio must accept to take more risk.

The notion of risk derives from changes in the prices of financial assets and their negative impact on the total financial value of the portfolio.

Therefore, the risk is a very important component in portfolio management. While the return is easy to assess, risk has not received consensus on what constitutes its fair measurement. Risk can be considered as variance (e.g., Markowitz [1], [2] [2], [3]; Tobin [4]; Sharpe [5]; Lintner [6], [7]; Mossin [8]; semi-variance Markowitz [3]; partial lower moments (e.g. Bawa [9], Bawa and Lindenberg [10], Fishburn [11] and Harlow and Rao [12], the so-called Value at

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¹Return is an indicator that measures the relative appreciation or depreciation of the value of a financial asset or portfolio of assets over a given period.

²The notion of risk derives from changes in the prices of financial assets and their negative impact on the total financial value of the portfolio.

Risk Morgan [13], Jorion [14], Grebeck [15].

So the risk and return couple will be very central terms in our analysis and it is essential that we understand the meaning of each term and how portfolios with different structures can be compared. To this end an overview of performance measures will be used to compare the performance of portfolios, providing investors with useful information on the capacity of managers and providing tools to assess the risk taken by the manager based on the different two-factor models.

In what follows, we will first briefly review the literature on two-factor models. The second section is devoted to the application of these models to real data from the Moroccan financial market. Portfolio performance measures will be used in the third section to compare the models.

2 Literature review

The advent of the Covid-19 pandemic, which includes both the Severe Acute Respiratory Syndrome (SARS) virus and the Middle East Syndrome (MOS), has led to major disruptions in world economies and particularly in financial markets. In fact, the financial markets reacted negatively to the growth of the cases confirmed by Covid-19 by posting abnormal negative returns on listed equities, reflecting investors' aversion to the pandemic. This crisis, like previous crises in the world's financial markets, has placed risk control at the center of the concerns of investors and portfolio management companies. Moreover, each of these crises is an opportunity to advance the risk measurement and management tools proposed by theorists and researchers in this field. In a risky environment, investors make decisions based on their selection criteria. Consequently, decision theory has been used as a basis for investment choice theory and portfolio management.

Indeed, many economists and financial theorists have used the fundamental contributions of decision theory since the middle of the 20th century to evaluate investment opportunities. The theory that has dominated risk studies since its emergence in 1944 is the theory of expected utility. The latter has become widely accepted in all areas of economic theory incorporating the risk factor. Parallel to this, Harry Markowitz [1] proposed his famous Mean-Variance model and gave the starting signal for modern portfolio choice theory. Indeed, the use of utility functions is often complex and does not lead to analytical solutions. This is why Markowitz simplified the problem of choice in uncertainty in order to solve it in a simple and explicit way. His idea was to measure the risk affecting a wealth by its variance.

The investor is then presumed to make decisions based on only two parameters: the first reflects the return on the investment measured by the expected return desired and the second reflects the risk measured by the variance. Markowitz asserts the strength of the relationship between return and risk because he has shown that, under certain conditions, investors can manage to balance their hopes of obtaining portfolios that have both the best possible return and a minimum of risk.

This approach leads to the theory of efficient portfolios, which suggests combining appropriate proportions of assets in a portfolio. A little later, Treynor [16], [17], Sharpe [5], Lintner [6],

and Mossin [8] developed the Financial Asset Equilibrium Model (CAPM) which, under certain assumptions, leads to an equilibrium return for any stock. Later, Ross [18] developed an alternative to CAPM called Price Arbitration Theory (PAT) based on multifactorial models. The Markowitz, CAPM, and APT models form the core of classical portfolio theory.

The latter has revolutionized the way portfolio management is conceived and its contributions have become absolutely essential even today. However, the application of the Mean-Variance (MV) model in portfolio selection is questionable because this model is only valid if returns are normally distributed or if the investors have quadratic preferences. However, several researches have shown that returns on financial assets are not normally distributed. Similarly, Ballestero [19], Bond and Satchell [20], [21], Estrada [22], and Unser [23] have pointed out that variance is a dubious measure of risk because it treats above-average and below-average returns in the same way, whereas investors associate risk with returns below the target rate of return.

The restrictive nature of variance as a measure of risk in the Markowitz model has motivated a large number of studies to seek more appropriate risk measures. Markowitz [3], Fishburn [11], and Bawa and Lindenberg [10] have proposed the use of Lower Partial Moments.

To remedy the imperfections of the Mean-Variance approach, Shalit and Yitzhaki [24] introduced the Mean-Gini model in portfolio management as an alternative to the mean-variance model. The Mean-Gini model (MG) uses the Gini coefficient as the risk parameter rather than variance. Thus, the concept proposed by Shalit and Yitzhaki [24] is similar to Markowitz's [1], because it is based on two parameters. In addition, the Mean-Gini strategy can circumvent assumptions about the normality of the distribution of returns, and of the quadratic function of the utility function. Yitzhaki [25] showed also that the Gini coefficient satisfies the stochastic dominance of the second degree, which makes the Mean-Gini model compatible with the theory of expectation of utility.

Later, Shalit and Yitzhak [24] [26] presented the Generalised Mean-Gini (GMM) as a model that provides a measure to embody the preferences of different investors regarding their degree of risk aversion. As a result, this model can better reflect the perceived risk of an individual investor, as highlighted in the recent study by Cardin et al [27]. For these reasons, this theory is seen as an alternative to the traditional approach that has been dominant in financial theory for more than half a century. While Konno and Yamazaki [28], in contrast to Markowitz's quadratic model, proposed the first linear model by replacing the variance with the mean absolute deviation (MAD) as a measure of risk.

2.1 The Mean-Variance of Markowitz

The Mean-Variance model offers the investor a set of efficient portfolios, i.e. those with the lowest risk for a possible overall return³, and vice versa. This method uses only the concepts of mean for the expected return and variance⁴ for the uncertainty associated with this return, hence the name Mean-Variance⁵ associated with Markowitz analysis.

The variance of a portfolio combination of securities is equal to the weighted average covariance⁶ of the returns on its individual securities:

$$Var(r_p) = \sigma_p^2 = \sum_{i=1}^N \sum_{j=1}^N x_i x_j Cov(r_i, r_j) \tag{2}$$

Markowitz's[2] model may be written as the following non-linear quadratic programming model:

$$min \sum_{i=1}^N \sum_{j=1}^N x_i x_j Cov(r_i, r_j) \tag{3}$$

$$s.t : \sum_{i=1}^N x_j r_j \geq w_0 \tag{4}$$

$$\sum_{i=1}^N x_j = 1 \tag{5}$$

$$0 \leq x_j \leq u_j, j \in N \tag{6}$$

The first constraint simply says that the expected return on the portfolio should equal the target return determined by the portfolio manager (w_0). The second constraint says that the weights of the securities invested in the portfolio must sum to one. The last constraint stipulates that asset weights must be positive, i.e. short sales are not allowed.

Since its appearance, the Markowitz model has taken a very important place in the evolution of modern finance and has achieved great success with its contribution to portfolio management. But with recent adjustments, this model has found several limitations raised by several practitioners of financial theory. As with any model, the limitations are generally focused around these assumptions⁷ as well as on the estimation of these parameters.

³In practice, the statistical parameters are often estimated at Based on time series (such as historical data from the financial markets), and after that they are somehow adjusted. Given any set of risky assets and a set of weights that describe how the portfolio investment is split, the general formula of expected return for n assets is:

$$E(r_p) = \sum_{j=1}^N x_j r_j \tag{1}$$

where: N the number of securities; x_j is the proportion of the funds invested in security j ; r_j are the return on i th security j and portfolio p ; and $E()$ is the expectation of the variable in the parentheses.

⁴As long as the assets are supposed to be characterized by distributions symmetrical, the variance or standard deviation are good measures because any normal distribution is fully described by its mean value and its variance (or standard deviation) (see, for example, Artzner et al [29]). Variance is not a good measure of risk if we are dealing with financial assets that are characterized by unsymmetric gains.

⁵Although the mean-variance approach proposed by Markowitz has been used extensively in practice, it has several limitations (computational load, the non-linear (quadratic) nature of the risk measure, the perception of non-symmetrical risk, the normal distribution of returns, and many others).

⁶High covariance indicates that an increase in one stock's return is likely to correspond to an increase in the other. A low covariance means the return rates are relatively independent and a negative covariance means that an increase in one stock's return is likely to correspond to a decrease in the other.

⁷As with any model, Markowitz-style portfolio selection is based on several assumptions about individual behaviour and the context of uncertainty.

⁸In the case where t is the mean of the return distribution, we find the traditional semi-variance as introduced by Markowitz.

2.2 The Mean-Lower Partial Moment Model

This concept was introduced by Bawa [9] and Fishburn [11] and Nawrocki [30]–[32] to define measures of downside risk in general. Since the variance takes into account all negative as well as positive deviations, lower partial moments only take into account negative deviations. Semi-variance is a special case of a class of asymmetric measures proposed by Markowitz [3] in the case where the investor is indifferent between two or more securities after having calculated the variance, i.e. the variance is sometimes insufficient to make the right decision. Semi-variance is a type of measure known as a measure of downside risk. This type of measure focuses primarily on losses. Unlike variance, no assumptions are made about the statistical distribution of asset returns. Thus, the lower partial moments represent, in a way, the standard deviation of returns below a target return. They do not penalize returns above a target return and differentiate between risk, returns below a minimum return, uncertainty and variability of returns. Bawa and Lindenberg [10], Lee and Rao [33], and Harlow and Rao [12] have developed lower partial mean-moment models (LPMM), and have shown their advantages over the Mean-Variance (MV) model. Despite these efforts, few studies have empirically examined these advantages.

Bawa (1975) developed the concept of downside risk by lower partial moments (MPM) of order n with a target rate of return τ^8 defined in continuous time by:

$$LPM_\alpha(\tau, R_i)^\alpha = \int_{-\infty}^{\tau} (\tau, R)^\alpha dF(R) \tag{7}$$

Where R , F , τ , and n denote respectively the rate of return of a security or portfolio, the probability distribution of that return, the target rate of return, and the degree of the moment.

Under these conditions, the portfolio choice problem according to the Mean-Lower Partial Moment Model criterion consists in solving the following optimization problem:

$$min \sum_{t=1}^T p_t z_t^2 \tag{8}$$

$$z_t \geq \sum (r_{jt} - r_j) x_j, t = 1, 2, \dots, T \tag{9}$$

$$z_t \geq 0, t = 1, 2, \dots, T \tag{10}$$

$$\sum_{i=1}^N x_j = 1 \tag{11}$$

$$0 \leq x_j \leq u_j, j \in N \tag{12}$$

In order to test the Mean-Lower Partial Moment Model, we chose to place ourselves in a semi-variance context.

2.3 The Mean Absolute Deviation

The alternative presented by Konno and Yamazaki [28] suggests that Markowitz-type portfolio optimisation could be replaced or even improved by a model using the mean absolute deviation (MAD⁹) as a measure of risk to overcome the weaknesses of Markowitz’s [2] non-linear model. The DSM results in a linear programming model, which proves to be equivalent to the Markowitz model and easier to compute. The DSM linear programming model, proposed by Konno & Yamazaki [28], can be posed as follows:

$$\min \sum_{t \in T} p_t y_t \tag{14}$$

s.t: “Markowitz” constraints (2)-(3)

$$y_t + \sum_{j \in N} (r_{jt} - r_j) x_j \geq 0, t = 1, 2, \dots, T \tag{15}$$

$$y_t - \sum_{j \in N} (r_{jt} - r_j) x_j \geq 0, t = 1, 2, \dots, T \tag{16}$$

$$0 \leq x_j \leq u_j, j \in N \tag{17}$$

2.4 The Mean-Gini (MG) model

The Mean-Gini (MG) model was originally developed by Yitzhaki [25]. Then, it was applied in finance by Shalit and Yitzhaki [24] as an alternative model to the Mean-Variance model to assess risk and construct optimal portfolios that are consistent with the theory of utility expectation and stochastic dominance. The Mean-Gini (MG) model shows strong results when the mean-variance model is doomed to failure, particularly when assets are not normally distributed.

The Mean-Gini (MG) approach in finance is used by Bey and Howe [34] in portfolio analysis, Okunev [35] to evaluate the performance of mutual funds, Shalit and Yitzhaki [24] and agouram & lakhnati [36] [37] [38] to obtain optimal portfolio selection, Cheung et al. [39] to examine the effectiveness of hedging options and futures contracts, and Berkouch et al. [40] introduced and applied the Tail Extended Gini functional and the Extended Gini Shortfall on daily returns for the MASI index.

Recall that the Gini coefficient is equal to:

⁹The mean absolute deviation is defined as the mean of the absolute values of the differences between the observations and their mean :

$$MAD(R) = \frac{1}{n} \sum_{i=1}^n |R_i - \bar{R}| \tag{13}$$

Where n is the number of observed values, \bar{R} is the mean of the observed values and R_i are the individual values.

Absolute mean deviation is a more robust scale estimator relative to standard deviation and more resistant to outliers in a data set. For a larger mean absolute deviation, the risk is high.

$$\Gamma_p = 2cov(R_p, F(R_p)) \tag{18}$$

where R_p is the portfolio return and $F(R_p)$ is the cumulative distribution function. Thus, the mathematical optimization problem is presented as follows:

$$\min \Gamma_p = 2cov(R_p, F(R_p)) = 2 \sum_{i=1}^N x_i cov(R_i, F(R_p)) \tag{19}$$

$$s.t : \sum_{i=1}^N x_j r_j \geq w_0 \tag{20}$$

$$\sum_{i=1}^N x_j = 1 \tag{21}$$

$$0 \leq x_j \leq u_j, j \in N \tag{22}$$

where Γ_p is the Gini coefficient of the portfolio, x_j is the weight of asset j , r_j is the expected return on asset j per period, w_0 is the minimum rate of return required by the investor.

3 Data and Methodology

Our study focuses on a sample of securities of the MADEX Index for which we collected daily prices over the period from September 7, 2015 to August 28, 2020. The MADEX Index groups the values of 45 securities according to their capitalization and volumes traded. The index is therefore representative of the most capitalized and liquid securities listed on the Casablanca Stock Exchange.

The data will be used as follows:

- First of all, we will use the first 1113 daily returns, corresponding to the period from September 7th 2015 to February 28th 2020 (the date of appearance of the first positive case in Covid-19), for the composition of the four portfolios.
- Next, we will estimate the performance measures of the four portfolios in order to compare them. To calculate the performance of these portfolios, we use the following three performance measures : Sharpe Ratio, Treynor Ratio, Jensen Alpha. To be more precise, we will use the risk-adjusted Sharpe ratio of each model. We will use the following formulas:

$$S_p = \frac{E(R_p) - r_f}{R_{measure}} \tag{23}$$

Where S_p is the Sharpe ratio, $E(R_p)$ is the portfolio return, r_f is the return on risk-free assets and $R_{measure}$ is the risk measure of each model.

$$T_p = \frac{E(R_p) - r_f}{\beta_p} \tag{24}$$

where T_P is the Treynor Ratio, $E(R_P)$ is the portfolio return, r_f is the return on risk-free assets and β_P is the beta of the portfolio.

$$\alpha = E(R_P) - (r_f + \beta_P(E(R_m) - r_f)) \quad (25)$$

where S_P is the Jensen Alpha, $E(R_P)$ is the portfolio return, r_f is the return on risk-free assets and β_P is the beta of the portfolio.

Table 1: Summary of datasets used

Stocks	Mean	Standard Deviation	Max	Min	Skewnes	Kurtusis	Jarque-Bera Test Statistic	P-Value Jarque-Bera
ADH	-0.0008	0.0230	0.0998	-0.0999	-0.0723	5.2333	1268.78	0.0000
ADI	0.0004	0.0333	0.2075	-0.1087	0.4387	3.0088	454.71	0.0000
ALM	0.0014	0.0308	0.0995	-0.1172	-0.1525	0.4731	14.67	0.0007
ATH	0.0002	0.0224	0.0999	-0.0999	-0.0115	2.0090	186.86	0.0000
ALT	0.0004	0.0197	0.0998	-0.0777	0.2459	2.7947	372.75	0.0000
ATW	0.0004	0.0099	0.0425	-0.0489	0.2240	2.7070	348.50	0.0000
BCI	0.0002	0.02892	0.0997	-0.2014	-0.2243	2.7009	347.00	0.0000
BCP	0.0002	0.0111	0.0685	-0.0925	-0.0133	8.1582	3081.04	0.0000
BOA	-0.0001	0.0130	0.0997	-0.0801	0.8456	8.2679	3296.83	0.0000
CIH	0.0001	0.0189	0.0820	-0.0754	0.2327	2.4187	280.83	0.0000
CMA	0.0012	0.0226	0.0994	-0.0993	0.0608	1.6813	131.53	0.0000
CMT	0.0004	0.0217	0.1000	-0.1146	-0.2687	4.7220	1045.55	0.0000
COL	0.0007	0.0290	0.2001	-0.2050	0.0516	4.8696	1098.20	0.0000
CRS	0.0010	0.0309	0.1000	-0.0997	0.2107	1.1873	73.47	0.0000
CTM	0.0015	0.0252	0.2553	-0.1522	1.2173	14.2007	9609.58	0.0000
DHO	0.0005	0.0232	0.0997	-0.0909	0.2774	2.3334	266.30	0.0000
DLM	-0.0009	0.0383	0.1231	-0.2189	-0.4775	2.1645	259.10	0.0000
DWY	0.0007	0.0251	0.1448	-0.0999	0.4550	3.2230	519.21	0.0000
FBR	-0.0003	0.0403	0.1415	-0.1550	0.0178	0.3493	5.70	0.0576
GAZ	0.0013	0.0286	0.0998	-0.0997	0.0523	0.7583	27.12	0.0000
HPS	0.0026	0.0283	0.1000	-0.1577	-0.0732	1.6319	124.27	0.0000
IAM	0.0003	0.0086	0.0582	-0.0752	-0.5511	12.7913	7630.40	0.0000
IBC	-0.0015	0.0424	0.1909	-0.2186	0.0141	1.5426	110.18	0.0000
INV	0.0006	0.0369	0.1238	-0.1150	0.0913	0.4477	10.82	0.0045
JET	0.0005	0.0288	0.1000	-0.1364	0.1825	1.9568	183.42	0.0000
LBV	0.0010	0.0257	0.0990	-0.0997	0.0424	1.4843	102.32	0.0000
LES	0.0007	0.0194	0.0993	-0.0877	0.4733	2.7353	387.82	0.0000
LHM	0.0004	0.0209	0.0997	-0.0997	-0.0274	2.4867	286.38	0.0000
LYD	0.0007	0.0275	0.0952	-0.0998	0.0352	0.8244	31.68	0.0000
M2M	0.0015	0.0344	0.1000	-0.1000	0.2485	0.3014	15.63	0.0004
MDP	0.0001	0.0390	0.2091	-0.3126	0.0467	4.5041	939.52	0.0000
MIC	0.0016	0.0273	0.0999	-0.0963	0.2107	1.0399	58.27	0.0000
MNG	0.0002	0.0290	0.2109	-0.0996	0.3517	4.0247	772.74	0.0000
NKL	0.0002	0.0280	0.0982	-0.0997	-0.0110	1.6414	124.73	0.0000
RDS	-0.0009	0.0235	0.0999	-0.0999	0.0537	2.1790	220.32	0.0000
RIS	0.0000	0.0289	0.1000	-0.0998	0.1481	1.1046	60.53	0.0000
S2M	0.0005	0.0277	0.1937	-0.1357	0.2211	3.2267	491.01	0.0000
SAH	0.0005	0.0280	0.0997	-0.0999	0.0060	1.8116	151.93	0.0000
SID	-0.0009	0.0285	0.1000	-0.1005	0.1213	1.6771	132.92	0.0000
SLF	0.0005	0.0212	0.0979	-0.1264	-0.2940	4.2780	863.19	0.0000
SMI	0.0008	0.0320	0.0908	-0.1334	-0.0988	0.2294	4.24	0.1199
SNP	0.0019	0.0331	0.1000	-0.1000	0.3789	1.4434	123.02	0.0000
STR	-0.0013	0.0422	0.1000	-0.1900	-0.0111	0.6210	17.87	0.0001
TQM	0.0007	0.0155	0.0758	-0.0656	0.1101	2.0392	194.73	0.0000
WAA	0.0005	0.0276	0.0989	-0.0998	0.0771	0.8688	36.03	0.0000

4 Empirical Results and Discussion

This study begins with an analysis of the characteristics of the 45 selected stocks that will enable us to build our portfolios according to the Mean-Variance (MV), Mean-Absolute Deviation (MAD), Mean-Lower Partial Moments (MLPM) and Mean-Gini (MG) strategies. Descriptive statistics are presented in Table 1. The normality test (Jarque-Bera) for each stock led us to reject the null hypothesis of the normality test at the 99% confidence level. This non-normality of returns does not seem to make the Mean-Variance test relevant (Amato et al, 1999 [39]), we assume that in the context of our data, the Mean-Variance strategy is the least appropriate. These results indicate a property already observed in the financial data series that returns are generally not normally distributed. In addition, other properties of risky assets were found in the data series such as skewness and kurtosis. Figures 1, 2, 3 and 4 represent the daily returns of the different strategies during the crisis period from February 28, 2020 to August 28, 2020.

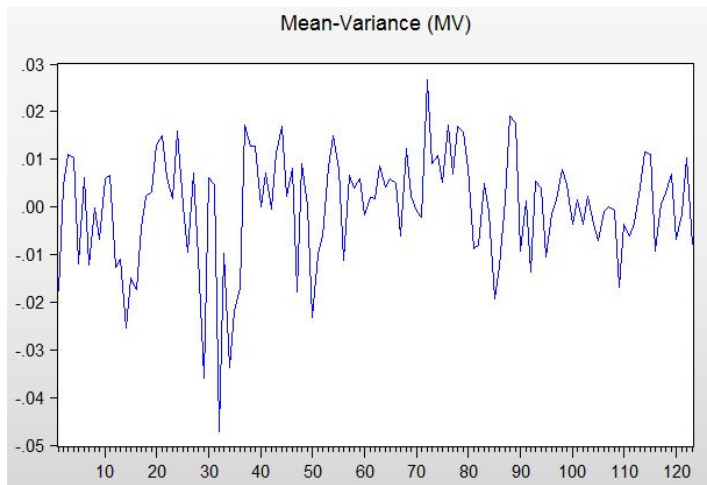


Figure 1: Graphical representation of return (Mean-Variance (MV)).

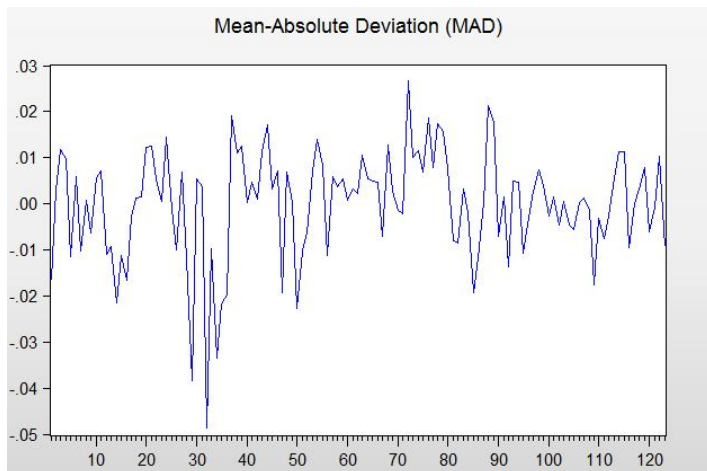


Figure 2: Graphical representation of return (Mean-Absolute Deviation (MAD)).

Table 2: Composition of the different portfolios

	Mean-Variance	Mean-Absolute Devaiation	Mean-Semivariance	Mean-Gini
ALM	7.73%	8.19%	3.97%	7.83%
CMA	2.40%	4.12%	2.61%	3.06%
CTM	11.40%	12.92%	11.14%	11.54%
GAZ	3.53%	2.70%	4.38%	3.77%
HPS	39.94%	41.27%	39.14%	40.51%
M2M	6.60%	5.50%	7.33%	6.05%
MIC	13.56%	13.06%	14.69%	13.30%
SNP	14.84%	12.25%	16.73%	13.94%

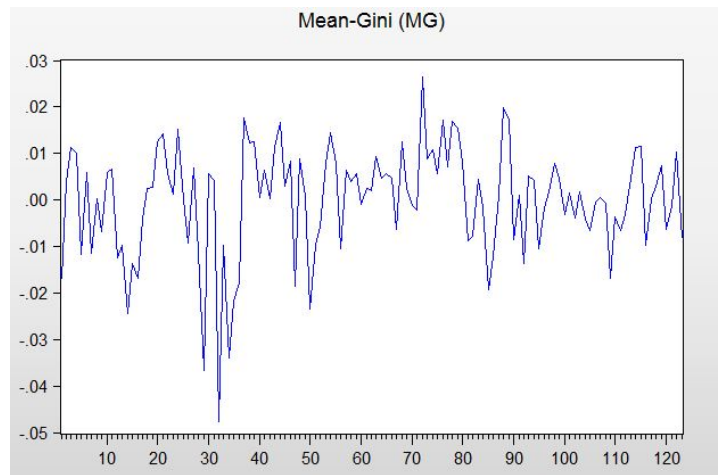


Figure 3: Graphical representation of return (Mean-Gini (MG)).

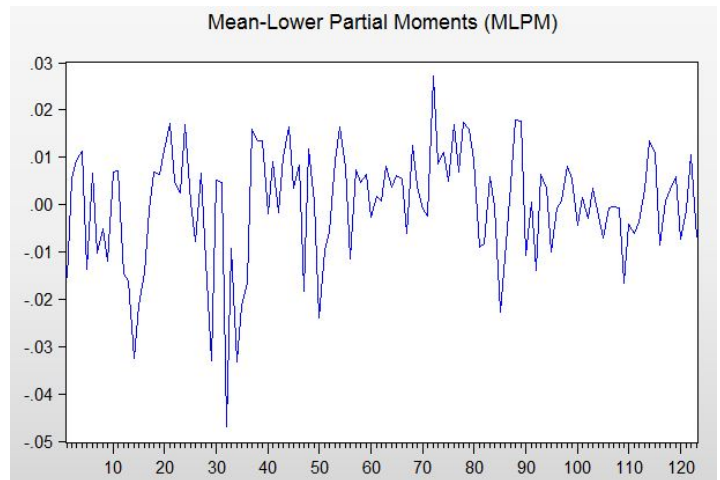


Figure 4: Graphical representation of return (Mean-Lower Partial Moments (MLPM)).

Table 2 above gives the proportions of each share in the optimal portfolios. The results show that the compositions are different as each portfolio has its own composition of shares but with the same assets (ALM, CMA, CTM, GAS, HPC, M2M, MIC, SNP) as the objective return for the period was 0.002 while the majority of the assets have negative returns. For the Mean-Variance strategy,

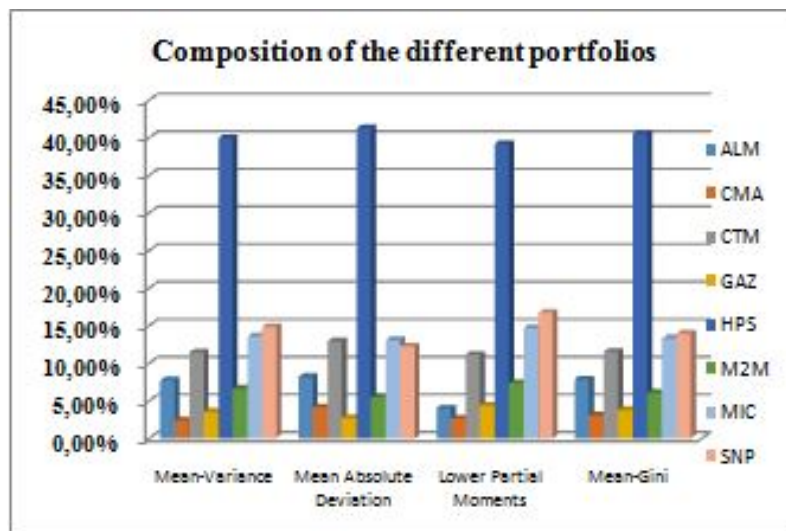


Figure 5: Composition of the different portfolios

HPS is in first place with 39.94, followed by SNP with 14.84, and CMA in last place with 2.40, while the other shares are not part of the composition. Figure 5 provides a detailed overview of the composition of each portfolio. Then, the summary statistics of the optimal portfolios obtained by the resolution of the optimisation programmes are presented in the table 3.

To compare the four stages over the crisis period, i.e. from the appearance of the first case of COVID-19 in Morocco Financial Market until now, we will use the Sharpe ration adjusted by each risk measure (Variance, Absolute Deviation (MAD), Lower Partial Moments (LPM) and Gini Coefficient). The results are presented in Table 4. These results show that the Mean-Lower Partial Moments (MLPM) strategy is the most efficient during this period of crisis compared to other strategies at the time. As shown in Figure 6 and 7, the Mean-Lower Partial Moments (MLPM) model is the

one that represents the maximum performance of the Sharpe ratio adjusted by the different risk measures used. Whereas the two models Mean-Gini (MG) and Mean-Absolute Deviation (MAD) are in second position. Finally, the Mean-Variance (MV) model occupies the last position. In general, a higher Treynor Ratio indicates superior performance, and vice versa. In our case and based on the table 4 data, the Mean-Absolute Deviation (MAD) model is the best performing model, followed by Mean-Variance (MV) model which slightly outperforms the other two models: Mean-Lower Partial Moments (MLPM) and Mean-Gini (MG). The results for the Jensen Alpha show that the Lower Mean Partial Moment Model (MLPM) is the one that represents the maximum performance of the Jensen Alpha. Followed by the Mean-Absolute Deviation Model (MAD). While the Mean-Gini model (MG) takes third place. Finally, the Mean-Variance (MV) model occupies the last position.

5 Conclusion

In this paper, we have assessed the contribution of the theoretical approach of Mean-Variance (MV), Mean-Absolute Deviation (MAD),

Mean-Lower Partial Moments (MLPM) and Mean-Gini (MG) to the resolution of portfolio management problems in extreme periods within the Casablanca financial center . Empirical application on a

Table 3: Descriptive statistics of portfolio

	Mean-Variance	Mean-Absolute Deviation	Mean-Semivariance	Mean-Gini
Mean	-0.00011	-0.00011	-0.00010	-0.00013
Median	0.00141	0.00175	0.001757	0.00164
Maximum	0.02676	0.02656	0.02712	0.02665
Minimum	-0.04877	-0.04763	-0.04697	-0.04720
Std. Dev.	0.01182	0.011768	0.01216	0.01181
Skewness	-0.99321	-0.98486	-0.92523	-0.94871
Kurtosis	5.18704	4.94169	4.41719	4.76167
J-Bera	44.7365	39.2064	27.8424	34.3566
Probability	0.00	0.00	0.00	0.00
MAD	0.898%	0.888%	0.936%	0.890%
Semivariance	0.949%	0.957%	0.970%	0.951%
Gini	0.7406%	0.7416%	0.7416%	0.7402 %

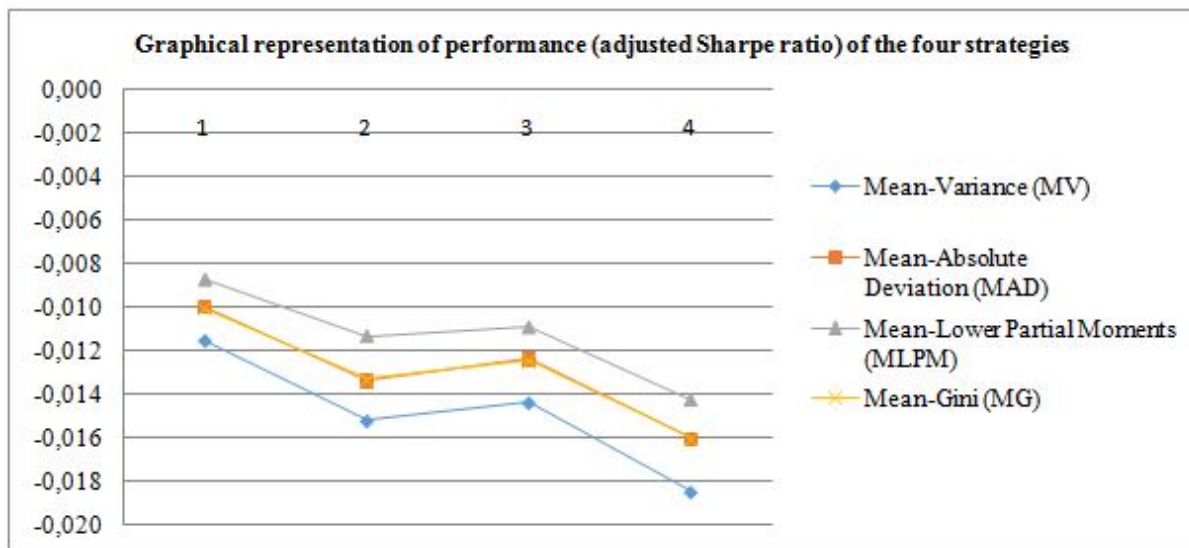


Figure 6: Graphical representation of performance (adjusted Sharpe ratio) of the four strategies.

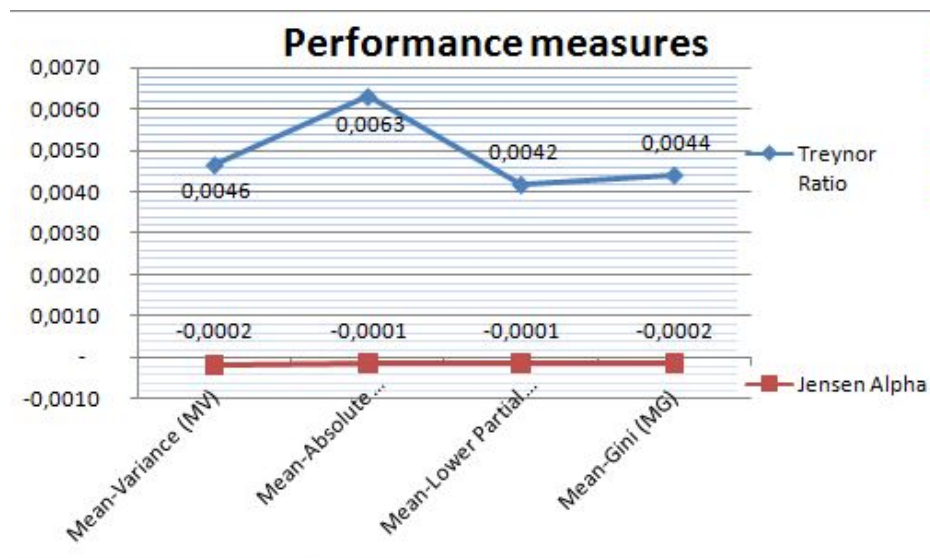


Figure 7: Graphical representation of performance (Treynor Ratio & Jensen Alpha) of the four strategies.

sample of stocks belonging to the MADEX index allowed the selection of four performing portfolios with a better risk/return ratio over the period before COVID-19. The main results show the superiority of the Mean-Lower Partial Moments (MLPM) model over other

models based on the results of the adjusted Sharpe ratio. This comparison has been made on the period of the onset and amplification of the COVID-19 pandemic in Morocco. Also note the inferiority of

Table 4: Performance measures (Sharpe ratio, Treynor Ratio and Jensen Alpha) adjusted by each risk measure (Variance, Absolute Deviation (MAD), Lower Partial Moments (LPM) and Gini Coefficient)

performance measures		Mean-Variance (MV)	Mean-Absolute Deviation (MAD)	Mean-Semivariance	Mean-Gini (MG)
Sharpe ratio adjusted	Return/Standard deviation	-0.0116140	-0.0100686	-0.0087240	-0.0100996
	Return/Absolute Deviation	-0.0152826	-0.0134055	-0.0113376	-0.0133471
	Return/Lower Partial Moments	-0.0144509	-0.0124426	-0.0109366	-0.0124972
	Return/Gini	-0.0185225	-0.0160531	-0.0143108	-0.0160553
Treynor Ratio		0.0046469	0.0063047	0.0041626	0.0043972
Jensen Alpha		-0.0001810	-0.0001471	-0.0001440	-0.0001590

the mean-variance (MV) model in terms of performance measured by the adjusted Sharpe ratio since the different series of returns composing our portfolios are volatile, leptokurtic and asymmetric. They lead to a rejection of the Jarque-Bera normality test. As a result, the distribution of daily returns of Moroccan equities deviates from the normal distribution. Similarly, the results for the Jensen Alpha show that the Mean-Lower Partial Moments (MLPM) is the model that represents maximum performance, followed by the Mean-Absolute Deviation (MAD) and the Mean-Gini Model (MG) in third place. Finally, the Mean-Variance (MV) model comes in last place. On the other hand, the Mean-Absolute Deviation (MAD) model is the best performing, followed by the mean variance (MV) model which slightly outperforms the other two models: the Mean-Lower Partial Moments (MLPM) and the mean Gini (MG) based on the treynor ratio results. The results for the Jensen Alpha show that the Lower Mean Partial Moment Model (MLPM) is the model that represents the maximum performance of the Jensen Alpha. This is followed by the Mean-Absolute Deviation (MAD). While the Mean-Gini Model (MG) is in third place. Finally, the Mean-Variance (MV) model occupies the last position.

Through these results, we conclude that the best model available to investors in the Moroccan financial market is the Mean-Lower Partial Moments model (MLPM) since it is the most appropriate model for our financial market and its characteristics. For that and despite the use of the Mean-Variance model in the optimization and management of portfolios by the majority of managers, we underline the inadequacy of this model to the reality of the Moroccan financial center. Indeed, this model is built on the assumption of normality of returns. However, the reality of the financial markets is far from approaching normal distribution law, as several works have pointed out (Agouram and Lakhnati [41]).

Conflict of Interest The authors declare no conflict of interest.

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Contingency Plan in the Supply Chain of Companies in the Retail Industry in the Face of the Impacts of COVID-19

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ABSTRACT

The main issue that is being presented in 2020 is the impact that all organizations are having due to the COVID-19 pandemic, and it is not for less given the global collapse that is occurring in all aspects. Many organizations have been affected by this catastrophe and in the face of an unforeseen scenario, the disruptions in the different supply chains have revealed the lack of some essential products for human consumption.

For organizations that are looking for alternatives of what to do and that are constantly analyzing how to reinvent their processes to mitigate the impacts of the pandemic and thus stay current during the contingency, they have before them the challenge of strengthening their supply chains, however It is difficult to think that the contagion of this virus that has brought the great powers of the planet to their knees, collapsing their productive, economic and especially health systems.

This research aims to propose a model that allows the development of an action plan in the event of the COVID-19 contingency in the sector of companies classified as essential, such as the retail industry. It is not enough to have well-defined and structured processes, these must also be dynamic and interconnected to privilege the distribution of essential products and for this it is important to be clear about the pillars of supply chain management and the key elements that they proposed.

Organizations must learn to protect their supply chains and to achieve it research offers a perspective on how to assess the level of risk of the processes of the retail industry and thus have identified the opportunities that will have to improve to build a resilient supply chain and strengthened.

1. Introduction

Throughout time humanity has faced a significant number of disruptions that have affected from basic aspects such as the very survival or health of human beings to the complete collapse of the productive and economic systems, some of these disruptions have been caused for decisions related to the political and economic interests of man, such as the armed conflicts of the two world wars of the last century and that meant significant changes in the way of life of the affected countries, mainly those of the defeated side. Like the group of disruptions caused by the hand of man, there are other disruptions that have occurred and that have their origin in sometimes predictable behavior, but in many other unpredictable ones in nature, in both cases destructive, causing the loss of human lives and the destruction of assets and infrastructure for the proper

functioning of business operations. In this group of natural disasters are hurricanes, earthquakes, tsunamis and fires, in addition to others, associated with diseases in humans that become epidemics and at a higher level of severity due to the size of the contagion, in the devastating effect of a pandemic.

Unfortunately, and due to this type of disruption, organizations are part of a side effect of what happens in the environment in which they find themselves. Each of these impacts and their post-mortem analysis are on an undesirable list of scenarios that have already occurred at the time, such as the SARS disease that occurred in Asia from 2002 to 2003, the tsunami in Indonesia in 2004, Hurricane Katrina that The United States struck in 2005, the 2009 - 2010 H1N1 influenza that occurred in Mexico, and currently the living pandemic of the COVID-19 coronavirus that started in China and is already spread around the world in 2020.

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The historical account of disruptions that humanity has faced is wide and with a diversity of origins, however, regardless of their origin, they have something in common, a collapse of the different supply chains in the territory, region or country. where it occurs, causing to the companies a series of disorders in their supply operation from suppliers, in-house manufacturing and in the supply of goods to customers. Businesses with a more robust supply chain will enable them to be better prepared to responded more effectively to the effects of a disruption.

A service oriented organization must take care that the processes of its supply chain, in addition to being efficiently structured, have characteristics of agility, adaptability and alignment to dynamically translate the needs that are being presented to the customer and can be respond satisfactorily in [1] the author explained the Triple A as a model that allows the supply chain to be adequately managed.

The supply chain management processes do not remain fixed over time, they have to be transformed according to the needs of the market and the sales point where the customer goes adapting to the purchasing trends of the consumer customer. Currently, from a commercial point of view in the retail industry, it is common to classify or have segmented the type of consumer that goes by store, this is a work of market intelligence, an emerging area in the modern design of organizations who have the need to know the sensitivity of how the market behaves, it is precisely this area that is responsible for doing this type of study to better define the commercial strategy to follow. In [2], the author explained the importance of having the commercial strategy integrated to the supply chain.

When talking about processes implicitly you have to consider two elements or vectors that converge on the subject, on the one hand, the capacity of the processes that in turn represent the potential designed to offer by the process, and on the other, the indicators of performance or kpi's (key performance indicators) of the processes.

To measure the performance of the processes, they must have indicators or metrics that provide feedback to the system for which they were designed. The indicators must be focused on the measurement of the operational processes and offer deliverables on what happens at the border of each process, maintain a standard of behavior that constantly aspires to excellence in performance and that are also consistent with the strategy of the organization supply chain. If the importance of the Triple A Model was previously highlighted, in [3] the author complemented the model by highlighting the importance of top management's commitment to agility, flexibility, efficiency and service. Metrics should provide feedback to the organization on the elements that make up the established strategy.

With the evolution of the supply chain, accelerated mainly by the digital era and e-commerce, organizations have focused their actions to maintain an efficient customer service process by establishing strategies that allow them to stay current in a highly competitive environment, however the backyard that integrate the supply network, the management of optimal inventories for the preparation of orders looks vulnerable or simply exposed to the risks that every organization faces in the midst of a pandemic. In [4] the author described the importance of having identified supply

chain segmentation and regionalization as a way to mitigate risk. The stage during which this situation occurs generates high uncertainty where many organizations are not clear on how to act. In [5] the author explained the fact of having clear and defined processes to mitigate the effect of uncertainty and to have a clearer direction to follow by taking disruptive measures integrated in a mitigation strategy.

The purpose of this research is to offer a perspective on how to classify for a better assessment of the risk level of the retail supply chain. The classification is supported by four management pillars and these in turn integrate seven key elements that will be addressed in the proposed research methodology.

2. Literature review

When addressing the issue of disruptions that have occurred in the past, that are present today and that will surely continue to occur in the future, and that affect the environment where the basic daily activities of the world population are carried out, and therefore that of organizations, on this topic you can find a great diversity of research work and a multivariate approach or point of view, which depends on the type of research that the author wants to highlight or highlight. Just as these perspectives are mentioned in the different investigations carried out and that will be cited throughout the work, this investigation has as its main contribution to offer organizations an analysis, diagnosis and proposal of contingency actions against the disruptions caused by catastrophes natural as the pandemic that we are currently experiencing with COVID-19 and that affects the supply chains of companies considered or classified as essential as the retail industry, due to the impact they have on society in the supply of food and products of first necessity.

This research would not be a complete work if it does not leave a learning that generates value to the society in which companies develop and is not accompanied by a proposal for organizations on how they should be better prepared to face unplanned situations such as disruptions of this type.

Before continuing and delving into such a relevant topic today, it is important to start with a proposal to classify the disruptions that occur in organizations and in general in the society where we live, even before making such a classification it is important to be clear the definition of this, disruption is the sudden or sudden interruption of something that presents an expected behavior.

Having clarity of the definition, now if we can have a classification on the different types of disruption that exist, this classification is part of the research that has been integrated by different researchers who have contributed to their work on the subject. As described, a disruption has to do with an unexpected scenario and behavior that causes human beings, in addition to uncertainty, a forced change in their behaviors and behaviors such as work, consumption, coexistence, socialization, fun , among others. According to this description that contemplates a change in people's behavior patterns, we cannot expect something different to happen in labor and social organizations where people are the central elements that integrate them and give them life.

2.1. Classification of disruptions affecting the supply chain

By ordering ideas we can then say that when speaking of a disruption that affects organizations it is closely linked to an

unexpected situation or scenario and therefore can be classified into two types of disruptions, (1) those that are in a controlled environment and that in many occasions they obey technological innovations, and (2) those that arise due to an uncontrolled situation caused by disasters or natural catastrophes and even human-induced situations without even having dimensioned the impact that this will cause, such as terrorists acts. In [6], the author explained that whatever the origin that causes a disruption brings with it impacts on the supply chain. Annex 1 shows the classification of controlled disruptive events most relevant to the retail industry.

There is, as already mentioned, another group of disruptive events that are uncontrolled and that are also worth classifying in order to have a systemic perspective of the disruptive events facing humanity. In recent years we have seen these types of incidents that affect a large part of our planet and that lead us to reflect on how to manage properly and how to be prepared to when they happen, to mention some of these incidents and their impacts, how to imagine that the eruption of a volcano in Iceland would paralyze much of Europe's air movements and with it the interruption of the flow of goods, a series of forest fires in The United States and Australia would lead to the closure of companies dedicated to the assembly of by-products or components in the United States and, in the case of Australia, the closure of companies and the displacement of the workforce to other areas of the country, the bird flu that occurred in Asia and that caused millionaire losses to many companies affected by this situation and the sanitary fence that was implemented. The hurricanes and tsunamis that have occurred in different parts of the world have caused, in addition to human tragedies, the paralysis of factories and even the complete disappearance of companies dedicated to the manufacture of inputs within different supply chains. Disruptive events caused by uncontrolled situations can be seen in Annex 2.

The focus of this research is directed to this group of disruptions in uncontrolled environments and to be more specific, to the impacts of pandemics and epidemics in supply chains, in this case to the affectation that COVID-19 is causing in the international market and in the different supply chains that integrate it, in [6] the author explained in his conceptual framework of supply chain disruptions, about disruptions in the behavior of demand and disruptions in the supply of products.

2.2. COVID-19 and its impact on supply chains

The effect of a pandemic like that of COVID-19 is anteceded by what happened more than two decades ago with the aforementioned H5N1 avian influenza and a few years later with the H1N1 influenza that occurred between 2009 and 2010, however, the prolonged effect by COVID -19 is unmatched in terms of economic, social and loss of life impacts.

COVID-19 has come to present itself as an evil that the present generation had not faced, it has come as a script taken from a horror movie in all aspects, a segment of the apocalypse that illustrates what the future of the world will be like after observing how the health systems of entire nations have collapsed, of the economy and not to mention the psychosocial aspect that this disease is causing. Various authors describe the current scenario using analogies that refer to a combination of interrelated variables, on the one hand the probability that it will happen and the impact that

it can cause when it happens. In [7] the author metaphorically described such events as the COVID-19 pandemic as a "black swan" for humanity, in [8] the author described in reference to the same hypothesis the rarity of seeing a "black swan" and on the other hand the high impact it represents for humanity in this case the pandemic that is sweeping the whole world.

As a member of a leading transnational organization in the retail industry, just a few months ago, to be exact the beginning of 2020, we did not imagine in our annual strategic planning process of the company the threat of facing a scenario like the one that is being presented by the effect of COVID-19, it was not a topic, much less a stage that our organization and many others imagined.

After a few months of experiencing this global collapse, it is possible to make a count of learning that has favored the operational continuity of the organizations that have remained standing to continue being a profitable option for their clients and consumers. Among these learnings we can mention some in which the research will be deepened:

- 1) Have a structure robust enough for management, seeking efficiency both in the execution of local operational functions and in staff functions.
- 2) Have an interconnected network of suppliers for each distribution center, with a solid alternative of local supply.
- 3) Having human resources and protecting them from the environment so that what has been previously described can take place, even becoming the most important aspect for the organization to remain current. Protecting people becomes a priority for organizations.

These three lessons help organizations have more resilient supply chains in order to get this complicated stage on track, affecting their operational continuity. The motivation to carry out an investigation to carry out this investigation is to contribute knowledge and learning in situations such as the one being experienced.

2.3. An overview of the retail industry as an essential company in the days of COVID-19

The COVID-19 crisis has affected the economy through different factors related to the health of the population, the mandatory blockades and interruptions to trade, as well as a series of collateral effects such as the decisions that organizations forced by the situation have had to make and which are related to maintaining sources of employment. In [9], the author explained about emotional factors such as the pessimistic feeling of consumers and companies derived from high uncertainty and financial stress.

For companies classified as essential due to the role they play before society for offering food products and other types of food considered basic for human consumption, it is a challenge to keep their supply chain processes active in a complicated environment and where many companies that are part of the supply chain gradually lose productive capacity given the situation of the pandemic and with it the available inventories. It is here at this point where presented the situation many organizations reflect on the design, the priorities and the strategy that they have followed to develop the business and where the supply chain and the supply network that integrates it become relevant, such as previously

described, “leverage” in the factors of people, network of providers, above all the development of the premises and lastly the operational and staff structure that it provides. In [10], the author explained about the key aspect of developing collaborative strategies with suppliers and together adopting best practices that help to have a better performance in the supply chain.

The pandemic shows that it may be too simplistic to base decisions about production locations solely on economic factors and many companies may not fully appreciate their vulnerability to global shocks through their supply chain relationships and the costs this imposes. In [11], the author explains the importance of having future risk assessments of companies before they decide to relocate production or when reconsidering their location options.

There is a social commitment to the population and to the government authorities to keep the supply network in force so that the population is not affected by the lack of basic necessities. In a situation like COVID-19, a strategy must be adopted to adequately manage the shortage and make efforts to carry out emerging actions to ensure the supply of essential products. This work proposes scenarios in which organizations classified as essential, such as the retail industry, can adopt a model based on a continuity matrix in the face of the loss of capacity of the logistics network.

The value chain for food or perishable products offered in the retail industry becomes more relevant in a scenario such as the one currently presented in the COVID-19 contingency. In [12], the author described that the supply chain must be designed in such a way that production, transformation and distribution generate the expected value in the supply chain and therefore to the consumer.

3. A structured proposal for supply chain management based on a contingency plan against COVID-19

The proposal that is developed in this work incorporates the key elements to take care of for the operational continuity of the supply chain of companies in the retail industry. Adequate management through the proposed contingency matrix will not only allow operating with well-defined criteria for decision-making based on the changes that the supply chain is having in the different processes that comprise it, but will also help to maintain an organization communicated at all organizational levels about the intention of senior management in the face of the pandemic. The group of researchers who have worked on the development of the document have had the opportunity to carry out the implementation of the tool in the leading company in the market in convenience stores in Mexico.

Talking about COVID-19 today is talking about a diversity of topics that converge on a macro issue such as the global collapse due to the effects of the pandemic that we had to live in this 2020 and that will surely go beyond this year. It is common to see the large number of articles suggesting how to bring life in all aspects to a new normal.

3.1. Method of assessing the level of risk of the supply chain

Faced with the impacts of the pandemic, supply chains have collapsed to a greater or lesser extent throughout the world, the network of suppliers has been compromised and, in worst case scenarios, disarticulated. This level of exposure highlights the importance of having a mechanism for assessing the level of risk

in the supply chain. As part of the research carried out, a method of assessing the level of risk of the supply chain is being proposed. For this, it is important to start from a statement that the authors of this work make based on the experience and consultations made in the works of other researchers. As a starting point it is necessary to start with the definition of the key, operational and service processes.

3.2. Operational and service processes of the supply chain

The key processes that make up the operation of the supply chain become a distinctive seal that gives identity to the organization and marks the success or failure in achieving the value proposition to the end customer.

Focused on the case of the retail industry where companies participate in an environment with some volatility and where business strategies change from one day to the next or in extreme cases, from morning to night with various promotions simultaneously and with packages or commercial combos from different suppliers, the supply chain must be directly connected to the commercial strategy in order to make each of its processes focused on providing the service work. The companies that make up the retail industry are considered essential due to the impact on the supply of food to the community where they are located.

Following are the key processes in the supply chain of a distribution center serving a network of convenience stores:

1. Supply
2. Receipt of merchandise from suppliers
3. Storage of merchandise
4. Order management and replenishment planning
5. Assortment of orders
6. Preparation and consolidation of orders
7. Loading and boarding
8. Delivery of orders to the store

The key processes of a distribution center operation can be seen in Figure 1. In [13], the author described the supply chain processes in the SCOR Model with the objective of having a valid reference for the construction of a proposal that offers visibility and focus on having an efficiency analysis of the supply chain processes. In [14], the author explained the approach to supply chain efficiency and the integration of best practices. In [15], the author contributed to the SCOR Model the hierarchy of processes for decision making and supply chain management. Table 3 shows the relationship of the proposed processes with those classified in the SCOR Model. Table 3 shows the relationship of the proposed processes with those classified in the SCOR Model.

3.2.1. Supply

It is the process by which all merchandise supply activities are managed from the supplier to the distribution center or directly to the stores. The supply process aims to guarantee the supply of goods in a timely manner, in the quantity required for sale and with the quality that meets the parameters of each product for sale to consumer customers.

This process groups a series of activities considered strategic by a team that is constantly analyzing inventories, sales behavior, in close communication with the categories in which the product catalog is classified and finally with the marketing part. for proper planning of promotions.

Table 1: Comparative relationship of SCOR Model processes and operating processes of the retail industry.

SCOR Model processes		Retail industry supply chain operational processes
Plan Supply Chain	Plan Source	Supply - Receipt of merchandise
	Source Stocked Product	Storage of merchandise
	Plan Make	Order management
	Make to stock	Assortment of orders
		Preparation and consolidation of orders
	Plan Delivery	Loading and boarding
Delivery of orders to the store		

3.2.2. Receipt of merchandise

It is the reception of merchandise orders from suppliers, they obey an appointment planning agreed with suppliers and must be in accordance with procedures and policies on the requirements to be met in the proper handling of products that in some cases require certain parameters of refrigeration, humidity and security, such as the height of the platforms where the merchandise arrives.

3.2.3. Storage of merchandise

Within sequential flow of operations, it is the process in which the merchandise is located in a site within the area destined for storage. This process aims to create the appropriate conditions for the safekeeping and control of different goods. Each movement of merchandise from its storage location to another point, obeys a merchandise flow instruction to send said merchandise to an assortment location that can be refrigerated boxes, pieces or parts assortment.

3.2.4. Order management

It is an administrative process that is carried out with merchandise replacement tools at the store and is practically the equivalent of having a production program or planning of order fulfillment activities, ordered by priority based on the criticality of inventories. in shop. This process represents the intelligence center that drives the operations of the distribution center and through which resources are allocated to fulfill store orders.

3.2.5. Assortment of orders

It is the process in which operation personnel carry out order fulfillment activities. There are three different areas of order assortment which are:

1. Refrigerated product area: The assortment of orders is made in a plastic container and each piece is placed inside.
2. Product assortment per box area: The order assortment is for a higher unit of measure and is defined for products with high turnover or high displacement at the point of sale. To carry out this type of assortment, the Operator uses mobile equipment

to place all the merchandise that is supplied per box on a pallet.

3. Product assortment area by piece, blister or minor packaging: The assortment is carried out online by assortment by pieces and the Assortment Operator uses a plastic container to place all the pieces that appear in the order of order.

After an order is filled from any assortment area, there is an assurance reliability check thread, offering feedback to the assortment team on the quality of the task performed.

3.2.6. Preparation and consolidation of orders

Process by which the orders already filled, both boxes and dry parts and refrigerated parts are ordered by store. It is consolidated by store and in the order in which they will be loaded in the transport unit; as well as how the orders will be delivered by store according to routing, which requires room temperature and which requires refrigeration.

3.2.7. Loading and boarding

Process in which the orders are loaded in the transport units according to a routing sheet and delivery order, as well as the invoicing of each order. It is important to keep a sequential control of the load so that the Distribution Operator does not have setbacks in deliveries.

3.2.8. Delivery of orders to the store

It is the transportation process by which the merchandise is transported and delivered from the distribution center to the store. The Distribution Operator delivers to the customer under certain conditions that have to do with product handling conditions such as maintaining the cold chain for products that require it and the corresponding administrative and control documents that support the order. Annex 3 shows the capacities of each process, as well as the associated unit of measurement.

3.3. System of metrics or performance indicators of key processes

As the key processes of the distribution center have been defined, each process has an associated performance standard and metrics to evaluate it. Table 5 shows the metrics for each process under the efficiency approach. In the context of the supply chain, the integration of the objectives in its different levels is an important factor for the correct selection of the indicators, which will provide a broader view of the business. In [16], the author described the importance of having identified key performance indicators, through which a reference will be available at all times to assess the resilience of the processes when a disruption occurs.

Of course, there will be other indicators that have to do with the result of the business if what you want to see is the economic contribution; however, these are more common to see throughout the chain. They are also described in Annex 5.

In order to have a level of detail that allows a better management of goods, it is essential to have an administration by product categories. In [10], the author explained the importance of interconnecting merchandise categories for efficient management of supply chain processes. Figure 1 shows the supply chain from the supplier to the store, passing through the distribution center.

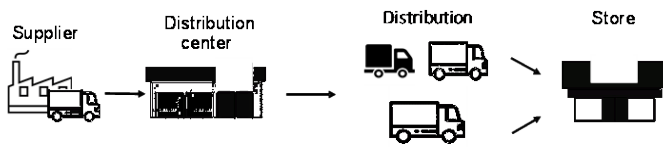


Figure 1: Supply chain from the distribution center to the convenience store (source: self made).

3.4. Key elements to successfully respond to the COVID-19 pandemic

During the research conducted, we had the opportunity to analyze different contributions from other researchers related to the key elements of the supply chain, which date back almost two decades. Without a framework for action that allows visibility of these key elements, it will be difficult to promote the improvement of supply chain performance. In [17], the author explained the importance for organizations of designing an operating model that facilitates the management of supply chain processes and identifying their restrictions, in addition to these elements. There are other researches that based on their studies make another proposal from a different perspective, where a classification is made according to the relevant aspects of supply chain resilience. In [18] the author presented a proposal to categorize resilience actions using four main categories: systems, process, control and recovery.

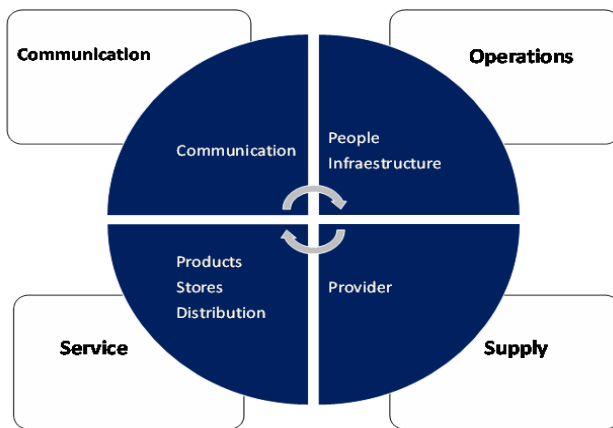


Figure 2: Key elements of the convenience store supply chain (source: self made)

The research proposal is contained in seven key elements, classified in turn into four supply chain management pillars comprising the proposed evaluation method, as shown in Figure 2. The key elements to consider in order to have a perspective and reference of the level of vulnerability of the supply chain to possible risks are grouped into four management pillars are described below:

- **Operations:** Refers to the group of activities that allow the continuity of the operation of the key processes. It includes the human resource, infrastructure and general facilities of the work unit.
- **Supply:** Includes the relationship and development of suppliers to guarantee the supply of goods from the supplier's facilities to the distribution center.
- **Service:** They are all the activities that allow the supply of goods from the distribution center to the store. The elements

that make up the service pillar are merchandise, distribution and stores.

- **Communication:** Refers to the strategy that the company intends to carry out to communicate its intention at all levels of the organization and even outside of it.

The key elements that, in turn, make up the supply chain management pillars and through which an evaluation of the level of response to the effects of a pandemic such as COVID-19 can be made are:

1. People
2. Facilities and infrastructure
3. Suppliers
4. Goods / Products
5. Stores / points of sale
6. Distribution / delivery to store
7. Communication

3.4.1. People

It comprises the most important resource at all levels of the supply chain, its well-being is a priority so that each of the supply chain processes can be carried out. Although it sounds like a very repeated cliché, "people are the most important thing" and they should know it and they should feel it, without a clear pronouncement from the organization of approach to people, it is difficult to advance in the other aspects.

Faced with a situation such as that of COVID-19, where the level of risk of contagion is present, there must be a consistency in the saying, in the being and in the doing from top management to the most basic positions in the structure. If there is no legitimate concern for the safety and health of people, there is no emotional bond that generates commitment.

3.4.2. Facilities and infrastructure

They are the assets of the organization necessary for the work units to be active. This element is closely related to human resources and must offer security and protection conditions so that personnel can carry out their activities without any distraction. It includes the industrial building or warehouse, the machinery and peripheral work equipment so that people can carry out their functions.

In the face of a pandemic like the one presented by COVID-19, maintaining the safety of the facilities becomes critical for the continuity of the operations of the companies that handle food and perishable products and that is why they are considered essential companies for society. Keeping the workplace pollution-free for employees represents a major challenge for companies and largely depends on the implementation of sanitation measures and / or protocols and strict compliance with government requirements for the preservation of hygiene standards.

3.4.3. Suppliers

It is the active network of suppliers that supply goods to the distribution centers or directly to the points of sale. It is important to have full knowledge of the conditions of each supplier in the

network, in [19], the author described the importance of having information from upstream suppliers several levels back. Companies that do not do so are less able to respond or estimate the potential impacts when a crisis erupts. Under the supply chain perspective, the objective is to maintain continuity in the supply of products in order to have them in a timely manner and in the quantity required in distribution centers and / or in stores or points of sale. A supply chain is as strong as is the capacity of alternative suppliers. Some researchers consider the supplier network as the benchmark to determine the level of resilience of the companies' supply chain, highlighting as a strategy the development of local suppliers to mitigate the risk of dependence on suppliers located outside their geographical area, of the country and even to the continent.

It should be borne in mind that in the face of a pandemic such as this one, companies must develop new supply alternatives, it is a fact that the companies that precede the chain will be affected in their operations.

3.4.4. Goods / products

Refers to the active catalog of items offered to the customer at the point of sale. When speaking of merchandise or articles, it is important to mention that the companies dedicated to the sale of basic necessities use for a better administration of these, a classification regularly called category. This classification consists of grouping the type of merchandise so that a group of people, regularly on a staff basis, can establish the marketing strategy that involves the relationship with suppliers, marketing, study of new developments and promotion plans. The categories together with the financial area determine the profit margin of each product to evaluate its performance, establishing for this purpose negotiations of costs and sale prices. In [20], the author explained the existence of algorithms or models that allow setting price points considering the market and the position as leader in the competition.

Faced with a situation such as COVID-19, organizations must be clear about the economic performance of each product, this will allow them to make better decisions about the profitability of the business and thus privilege the items that in their classification are considered essential for society but that are also profitable for the organization. In [21], the author explained the strategy of increasing inventories can be a measure to mitigate the risk posed by a disruption, however, it is reactive to an actual shortage; the strategy can include product substitution or back-up supply.

3.4.5. Stores / points of sale

These are the points of sale to the consumer customer or stores that the company has. They can be classified according to their location and format by the type of customer who regularly comes to buy. In [22], the author described that the complexity of the store as such lies in the number of stores in operation and the store formats it has with different sizes, catalog and price points.

The commercial and marketing team are the ones who carry out this classification of stores and thus be able to establish a catalog of products for each type of store. This classification of stores allows in addition to establishing a catalog of particular products, establishing the entire campaign of promotions, prices and launches, this differentiation is key to evaluating the performance of each store in its sales volume.

An example of differentiation in the classification of stores is the store that is located inside a high-density residential subdivision with the store that is located inside a hospital, it will be found that neither catalog of products for sale is the same and due to the location conditions, nor is the sale income.

3.4.6. Distribution or delivery to store

It is the transportation process by which the merchandise is delivered from the supplier or distribution center to the point of sale. The transport equipment used is conditioned for handling both merchandise that requires refrigeration and room temperature.

Under the store delivery conditions required in this contingency stage, the distribution personnel must have the necessary protective equipment to carry out the merchandise delivery tasks at the point of sale, as well as the sanitation measures for the units must be in accordance with certain regulatory measures for the handling of perishable product.

3.4.7. Communication

They are the means or mechanisms established by the organization to maintain timely and assertive communication at all levels of the organization, and even in the event of possible communication with the press and / or a statement to government authorities. Communication must at all times be reliable, truthful and above all timely about the organization's intentions in the face of the contingency it is facing.

There are different methodologies that help organizations to be prepared to face a contingency from the point of view of information management and what they want to communicate from a 360° perspective, as described above. We will mention that there is a methodology that helps coordinate and this is Incident Management and Crisis Resolution (IMCR), methodology developed in the United States.

3.5. Scenarios taken to a continuity actions matrix of COVID-19

Organizations are facing an unprecedented global crisis, human survival depends on essential elements during the pandemic and that can be met by properly utilizing key resources such as raw materials, employees and active logistics systems. In [23], the author described that the priority of nations during the pandemic is to save human lives, but shortages of essential commodities such as food, drugs, diagnostic equipment, clinical healing and personal protective equipment have made it difficult to fight the infection.

Having defined the priorities of nations and organizations to preserve the health of people as the most important priority, it remains for organizations to resolve the most important aspects to ensure the operational continuity of businesses, in [24], the author explained the importance of uncertainty management in the supply chain and how strategies can be established in inventory management. In [25], the author described that organizational leaders must urgently implement short-term strategies to be more resilient while making longer-term considerations that will reconfigure supply chains to protect against risks.

- Develop visibility of the entire value chain in primary, secondary and even tertiary players.

- Evaluate nearby options to shorten supply chains and increase proximity to customers.
- Take advantage of advanced manufacturing technologies to be more resistant. Another important point is to systematically evaluate the end-to-end value chain, to establish agile action plans.

Organizations are facing an unprecedented global crisis, and one approach that has not exactly been the most appropriate for supply chain management is to think about generating efficiencies and savings at the expense of eliminating slack or "margins of maneuver", such as operating with a diversity of suppliers for the same product, operating with safety inventories in the chain, etc., which in the face of a disruptive situation such as the COVID-19 pandemic leaves the organization exposed. In [26], the author explained that there has long been a focus on making the supply chain more efficient based on reducing costs, reducing inventories and increasing asset utilization, thus eliminating buffers and flexibility to absorb disruptions.

With the description of the key elements and their classification by management pillar, a continuity actions matrix can be integrated in a more practical way to evaluate possible scenarios and trigger actions focused on ensuring supply to stores.

In summary, after presenting the key elements for business continuity in companies classified as essential (and largely applicable to non-essentials as well), organizations will need to work on:

- Guarantee that people feel protected in a work environment that complies with the conditions and measures of control, sanitation and use of personal protective equipment that mitigates the risk of contagion, also keeping facilities and work tools under a protocol frequent cleaning. In [19], the author explained that employee welfare is paramount, and obviously people are a critical resource.
- Developing local suppliers for the supply of key merchandise, that implies redesigning the supply network to a great extent. If COVID-19 has revealed anything, it is the high level of risk represented by having a large number of suppliers in one place.
- Organizations should develop suppliers close to their main markets; this strategy will help mitigate the risk of centralized dependence, which can be maintained and alternatively explore other sources of supply. In [4], the author explained that another important factor to consider is that as transportation and other costs increase, global supply chains may be replaced by regional supply chains.
- Provide the service as far as the contingency allows and maintain the value proposition of the stores, without infringing the care of the workers and complying with the requirements established by the government agencies. As organizations considered essential, those products of first necessity for the population must be privileged and, on the other hand, they also represent a greater profitability for the organization, for this it is important that a detailed analysis of those products is made and that level is established with suppliers. priority in supply.

- Maintain communication at all levels of the organization about the decisions that the company is taking, from issues of personnel health and care of facilities}, to those that could be more critical as partial closure of operations and in the worst case, the total closure of work units.
- For people, it is important to be informed about how the organization is facing the pandemic and what decisions are being made by senior management. To the extent that there is clear communication, the uncertainty will be combated and the staff will be focused on their care and the performance of their tasks.
- Assessing the level of risk in the supply chain is to have a preventive approach and it must be considered from the strategic planning process of organizations, that annual exercise that most organizations that describe themselves as preventive and that base their management under procedures and well-defined work systems, should consider in such planning an assessment of the risk level of their supply chain. Does this evaluation require an expense to be considered in the annual budget? The answer is yes, and excess spending due to not having an action plan to mitigate risks in the face of a disruptive event such as this pandemic may be much higher than the cost of a supply chain assessment.
- There will be many lessons learned from this disruption by COVID-19, even some organizations will not survive in order to capitalize on the learning it leaves. For the surviving companies it will be an opportunity to integrate the knowledge acquired and the recommendations that lead them to strengthen their processes and increase their resilience in the face of a disruptive event that submitted their performance and put their permanence at high risk.

The proposal made in this research is the COVID-19 business continuity matrix and is intended to provide a complete picture for organizations to evaluate the variables faced by organizations. In [27], the author described that robust strategies must be developed that integrate the purposes of reducing costs and improving customer satisfaction during and after a major disruption. In [28], the author described the importance of the design of the supply chain conceptual framework and the essential elements that have to do with resilience to disruptions that occur and supply chain resilience recovery policies. In [29], the author explained that the problem for top management of organizations is to choose a good strategy and quantify the benefits to develop a robust model for supply chain disruption analysis, for this it is important to identify and understand the overall behavior and intrinsic weaknesses of these systems and their components, especially in the face of negative events such as disruptions. In [30], the author presented that only a small minority of companies that invested in mapping and measuring the vulnerability of their supply chains are the best prepared to face this pandemic. Annex 5 shows the matrix of continuity actions to face the different impact scenarios of COVID-19.

3.6. *Stabilization of the post-disruption operation*

The stabilization stage of the operation is a continuation of the actions described in the continuity actions matrix as part of a plan where the regeneration or recovery of the resources of the supply

chain is taking place through the effect of the disruption has yielded. It is important to prepare a recovery plan and periodically review it by the management team so that the scenarios that require decision-making are updated. To the extent that there is an updated plan and communicated to the entire organization, the horizon will be visible when a total restoration of the organization and its supply chain will be presented and thus decisions can be made as to decide when to stop buying, when to stop transporting or when to stop producing, among other operations that have had to be implemented with an over cost justified by the disruption.

Another important aspect mentioned in the key elements is the communication that exists at all levels of the organization and which must be used to reach the collaborators with what they need to know, having a single source of information helps maintain the credibility of people when their health and that of their families is at stake.

Any action plan focused on treatment, solution or simply trying to coexist with a problematic situation, in this case a disruption of natural origin, must leave knowledge to organizations, considered essential or non-essential, if organizations do not learn from these lessons they will not have the opportunity to leave a legacy and an ABC of what was done as good practice to come out in front of a pandemic like that of COVID-19 and new managers, they will not be able to learn from those experiences to face the new challenges that they will surely have during their management when new disruptions arise.

Among the relevant contributions that integrate the research is a series of strategies that help stabilize operations and that focus on the objectives of identifying the level of risk in the supply chain, adequately managing resources and having an action plan to mitigate risks with suppliers and internal processes. In [31], the author explained that actions should be taken to improve internal capabilities, prepare inventory levels that meet projected sales and reserve logistical capacity.

4. Conclusions

The importance of having defined and structured processes for proper management of the supply chain offers a scenario that helps to better manage uncertainty and for this reason to mitigate disruptive environments that arise. Having performance metrics aligned to the strategy and capabilities of the processes help not to fall into the obsolescence of the supply chain. The processes and their metrics make it easier to be able to develop a proposal that allows evaluating the level of risk in the supply chain and consequently developing an emerging action plan for each scenario that presents a disruption of the magnitude of COVID-19.

Many organizations must be sensitive to the fact that the supply chain is a series of processes that have life and that must be evaluated periodically from the perspective of the level of risk to which they are exposed due to the dynamism of environmental variables. It will always be a successful and strategic alternative to diversify the sources of resources and related to this point, these types of decisions are what organizations must bear in mind when it comes to making decisions to pulverize the supply of goods from suppliers located in another region, in another country or even on another continent.

This research aims to offer a point of reference that allows evaluating the supply chain of organizations in the retail industry, from the perspective of the key elements raised throughout the work and that in the end is the main contribution that is made.

Finally, a supply chain oriented to service and to a value proposition committed to the customer allows creating a virtuous cycle to reinvent the increasingly resilient and anti-fragile supply chain. It is important to recognize that there are different investigations that focus on the management of disruptive stages in organizations, as well as these extremely valuable work carried out, there will be other future contributions that will come with new approaches and other variables to consider. Given this scenario, there is the commitment of those who collaborated in this scientific work to leave a documented learning for future generations of how to handle these disruptions, we will not be fulfilling a professional commitment, nor would our legacy be complete on how it was managed and left ahead of COVID-19.

Conflict of Interest

The authors declare no conflict of interest.

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Annex 1. Main disruptive events in a controlled environment in the retail industry.

Disruption	Description
Technological effect / e-commerce	Definitely the disruptive element with the greatest impact in the last decade, those who dominate networks and online shopping have ample possibilities to position themselves in a highly competitive market. Today it is a must for organizations to be in the online market.
Proximity, time dedicated to home purchase and delivery	Another disruptive element associated with the first, the famous last mile represents for the consumer customer a key decision factor to carry out the purchase. Delivering merchandise at the consumer's door is a battle that is being waged every day today.
Specialty market and lifestyle	Not all stores have the same product catalog, for different reasons or circumstances, the store's commercial design may change to serve certain types of customers who come to or are in that market. A convenience store located in a popular sector should have a differentiation from a store located in a university.
Catalog of products and services	With the passage of time the convenience store has become a strong competitor for large supermarkets, let's say that the evolution of the "corner store" has become a convenience store that offers the consumer customer a wide catalog of products and services.
Perishable management	Bet on handling products that require refrigeration such as prepared food, meat and fruits and vegetables. Even a growing market that procures organic products claims a segment for this type of product.

Annex 2. Main disruptive events in an uncontrolled environment in the retail industry.

Disruption	Description
Natural disasters such as earthquakes, hurricanes, tsunamis, volcanic eruptions, fires, among others.	Natural events that happen suddenly in different locations in the world and that cause a collapse in the flow of goods and in the economic aspect. Although they may be areas that have identified the level of risk, this type of natural disaster cannot be forecast.
Pandemics / epidemics and other health issues involving a sanitary fence	Condition where the health of the population of a country or countries that have a commercial relationship is affected by the exchange of goods among themselves. The effect of a global pandemic has an impact on the flow of goods of all the countries that are interconnected for the transfer of goods and other types of resources.
Terrorist acts	Premeditated or intentional actions that aim to cause destabilization through inflicting damage to a specific place or society and that through chaos there is an expected size of affectation. In general, the disruptive event that it causes has to do with reinforcing security measures and trade blockades.
Socio-political and economic decline	Aggravation of the socio-political conditions of a country which causes a recession or deceleration in the economic development of the industry and in general for the population. This type of disruption can take time to appear at the maximum level of affectation and as it is a slow process, it also usually takes time to mitigate the level of maximum affectation.
Armed conflicts	Like the disruptions considered as deterioration of the social and political fabric and as a consequence an adverse economic impact, in many cases society ends up rising up in arms before an unacceptable government. This type of disruption often takes a long time to find a solution that manages to offer social and economic stability.

Annex 3. Operational and service processes of a retail industry supply chain.

Processes	Capacity	Unit of measurement	Description
Supply	Active code catalog	No. active codes	It is the catalog of active product codes.
	Active providers	No. of active providers	The number of active suppliers supplying merchandise.
	Supply service for criticality of merchandise and supplier	% service level	It is the level of supply service that can be measured according to the criticality by merchandise and by supplier.
Merchandise reception	Merchandise reception	Pallets	Pallets received from the supplier.
Storage merchandise	Case storage positions	Pallets	Number of positions for storing product pallets in cases.
	Case assortment positions	Pallets	Number of positions for product pallets that will be supplied by cases.
	Dry parts storage positions	Pallets	Number of positions for storing product pallets in boxes. Shares storage with group of cases.
	Dry pieces assortment positions	Assigned positions / lanes	Number of positions fed by cases and to be supplied by pieces.
	Refrigerated parts storage positions	Pallets	Number of positions for storing product pallets in refrigerated product cases.
	Refrigerated parts assortment positions	Assigned positions / lanes	Number of positions fed by boxes and to be supplied by refrigerated pieces.

Order management	Assortment of cases on shift	Cases	Capacity considered for planning and assigning tasks of assortment cases.
	Assortment of pieces dry pieces on shift	Pieces	Capacity considered for planning and assigning dry parts assortment tasks.
	Assortment of refrigerated parts on shift	Pieces	Capacity considered for planning and assigning chilled parts assortment tasks.
Assortment of orders	Assortment of cases on shift	Cases	Assortment capacity per shift of the assortment staff of boxes assortment.
	Assortment of dry pieces on shift	Pieces	Assortment capacity per shift of operating personnel for assorting dry parts.
	Assortment of refrigerated parts on shift	Pieces	Assortment capacity per shift of assorted operating personnel for refrigerated parts.
Preparation and consolidation of orders	Lowling of containers (pieces)	Containers	Number of drops for containers that were supplied by dry pieces.
	Preparation of pallets on duty	Pallets	Number of pallets prepared in the convergence of the assortment of dry pieces and cases.
Loading and boarding	Staying of prepared pallets	Pallets	Ability to safeguard assorted orders waiting to be loaded on the platform.
	Pallet load per hour	Pallets	Loading capacity to transport units associated with mobile equipment movements.
Delivery of orders to store	Transport fleet	No. of units	Transport units that make up the vehicle fleet.
	Gates	No. of loading gates	Number of platforms enabled for loading and unloading operations.

Annex 4. Key performance indicators of supply chain processes.

Processes	Indicator	Unit of measurement	Description
Supply	Inventory level in distribution center	Days	This indicator represents the level of merchandise inventory expressed in days in the distribution center and is a function of the volume of daily movement or transfer to stores. From the perspective of the Abasto process, it measures the effectiveness of planning the supply of suppliers to the center of distribution. Calculation: The inventory of the merchandise is divided by the value of its daily trip to stores.
	Lost sale	%	It is the percentage of merchandise that is not in inventory or not available for sale in the store and that has a daily sales behavior based on statistics. Calculation: The shortage of each merchandise is divided by the projected daily sale behavior of each merchandise.
	Inventory level in store	Days	This indicator represents the level of merchandise inventory expressed in days in the store and is based on the store's sales volume. From the perspective of the Abasto process, it measures the effectiveness of planning the supply from the distribution center to the store. Calculation: The inventory of the merchandise in the store is divided by the daily sale value of the store.
Merchandise reception	Compliance with supplier receipt program	%	Level of compliance with the appointment schedule established with providers. Calculation: The number of arrivals within the window is divided by the number of scheduled appointments.
	Fill rate providers	%	Level of compliance that is carried with suppliers on the requested merchandise. Calculation: The quantity of merchandise received is divided by the quantity of merchandise scheduled to be received.
Storage of merchandise	Inventory days in the distribution center	Days	This indicator represents the days inventory of merchandise in the distribution center, is based on the volume of daily trips to stores. Calculation: The inventory of the merchandise is divided by the value of its daily trip to stores.
	Product wastage	%	This indicator shows the decrease generated in the warehouse due to internal handling and product obsolescence. Calculation: The value of the lost merchandise is divided by the value of the total inventory of the distribution center.
	Inventory rotation	Cycles or number	This indicator measures the efficiency with which you have the ability to rotate inventory in the cedis. Calculation: It is the number of cycles or times that stocks were turned over during a period of time that can be monthly.
Order management	Product missing	%	This indicator shows products scheduled to be shipped to the store and not in the inventory available from the distribution center. Calculation: The total number of missing merchandise is divided by the number of merchandise scheduled to be shipped to the store.
	Cycle time	Hours	This indicator shows the cycle time of an order, it is also known as lead time. Calculation: It is the time elapsed since the store order is generated until the distribution center delivers it to the store.

Assortment of orders	Assortment productivity	Units / hr	Efficiency indicator that shows the use of resources for the productive tasks of operating personnel in each work area. Calculation: The volume supplied (pieces or boxes) is divided by operator per hour of work. There are three work areas and there may be different productivity units.
	Assortment error rate	%	Quality indicator that shows the reliability of the assortment of the productive groups. Calculation: Divide the number of errors in the operating staff assortment by the total assortment volume per operator.
Preparation and consolidation of orders	Productivity in preparation	Units / pallet	Indicator that shows the performance in the preparation and consolidation of the order prior to loading it on the platform. It is intended that the integration of orders, both for parts (plastic basket) and boxes, is of maximum density per pallet. Calculation: Number of packages placed per pallet prepared.
Loading and boarding	Productivity under load	Units / truck	This efficiency indicator aims to measure the load capacity of packages in the transport unit. The aim is to make the most of the volume of the transport unit. Calculation: Number of packages loaded per transport unit.
	Unit charging time	Hours	This indicator measures the time the transport unit remains on the loading platform. The objective is for the unit to be released as soon as possible so that it begins its journey. Calculation: It is the elapsed time from when the transport unit is assigned to the platform until it is released to start the journey.
Delivery of orders to store	Compliance to delivery windows	%	This service indicator reflects arrivals within the expected time period or store delivery window. Calculation: The number of orders arriving within the assigned time window is divided by the total number of scheduled orders.
	Fill rate	%	Level of fulfillment of the delivered merchandise vs. the merchandise requested in the store order. Calculation: The quantity of merchandise delivered to the store is divided by the quantity of merchandise scheduled to be delivered.
	Cycle time deliveries	Hours	This indicator seeks to measure the time it takes for the transport unit on its order delivery route until it returns to the distribution center to start another cycle. Calculation: It is the elapsed time from when the unit is released to start an order delivery trip to stores until it returns to the distribution center.

Annex 5. Economics indicators of supply chain processes.

Processes	Indicator	Unit of measurement	Description
Group of processes inside the distribution center	Warehouse expense	\$ / package	Represents the expense incurred in the warehouse operations considering the direct labor related to the operation.
	Wastage expense	\$ / package	It is the expense attributable to the loss of product and inventory differences in the warehouse.
Entrega de pedidos a tienda	Distribution expense	\$ / package	It is the expense of the distribution and delivery of merchandise to the store.
All processes in the supply chain	Total logistics expenditure	\$ / package	It is the integral expense of all the key processes that make up the supply chain of the distribution center.

Annex 6. Continuity actions matrix of COVID-19.

Health phase	Risk level	Capacity level	Operatives		Supply	Service			Communication and diffusion
			People	Facilities and infrastructure	Providers	Merchandise	Stores	Distribution / delivery to store	Communication
Does no apply	0	Normal operation 100%	<ul style="list-style-type: none"> 100% operational team Recruitment of personnel as a protection measure against possible damages due to loss of labor 	<ul style="list-style-type: none"> Review and evaluation of risks of manipulation of equipment and infrastructure Survey of vulnerable areas to contagion 	<ul style="list-style-type: none"> Identification of suppliers with risk of shortage Communication and risk mapping with strategic suppliers Explore alternative vendor alternatives 	<ul style="list-style-type: none"> Normal marketing plan Normal releases and promotions Local and regional promotions in the normal way 	<ul style="list-style-type: none"> 100% supply of stores Monitoring of stores closed due to contingencies 	<ul style="list-style-type: none"> Strengthening of the transport fleet (own and contracted) Routing planning with sequential time windows 	<ul style="list-style-type: none"> Activation of the Incident Management and Crisis Resolution Committee (MIRC) Establishment of the crisis action plan Establishment of communication roles in the management team <ul style="list-style-type: none"> Towards the staff Towards the client Towards the General Directorate Towards authorities and government With the press and social media Carry out a follow-up session to the operation and review each element of the contingency matrix
1	1	Operation with emergenging actions 90% - 100%	<ul style="list-style-type: none"> Assignment of personnel to the operational workforce by 10% Identification of areas that require working overtime Isolation for personnel classified as vulnerable group Activation of health filters to identify symptoms in the staff 	<ul style="list-style-type: none"> Installation of health and safety measures such as health filters Restriction of access to confined areas or without adequate ventilation Cancellation of meeting places that do not comply with the distance measures 	<ul style="list-style-type: none"> Establish a supply plan for items considered to be in high demand due to contingencies Establish prioritization strategy with merchandise categories (privilege suppliers of basic products) Activation of alternative providers and privilege regional alternatives 	<ul style="list-style-type: none"> Normal marketing plan Normal releases and promotions Local and regional promotions in the normal way Identification of the articles considered essential to prioritize their supply from suppliers 	<ul style="list-style-type: none"> 100% supply of stores Monitoring of stores closed due to contingencies Monitoring of rejection of deliveries to store by contingency 		
2	2	Operational performance 70% - 90%	<ul style="list-style-type: none"> Exploration and activation of operating schedules, working days and shift duration Activation of shifts on non-working days Keep staff from vulnerable groups in isolation Maintain health filters to identify symptoms in staff 	<ul style="list-style-type: none"> Installation of health and safety measures such as health filters Restriction of access to confined areas or without adequate ventilation Cancellation of meeting places that do not comply with the distance measures Installation of physical barriers in work areas to avoid the risk of contagion 	<ul style="list-style-type: none"> Generation of advance purchases for items classified as essential Prioritization of supplier receipts Consider the exchange of merchandise between distribution centers and stores (optimally distribute shortages) Activation of alternative providers and privilege of regional alternatives 	<ul style="list-style-type: none"> Adjusted marketing plan and according to merchandise availability Prioritize the marketing of essential contingency items, such as food and perishables, cleaning and hygiene Management with capacity planning, inventory replacement adjust purchases according to demand and capacity level of the distribution center 	<ul style="list-style-type: none"> Monitoring of stores closed due to contingencies 100% supply of stores Monitoring of rejection of deliveries due to contingencies Decrease in the frequency of delivery of orders to stores Financial analysis that favors sending orders to the best-selling stores 	<ul style="list-style-type: none"> Extension of distribution days Modify daily delivery plan to a less frequent one 	
	3	3	Operational performance 50% - 70%	<ul style="list-style-type: none"> Balancing of operating loads according to staff availability, activation of extra shifts according to availability Keep staff from vulnerable groups in isolation Staff working remotely (for those who apply the scheme) Strengthening of established health filters, identification of symptoms in personnel 	<ul style="list-style-type: none"> Installation of health and safety measures such as health filters, sanitizing mats, sanitization application with authorized cleaning fluids Restriction of access to confined areas or without adequate ventilation Cancellation of meeting places that do not comply with the distance measures Installation of physical barriers in work areas to avoid the risk of contagion 	<ul style="list-style-type: none"> Generation of advance purchases for items classified as essential Prioritization of the receipt of strategic merchandise suppliers Consider the exchange of merchandise between distribution centers and stores (optimally distribute shortages) Activation of alternative providers and privilege regional alternatives Daily communication on the operational continuity of suppliers based on the priority classification of their products Evaluate the collection of merchandise at the supplier's facilities 	<ul style="list-style-type: none"> Prioritize the marketing of essential contingency items, such as food and perishables, cleaning and hygiene Management with capacity planning, inventory replacement adjust purchases according to demand and capacity level of the distribution center Carry out financial analysis to privilege the articles that provide the greatest economic benefit to the organization. Exchange of merchandise between operating units and stores 	<ul style="list-style-type: none"> Validation of stores that remain open and capable of receiving merchandise Supply to stores classified as private based on sale Decrease in the frequency of delivery of orders to the store		Extension of delivery days to store Balancing operators in deliveries 24 hours Decrease the frequency of delivery of orders to the store Perform dynamic routing with priority stores and Eliminate restriction of order delivery windows
3	4	Operational performance 30% - 50%	<ul style="list-style-type: none"> Balancing of operating loads according to staff availability, activation of extra shifts according to availability Keep staff from vulnerable groups in isolation Staff working remotely (for those who apply the scheme) Strengthening of established health filters, identification of symptoms in personnel 	<ul style="list-style-type: none"> Installation of physical barriers in work areas to avoid the risk of contagion 	<ul style="list-style-type: none"> Activation of alternative providers and privilege regional alternatives Daily communication on the operational continuity of suppliers based on the priority classification of their products Evaluate the collection of merchandise at the supplier's facilities 	<ul style="list-style-type: none"> Validation of stores that remain open and capable of receiving merchandise Monitoring of rejection of deliveries due to contingencies Supply of stores that remain open and classified as high sales Delivery of orders according to availability and receipt capacity 	<ul style="list-style-type: none"> Validation of stores that remain open and capable of receiving merchandise Monitoring of rejection of deliveries due to contingencies Supply of stores that remain open and classified as high sales Delivery of orders according to availability and receipt capacity 		

Covid-19 Pandemic Lockdown: The Consequences Towards Project Success in Malaysian Construction Industry

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ABSTRACT

The Covid-19 is a pandemic issue that is causing widespread global disruption forcing lockdowns in many countries including Malaysia as an effort in disconnecting the virus from spreading. As an initiative, the Malaysia government has call for the Movement Control Order (MCO) as one of the lockdown alternatives starting on 18th March 2020. Due to that, the MCO has given a huge impact on Malaysia's industries including the construction industry. Hence, to successfully deliver projects, time and cost become the essential component which in this current scenario, most of the on-going projects declined to deliver the project according to the time and cost as planned. Thus, this paper intends to explore the consequences of the Movement Control Order (MCO) towards project success. In getting an authentic data and fast feedback from the respondents during this current scenario, uses alternate methods as face to face interview is not encouraged. The interview sessions were held thru telephone conversation with 8 contractors in Klang Valley and Penang which randomly selected based on contractor listing in Malaysian Construction Industry Development Board (CIDB) website and content analysis are used to figure out the main consequences using Nvivo software. Results from the interviews found that the MCO has resulted in 6 main impacts consists of (1) regulation compliance; (2) safety; (3) additional time for project delivery; (4) increase in development cost; (5) limited human resources supplies; and (6) limited resource availability on-site. These shows the MCO has given the negative impact to the project success. This result is important for the government to ensure their awareness on the consequences of the MCO towards construction industry and facilitate the construction players to overcome the six factors mentioned in this paper.

1. Introduction

The 2019 Novel Coronavirus or Covid-19 is currently a pandemic issue that is spreading globally [1] which have affected 9.54 million people and 485,000 recorded in 215 countries up to 25th June 2020 [2]. This pandemic was first identified in Wuhan City, located in Hubei Province in China [1,3,4]. Due to that, on January 11, 2020, the Covid-19 was recognised as a global pandemic by the World Health Organization. Then, on 30th January 2020, the Emergency Committee of the World Health Organization (WHO) has declared the on-going Covid-19 outbreak to be a global Public Health Emergency of International Concern (PHEIC) which the PHEIC defined as an “*extraordinary event*” that “*constitute a public health risk to other States through*

the international spread of disease” and “*potentially require a coordinated international response*”, this definition implies the situation faced is a serious, sudden, unusual or unexpected situation that can give a huge insinuation to the public health beyond the State's national border and it may require immediate internal action [5]. In the situation of Covid-19, the PHEIC is significant to prevent the outbreak from affecting other countries with weak health system.

Due to rapid spreading of Covid-19 among the people, a lockdown has been implemented in several countries affected by the virus to disconnect the virus from spreading. The lockdown is divided into two categories which are the nationwide traffic restriction and stay at home movement [6]. Hence, many sectors were advised to stop their operations and services during the lockdown including the construction sector [7]. In Malaysia's situation, the Covid-19 is not as worse as in United State of

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America (USA), Russia, United Kingdom, Brazil, Spain, Italy and China. However, tight measures have been implemented by the Malaysia government to prevent this pandemic from wide spreading. Like other countries, Malaysia has also implemented nationwide traffic restriction and stay at home order since 18th March 2020 until this date (RMCO). The government has imposed restriction in term of movement control order (MCO) with a special standard operation procedure (SOP) and not a tight lockdown as China's.

Furthermore, Covid-19 pandemic is not just affecting human health but also bringing the economy to the worst level where all the industry was severely hit. Therefore, construction activities were also facing project suspension and cancellation due to shortage of materials, equipment and parts because of the lockdown. Hence, most of the supplier had to close their businesses and they cannot deliver the requested materials during that time. Moreover, there are several consequences of lockdown to the construction industry as recorded in United State of America (USA) in term of time, cost, resource availability and construction worker layoff [8]. As for Malaysia, the government has also halted all construction progress within MCO phase 1 to phase 3.

In line with the issue, this paper intends to explore the consequences of the Movement Control Order (MCO) towards the project success in Malaysia's context. Hence, this paper will be explaining the theoretical background about the movement control order (MCO) and the related project success factors. Then, methodology used for this study will also be enlighten, followed by the findings, discussions and the conclusion for this study. It is important to acknowledge the consequences of the MCO towards project success because the result from this study will assist the government and industry to plan a post-Covid-19 roadmap to enhance the construction industry in the future specifically to overcome the issues of the consequences among affected construction players like contractor.

2. Theoretical Background

This section provides a theoretical background for the paper. The first part discusses the Movement Control Order in Malaysia's context, followed by the literature of project success and the current state of the Malaysian construction industry.

2.1. Lockdown Alternative in Malaysia: Movement Control Order (MCO)

Movement Control Order (MCO) known as *cordon sanitaire* refers to the restriction on the people movement from one place to another either locally or internationally which can cause spreading of unexpected disease or viruses. This movement control has been used as a preventive measure to stop the spreading of unwanted diseases or viruses. Moreover, the MCO in Malaysia was enforced under the Control and Prevention of Infectious Diseases Act 1988 and the Police Act 1967 [9]. In Malaysia, the government has implemented four (4) types of MCO as this date according to the situation needed with differing Standard of Operation (SOP) which are;

2.1.1. Movement Control Order (MCO)

MCO applied nationwide in Malaysia where most of the main sectors are not allowed to operate during this time and most of the workers are encouraged to work from home or stay at home to

minimize the virus transmission started from 18th March until 28th April 2020 in three phases with every phase allocating 14 days of quarantine time [10]. To ensure the MCO successfully breaks the chain of Covid-19, there are six (6) restrictions or orders imposed during the MCOs period which are [9];

- Complete restriction of movement and gatherings nationwide, including religious activities, sports, social and cultural events. To enforce this restriction, all houses of worship and business premises are to be closed, except supermarkets, public markets, sundry shops and convenience stores selling essential goods.
- Complete travel restriction for all Malaysians going overseas and mandatory to undergo health checks and voluntary self-quarantine for 14 days.
- Complete restriction to foreign visitors and tourists into Malaysia.
- Closing of all kindergartens, public and private schools including day schools and residential schools, international schools, Tahfiz centres and all other institutions of learning in primary, secondary and pre-university levels
- Closing of all public and private institutions of higher learning nationwide including skills training institutes.
- Closing of all government and private premises except those involved in essential services such as water, electricity, energy, telecommunications, post, transportation, irrigation, oil, gas fuel, lubricants, broadcasting, finance, banking, health, pharmacy, fire prevention, prisons, ports, airports, security, defence, cleaning, food supply & retail.

2.1.2. Enhanced MCO (EMCO)

This EMCO phase started from 27th March and it only applied within certain areas with high cases of Covid-19 such as in Simpang Renggam, Johor; Sungai Lui, Selangor; City One, Kuala Lumpur; Selangor Mansion and Malayan Mansion, Kuala Lumpur; Jalan Masjid India, Kuala Lumpur and Wholesale Market in Selayang. In this EMCO, the government has announced this control to curb the spreading of the Covid-19 as well as to make it easier for the authorities to trace the cases unit by unit throughout the EMCO period. Therefore, the government has categorised the affected area in three colour zoning (red zone, yellow zone and green zone) as a differentiation to show the level of the affected area according to the numbers of Covid-19 active cases recorded. The red zone represents the area with more than 41 cases recorded and will be designated as EMCO area for fourteen (14) days or until the cases reduced to satisfied level. Meanwhile, for the yellow zone, it represents areas that recorded cases within 1-40 cases and for the green zone, represent "zero" cases area. There are a few accomplishments in the EMCO which are;

- All residents are prohibited from exiting the EMCO area throughout the EMCO.
- All non-residents and visitors are prohibited from entering the area throughout the EMCO
- All business activities are to be closed, except for the shops selling daily essential items in buildings
- Residents are allowed to use food delivery services
- A medical base will set up in the EMCO area.
- All in and out points of the EMCO will be sealed.

- The Royal Malaysian Police (PDRM), Malaysian Armed Forces (ATM), Angkatan Pertahanan Awam (APM) and Jabatan Sukarelawan Malaysia (RELA) will act as administrators in the EMCO area.

2.1.3. Conditional MCO (CMCO)

Then, after the number of new Covid-19 cases have dropped to below 100 cases per day, the government has announced Conditional MCO (CMCO) as Phase 4 MCO starting on 4th May 2020 until 9th June 2020 [11], seeing a more relaxed implementation of CMCO regulation compared to the previous MCO regulations where certain sectors are allowed to reopen their business. The main purpose of this CMCO is to help the government regenerate and regain the momentum of Malaysia's economy, a step up from essential sectors only previously. Thus, starting 4th May 2020, the sectors that have obtained the permission to reopen their business from MITI (Ministry of International Trade and Industry) are allowed to operate but with a tight SOP (Standard Operational Procedures) determined by the government. There are few conditions and requirements that need to be fulfilled by the employers and employees in preventing the virus from spreading in their workplace including the construction sectors. According to the Prime Minister, within the MCO phase 1 to phase 3 period, the government has lost around RM 2.4 billion per day, meaning the total losses is around RM63 billion until 1st May 2020 and if the MCO continues for one more month, the overall total losses will reach RM98 billion [11]. Related to that, the construction sector also estimated about RM 11.6 billion per day in losses as stated by Minister of Work Department, Dato' Sri Hj Fadillah in *Bernama TV* interview session on 5th May 2020. Therefore, the implementation of CMCO is important for the government and industry to generate income but the prevention of the Covid-19 from spreading is still highly prioritised.

2.1.4. Recovery MCO (RMCO)

Starting on 10th June until 31st August 2020, the RMCO will take over as an exit strategy for the MCO and CMCO, where in this phase more economic sectors are allowed to be operated, sport and recreational as well as domestic travelling also are allowed but with a tight SOP. Moreover, education sectors are starting to gradually reopen in phases as in 24th June, only form 5 and 6 starts their school session while kindergarten will reopen on July, 1st. In the construction industry, the RMCO facilitated the industry to increase their productivity to produce sufficient construction materials to be supplied, as more skilled workers and working time returns back to normal.

Somehow, the MCOs, as well as the CMCO and RMCO with tight SOP, hugely impacted the construction industry either the established companies or small and medium companies. The consequences are not only related to the financial aspects but also impacting the project success as well as the project performance. Due to that, the productivity of the project performance has dropped and to deliver a project is seen to be hard during this time.

2.2. Project Success

In defining the project success, it is vital to clearly understand the terms of project success to avoid misleading information to this study. The definition of a project success is broad, ambiguous and subjective [12–14] as well as multidimensional in concepts [14–

16] based on the process and the nature of the project [17]. Project success is frequently defined by the previous authors as the achievement of the project's objective, which in construction development, the project can be classified as project success when it efficiently achieved the iron triangle of time, cost, and scope or quality of the project outcome [18–20]. Moreover, [21] has defined "success" as the accomplishment of an aim in which the outcome is favourable.

Meanwhile, [22] expressed that project success is an accumulation of factors such as timely completion, within the budget, according to the specification and customer satisfaction. Then, [23] have defined the project success according to the project level where the project duration, monetary cost (budgeting) and project performance are highlighted as the key project success in their perspective. Additionally, there are a variety of factors that contribute to the project success other than factors mentioned above which the factors are according to the specific objectives for each of the projects such as safety, leadership, communication, teamwork, cognitive skill and so on [24]. Overall, project success is not just about completion of a project within the defined scope, time, and cost, nonetheless it is also about gaining the customer acceptance, stakeholder satisfaction, commercialization, and future project opportunity [25, 26]. Otherwise, for current construction industry, defining and measuring success lead to discussions on efficiency and effectiveness of the organizational, team and individual performance in managing the project lifecycle [18]. Despite that, there are different parties involved in a project such as the client, architect, contractor, and various surveyors and engineers which each of them will have his or her view of success according to their job scope [27]. Therefore, there is no common set of project success definition agreed yet due to the nature of the projects which are unique and differs widely in the practice.

According to the [25] there are two types of project success that needs to be precisely understood the differences between it; which are the project success "factors" and the project success "criteria". The *Project success factors* are related to the elements of a project that when it is influenced, it will increase the likelihood of success and act as the independent variables that make success more likely. Moreover, it is also referred to 'how to achieve' the project success [28]. Meanwhile, the *Project success criteria* is a measurement that used to judge on the success or failure of a project; these are the dependent variables that measures the success by focusing on "what to achieve" in the project. Besides, the success factors presence the inputs to the management system that directly or indirectly contribute to the success of a project, while success criteria are measures by which success of a project is judged [22]. Numerous previous studies on project success concentrated on identifying the success factors rather than success criteria as their subject because it is important to identify the success factors for a project before establishing which criteria should be used to judge or determine the project success [29]. Due to this explanation, this study indicates that the project success factors are the relevant type to be studied in this research because at the end of this research, the outcome will contribute to the body of knowledge for the industry and the government on what factors are affected due to the MCO in delivering a successful project; beneficial for them to overcome the issue based on the factors produced by this study.

Besides the listed project success factors as discussed above, the safety and health condition either the workers or the environment of construction sites and regulatory compliance should be one of the factors in successfully deliver the project

according to the current situation faced. It is because to ensure the project can be operated as usual without distressed project progress, the construction players need to play important roles in closely implementing the SOP announced by the government.

2.3. Current Situation in Malaysia Construction Industry

On 13th of April 2020, the Prime Minister has announced that the main services including construction sector is allowed to operate during the CMCO but with a strict SOP [11]. Later on 30th May, there are 28 of workers affected by Covid-19 in a construction site located in Jalan Ampang [30]. Hence, to overcome the spreading of Covid-19 in construction site while still be in full operation, the government has declared a specific SOP for construction sectors on 1st May 2020 stated under Act 520. This SOP also applicable for all construction sector related professional services (Quantity surveyor, engineers, architect firm etc.). Moreover, in the SOP, the developers and contractors are fully responsible to ensure their site workers and staffs follows all the terms and conditions particularly to keep the workers' health and hygiene as a priority. Besides, any violation of the SOP will cause the construction site to be closed.

As at 15th May 2020, CIDB has declared that within 20th April to 18th May 2020, there are 515 or 11% of the construction site in the whole Malaysia successfully complied to the SOP, meanwhile, 167 (4%) are non-compliance (warning notice) and seven (7) are ordered to be closed. Besides, there are 3,870 (85%) construction sites still not resuming their project at that time. Furthermore, as recorded on 22nd June 2020 through CIDB Telegram Channel, the operating construction site increased to 2245 (84%). Meanwhile, 437 (16%) construction site were issued warning notice and 19 (1%) of the construction site are ordered to be closed because of SOP non-compliance such as not implementing Covid-19 screening tests for the workers, not registered with CIDB, does not provide Covid-19 health supervisor and 90% not practising the SOP properly in the construction site. From the increment of the project which is successfully compliance to SOP, it was proven that the construction players have a good awareness and understanding regarding to SOP imposed by the government.

There are 15 actions highlighted by the government in the SOP for construction industry including the (1) Preparation of information and Documentation for the project (2) Workers management (3) Workers transportation vehicle (4) Workers movement (in-out construction site) (5) transportation of construction materials and supplies (6) Information blasting and awareness regarding the SOP in construction site (7) Emergency management and response (8) contact tracing (9) the entrance of the construction site/premise (10) Compliance that need to be implement while carrying out construction work (11) Toilet management (12) Time-break management (13) Procedure for returning from work (14) Accommodation at construction site/premises and (15) Record all the related data in for SOP compliance as required by the government [31].

Starting from the first phase until the third phase of MCO most of the construction site is directed to be closed by the government for approximately 6 weeks except for critical development categories. Due to this, most of the project schedule is interrupted and causes delay in delivering the project. The delay is not only related to the project progress on site; it also affected the suppliers who deliver the materials due to the restricted movement from one place to another place. The machinery availability is also limited and this caused hectic to the construction players. To overcome the

lagging progress, extra work from all parties, additional time and cost should be prepared by the developers and contractors. Additionally, the limited number of workers are allowed to work on-site in conjunction with the social distancing hugely impacted the project's progress as well as productivity. In getting more precise information regarding the current scenario of the construction industry in Malaysia and the consequences that the construction players are facing now, this research is essential to be explored.

3. Methodology

In producing accurate and apparent data, a qualitative method of research was used for this study. A qualitative method chosen for this study is due to the appropriate method in collecting the data where the respondents experience the issue or problem under the study and the data was produced subjectively from their minds [32]. A stratified random sampling technique was used in this study in which simple random subsample was taken from different strata in the same or equal characteristic [33]. This technique is less in error and enhanced the precision of the sample selection. In this case, the population of this study is Malaysian construction players and the strata consists of contractors. Then, for subsample selection, a simple random sampling is used for each of the strata group. This study was conducted in Klang Valley and Penang where both of these areas are currently active in developing new construction project.

Table 1: Respondents Profile

Respondents	R1	R2	R3	R4	R5	R6	R7	R8
Designation	Contractor	Contractor	Contractor	Contractor	Contractor	Contractor	Contractor	Contractor
Years of Experience	5	10	20	10	15	1	7	10
Current Project	Housing	Housing	Housing	Housing	Housing	Housing	Housing	Housing
Expected Completion Time Before MCO	3 y	3 y	4y	8m	3.5y	3.2y	4y	4y
Expected Cost Before MCO (RM'000)	50	900	1.5 mil	470	1.5 mil	130 mil	NA	42 mil
Expected Completion Time After MCO	TBA	3.2y	4.6y	11m	4y	3.5y	4.7m	4.4y
Expected Cost After MCO (RM'000)	70	900	1.51 mil	611	1.8 mil	132 mil	Increase 20% from previous	42 mil

Due to the MCO, most of the construction company halted the construction activities and the employees are encouraged to work from home. Hence, the telephone conversation is selected as the medium for interviewing them. Before conducting the interview, the researchers have set the eligibility criteria of the respondent for this study such as respondents is a contractor, have an active project, involved in the construction project in Klang Valley and Penang, and registered with CIDB. Firstly, the researchers had selected a few companies through CIDB website, then the researchers browsed the selected company's website to identify their on-going project. After being satisfied with the criteria, the invitation email was sent to the respondents using their registered email in CIDB website. From 20 emails sent out, only 8 contractors gave feedback and willing to be part of this study. According to [34], the amount of the useable data obtained from each respondent is more important than the number of the participants in which the greater the amount of useable, the fewer the number of participants is needed. It also supported by [35] where the number of interviews between five and twenty-five interviews is enough to understand about their experience in that situation. Hence, eight respondents are adequate in getting feedback related to this study. Table 1 shows the respondents' profile.

An exploratory study has been conducted in this study by using semi-structured interview with the contractors based on their experience during the MCO. There are 17 questions were developed by the researchers which were designed to allow respondents to express their opinion and experience freely during the interview session. The interview was divided into 3 sections involving the social demographic which includes working experience in the construction field, current project, expected completion date & total development cost before MCO and expected completion date & total development cost after MCO. The next section is to measure their understanding and awareness on the SOP for the construction industry during the MCO and RMCO. Then, the last section is about the consequences of the MCO towards project success. The duration for each of the interview session was about 30 to 40 minutes. The questions for the interview were developed based on the previous literature and focused on factors generated by the previous project success factors namely; time, cost, human resource, resource availability, safety prevention and regulatory compliance.

Then, the data obtained from the interview were analysed using content analysis which according to the [36] the data for qualitative mainly consist of words, which can have several meanings and could lead into wrong interpretation, therefore the content analysis is used because it can identifying the quote, coding the quotes and categorising the codes and also mapping approach being used to find the relationship between the different categories. Thus, content analysis was being used in this study to analyse the data gathered from the interview by using Nvivo Software. Nvivo Software can quickly run the frequent word in the script to find the same theme, provides word cloud and the connection between the theme can easily be identified. During the

telephone conversation, the researchers had recorded the interview session and the data was transcribed manually by the researchers. Then, the transcribed script was analysed using Nvivo which then the results are based on the highest theme that shows in the shape of boxes. The bigger box shows the high consequences event and vice versa. From the content analysis, this study found that there are 6 themes listed as the main consequences' factors of the MCO towards the project success.

4. Finding and Discussion

From the consequences of the MCO towards project success, this paper has classified the consequences into two which are in the perspective of *negative* where the factors turns the project to not achieving the success and *positive* views for the factors that help the project successful delivered because it is important to address both of these views to help the government, industry and construction players understand the current scenario as well as to guide them for planning post-Covid-19 for the industry.

4.1. General Consequences of MCO

From the content analysis, 6 themes were emerged from this study. These themes were further grouped into two general themes which are negative consequences and positive consequences of MCO towards the project success. The following findings and discussions are structured around themes that were mentioned by respondents as shown in Table 2. Meanwhile, the subthemes were considered as the factors influencing the theme in achieving the project success was shown in Figure 1 as the conceptual framework for this study. The first theme that was identified was time, which consists of delay on hand overring the project due to delay in material supplying, changing in work breakdown as well as rescheduling the project timeline because of time-lapsed during the MCO period. Cost emerged as the second theme, comprised of cost in providing hygiene kits (face mask, hand sanitizer, soap), Covid-19 tests for workers, cost in appointing Covid-19 Health Supervisor to oversee Covid-19 prevention on-site and cost in providing transportation for the workers to promote social distancing among the workers. Then, the safety aspect becomes the third theme with several subthemes which are significant in preventing the workers from the pandemic cluster like compulsory recording the daily temperature, social distancing, Covid-19 test for all foreign workers, workers management (movement, arrangement, job scope), workers hygiene, contact tracing, break time management, worker's residential management and regularly educate the workers about the pandemic. The fourth theme is related to the regulatory compliance which is the most significant in ensuring the project can be operated and the authority reserves the right to authorize or terminate the site due to noncompliance of SOP. The human resource theme consisted of the level of workers expertise (skilled, semi-skilled and unskilled), limited of workers at any one time at the same space, low productivity due to limited workers and working time as well as the termination of workers to reduce the project cost. The final and the sixth theme that was observed was the resource availability in the market and site which are limited including the material, equipment as well as skilled workers.

Table 2: The Results of the Consequences of MCO towards Project Success

Respondent	TIME				COST				SAFETY								REGULATION COMPLIANCE		HUMAN RESOURCES				RESOURCE AVAILABILITY		
	DP	RE	DM	BR	HK	COV	HS	TR	DT	SD	COV2	WM	WH	CT	TBM	WRM	EDU	FULL	VIS	WE	LW	LP	WL	LME	LSW
R1	/	/	/		/	/	/		/	/	/	/	/		/	/	/	/	/	/	/			/	/
R2	/	/			/	/			/	/	/	/	/	/	/			/	/		/	/			/
R3	/	/	/		/	/			/	/			/					/	/		/	/		/	
R4	/	/	/		/	/	/		/	/	/				/	/		/	/	/	/	/		/	
R5	/	/	/		/	/		/	/	/	/	/						/	/	/	/	/		/	
R6	/			/	/	/	/		/	/		/	/	/			/	/	/	/		/	/	/	/
R7	/	/		/	/	/	/	/	/	/	/			/				/	/	/	/	/		/	/
R8	/	/		/	/	/			/		/	/		/	/	/		/	/	/	/		/	/	/
TOTAL	8	7	4	3	8	8	4	2	8	7	6	5	4	4	4	3	2	8	8	6	7	6	2	7	5

Subthemes	Abb.
Delay on hand overring the project	DP
Rescheduling the project	RE
Delay on material supply	DM
Change the work breakdown	BR
Cost for providing hygiene kit (face mask, hand sanitizer, soap)	HK
Covid-19 test	COV
Cost appointing the Covid-19 Health Supervisor	HS
Providing worker's transportation	TR
Daily Temperature	DT
Social distancing	SD
Covid-19 test for all foreign workers	COV2
Workers management (movement, arrangement, job scope)	WM
Workers hygiene	WH

Subthemes	Abb.
Contact tracing	CT
Time break management	TBM
Worker's residential management	WRM
Educate the workers about the pandemic	EDU
Fully compliance the SOP regulation	FULL
An unexpected visit from the authority	VIS
Workers expertise	WE
Limited workers	LW
Low productivity	LP
Workers layoff/termination	WL
Limited material & equipment in the market and on-site	LME
Limited Skill workers	LSW

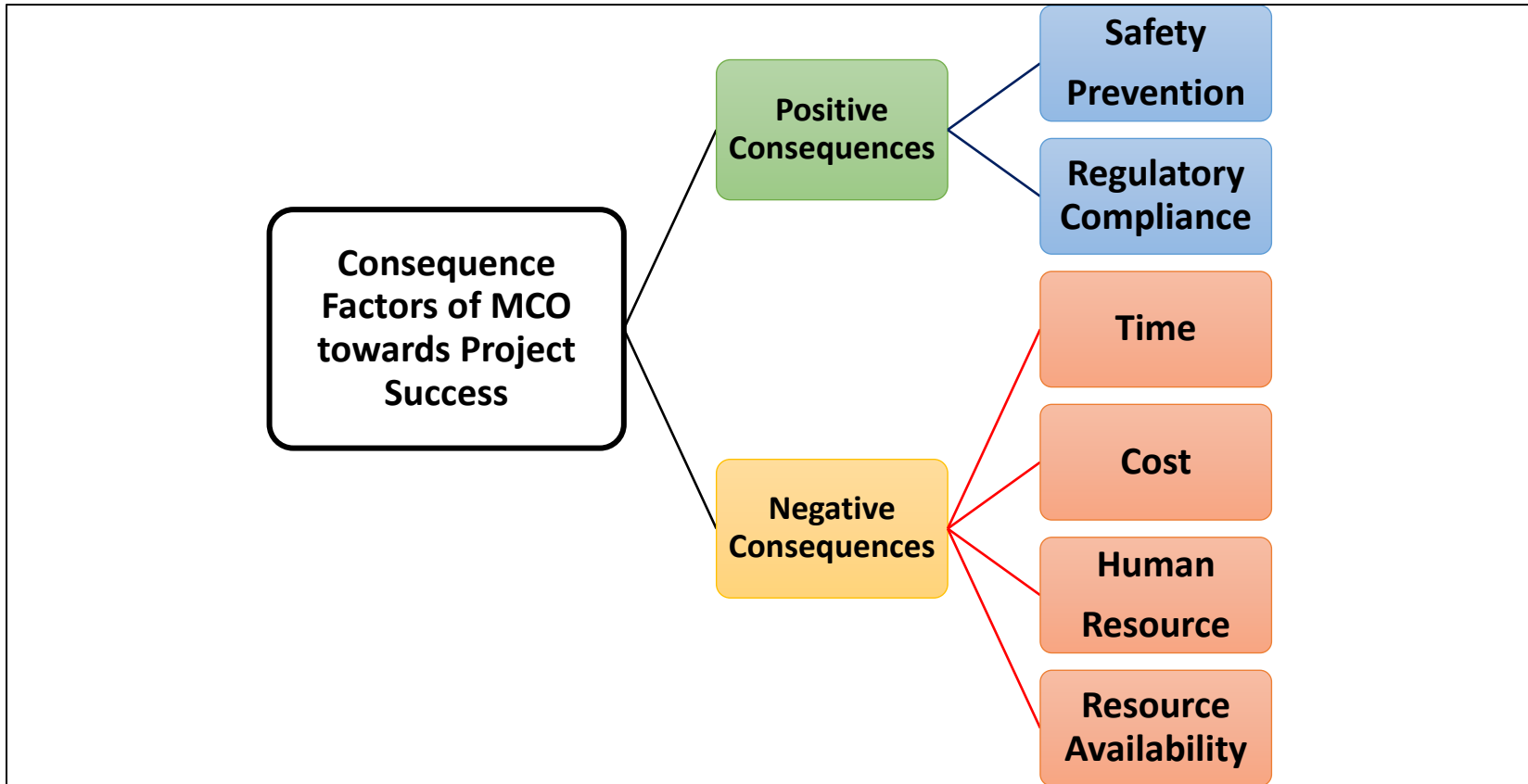


Figure 1: The Conceptual Framework of Consequences of MCO towards Project Success

4.2. Negative Consequences

The consequences of the MCO towards the project success gave negative impact mainly to (i) time, (ii) cost, (iii) human resources and (iv) resource availability in the market as well as on-site. Therefore, the construction players and government need to give more attention to these negative consequences factors in order to overcome the project delay, project losses and to optimize the project timeline and the project performance.

4.2.1. Time

Time is considered as one of the main factors that gave high impact to the project success, the project is considered successful when it can be delivered on time to the client within the budget and good in quality [37,38]. In the event of any delay, it will cause an extension of time and rise in cost, in which the project failed to achieve the success [25]. In regard to time, it has found that the MCO has delayed the handing over of the project to the client and this were affected by several issues like delayed material supply due to the manufacturers halting their business, as well as the supplier, cannot across the state or region during the MCO period. Due to that, the contractors need to reschedule the project timeline and change the work breakdown which invited stress among the contractors to fulfil the client requirement with tight budgeting in limited working time. Somehow, there are respondents mentioning that they are facing the extended time in their project of 2 to 7 months to complete the project development. As quoted by most of the respondents regarding the consequences of time during the MCO in Malaysia such as;

Respondent’s Feedback on Consequences of Time – Delay & Extended of time
“delay on hand over the project, delay on material supply most of the work breakdown need to change and rearrange the time schedule”
“it’s important to cover all the previous delay work”
“difficulties to hand over the project which delayed 2 months from the actual delivery time”
“our project delay for 2 months from the previous completion time”
“project timeline due to the limited time in term of working hours, material delivery and number of workers allowed in any one time. So, the project will be delayed for about 7 months from the actual timeline”

4.2.2. Cost

In term of cost, the respondents have mentioned that they are facing cost increment between RM 100,000 to RM 300,000 for their housing project of which 2 respondents facing a huge cost increment due to their big project involving the development of public project housing under Armed Forces. Meanwhile, another 4 respondents are involved in affordable housing project. Moreover, there are 2 respondents remaining at the same cost as the previous costing before the MCO because their project is already at the final stage therefore not much work to revise. Based on the respondent's feedback, the increment of the project costing because of two additional requirements highlighted in the SOP, the first cause is providing all the workers with face mask, hand sanitizer, keeping the site in good hygiene also cost of regularly sanitize the areas frequently used by the workers. Then, the

second cause is related to Covid-19 tests that is compulsory to the workers especially the foreign workers before resuming their work on-site. Furthermore, 4 of respondents mentioned that appointing a Covid-19 team or health supervisor in the construction site will also increase the cost of their project. Below is the respondent’s explanation regarding the consequences of MCO towards the costing aspect in construction project;

Respondent’s Feedback on Consequences of Cost – Provide the workers with safety kits
“We also need to provide face mask, hand sanitizer and hand soap to promote hygiene among the workers, but the cost of providing the face mask is high due to daily usage”
“increased total development cost from the original because according to the SOP we need to provide face mask, hand sanitizer”
Respondent’s Feedback on Consequences of Cost – Provide the workers with Covid-19 Test
“The most influential cost aspect is COVID-19 tests for the workers especially the foreign worker, you already know that the price for 1 test per person is between RM 150 to RM 300, so if we have about 20 persons foreign workers, so it will cost us a lot”
“running Covid-19 test to all workers especially the foreign workers before we resume work on site. The covid-19 test is expensive and you can calculate by yourself how many should we spend on that test if we have more than 10 workers, it will cost thousands of Ringgit Malaysia, huge cost”
Respondent’s Feedback on Consequences of Cost – Providing Health Supervisor/Covid-19 Team at site
“we also need to appoint a health-supervisor as representative to manage and monitor the safety on-site including to monitor our compliance with all the SOP. This will also be an additional cost that we need to bear”
“we also need to appoint a health supervisor on-site to monitor the regulation compliance among the staffs and labourers on-site who can update us on the daily SOP compliance on-site”

4.2.3 Human Resources

The third negative consequences of MCO towards project success is focused on human resource which included the limited numbers of workers and skilled workers allowed to work in one time in the same area or space in practicing social distancing among the workers. Due to that, it will give a negative impact to the project productivity, previously the workers managed to complete 30% to 50% of work in one area or space with a few workers in one day but for this current situation, the productivity slid down between 10% to 30% according to the project. Other than that, the MCO also causes some of the unskilled workers layoff due to limited budget to hire them without any relevant skills. The skilled and semi-skilled workers are seen to be significant in this constricted project timeline [37].

Respondent’s Feedback on Consequences of Human Resource – Limited number of workers & Skilled workers
“limited number of workers allowed to work in one time to ensure the social distancing are implemented, this will affect the productivity of work per day and the daily percentage of project completion”
“the limited numbers of workers allowed to work in one time also get us headache because some work need lots of people in one time so we need to arrange it by minimizing the workers and job scope”

“to maintain our project financial, some of unskilled workers are laid off because we need a skilled worker to work faster and reduce the error risk”

4.2.4. Resource Availability

Finally, limited resource availability on-site and in the market such as manpower, materials and machinery are also a challenging situation during the MCO period and causes time as well as cost overrun. According to [37], the construction delays causing risks on time and cost are including the materials, manpower, plants and equipment, changes, scheduling and control as well as government relation which all of these are related to the MCO situation.

Respondent’s Feedback on Consequences of Resource Availability
“Resource are very limited in current situation due to the manufacturer are closed for a few weeks, so the supplier cannot get their sources and the limited resource in market has cause the price to go up. Other than that, the supplier also cannot deliver the exact amount that we need in one time because they need to get permission from the police before they can travel and deliver the material to us. So, we need to hold some of the work because of inadequate material”
“limitation on resource availability either in term of human, materials and machineries. All are interconnected by each other”

4.3. Positive Consequences

Besides the negative consequences of MCO, there are also positive consequences that give good impact to the construction industry. According to the respondents, all of them agreed that the MCO is a good initiative to disconnect the Covid-19 from spreading especially in the construction site where most of the time the social distancing and cleanliness are hard to practice. But, through this study, it can be seen that with the new SOP imposed by the government, changed the construction site into a better site and human resource management. The improvement of the safety practice aspect and the regulatory compliance by the construction players are the positive consequences that has been practised in the construction industry since the Covid-19 pandemic.

4.3.1. Safety Prevention

The safety in construction site is significant to ensure the site is free from hazards and to minimize the accidents in construction site [39]. At the same time, to increase the probability of project success, attention to construction safety need to be heightened in preventing the workers and other related parties from illness and accidents thus avoiding unnecessary cost and delays [40]. In the pandemic situation, every worker, supplier, staffs or any person who visited the construction site must be thermally scanned before entering the site. Moreover, the workers especially the foreign workers are compulsory to get Covid-19 test before they are allowed to work in construction site. Other than that, the contractor, as well as the construction workers, are responsible for managing the social distancing and hygiene in their construction site. In conjunction with that, the contractors practicing a proper workers’ residential, time-break schedule (to make sure the

canteen is not crowded in one time), worker’s transportation for purpose of social distancing and control the worker’s movement to minimize the spreading of the Covid-19.

Respondent’s Feedback on Consequences of Safety Prevention
“daily temperature must be recorded for all workers before entering the site”
“compulsory for covid-19 test for all workers before our project resume back as usual to prevent the pandemic”
“For daily check, the body temperature is recorded for all of the person working or entering the site including the worker, supplier, site clerk, engineer and other related parties”
“All foreign and local workers are compulsory to be tested for covid-19 before they are allowed to work”
“make a marked area for practicing social distancing in worker’s residential, café area, prayer room. We also record all the workers details and movements for contact tracing as well as the project detail”
“managing the workers on-site include managing their residential, time break scheduling, record all the movements and also provide transportation for our workers and we are strictly concerned regarding the hygiene”

4.3.2. Regulatory Compliance

In construction industry, the regulatory compliance is essential because failure to meet the regulation requirement means the project failed to meet the core requirement that has been decided [41]. In this research, it was found that this theme is significant in determining whether the construction site is allowed to operate or not because the authorities will randomly conduct an unexpected checking to the construction site and if the site is not properly implementing the SOP, their project will get warning notice or ordered to be closed. This tight regulation is good to practice in the construction industry to make sure all the construction workers and staffs are in a safe condition. The respondents also aware about the important to comply the SOP on the site.

Respondent’s Feedback on Consequences of Regulation Compliance
“This part is hard to comment because it was related to the government order, so like it or not we need to comply to the SOP for construction because once we agree with that SOP, we need to adhere to it. The authorities will visit our project in unexpected time so we need to always be ready in term of project details, project documentation, workers detail and move in and out parties in the site for contact tracing”
“if you comply to all the SOP so you will be safe even if the authorities make unexpected spot check to your site. Then, we need to prepare a proper documentation management to record the project detail and the workers. Actually, it is difficult to manage all this, but if you want to save your project like it or not you need to do it”

4.4. Discussion

Based on the 6 consequence factors that have been decided in this study, the regulatory compliance became the main factor to determine if the project either is allowed to continue to work or closed during this pandemic issue. Once the project is directed to be closed because of non-compliance of the SOP, the project will be facing delay, losses and the cost will keep increasing day by day and in the end the project will be stuck and abandoned. Hence, the regulatory compliance is essential in this pandemic situation.

Then, followed the safety prevention factors, in which the safety precaution is important to prevent the workers and the construction site from being a new cluster for spreading the virus. There are several preventive actions that has been introduced by the Ministry of Health in the SOP and this safety prevention is connected to the regulatory compliance. The awareness and understanding regarding these two issues are seen to be positive due to the number of projects allowed to operate is getting higher.

Another 4 factors such as time, cost, human resource and resource availability is turned to negative aspect during this pandemic issue due to the movement control order for 6 weeks. The project timeline and costing need to rescheduled and recalculated which caused extended time and increasing costs. However, the project will still need to be done even if it will stress the contractors and workers to deliver the project within the new adjusted time and cost. In conjunction with that, the low production by manufacturers for suppling the materials will cause an extension of time because there is higher demand but low in supply. It also happened to the supply of machinery and limited skilled workers in this hectic situation. Furthermore, the contractors need to be more particular with all the issues in the construction site to minimize the error in the project progress and at the same time comply to the SOP especially in practising social distancing, hygiene and worker's health. From the discussion above, the MCO has gave high impact to the 6 consequence factors mentioned above and the government should give due concern to all the factors to facilitate the construction players especially those categorized as small and medium construction companies because most of them are affected during this MCO.

Due to these 6 factors, there are still have a few factors that attached with these factors, but in this current situation only these 6 factors are mainly have given high influenced to the project either it can be successfully delivered or not. Thus, the limited information from the respondents also being the limitation in this research due to the telephone conversation which sometimes having distressing because of the noise, unfocused of respondents while answered the questions and no face reaction can be detected.

5. Conclusion and Future Work

Based on the negative and positive consequences recorded through the interview session, the MCO has given lots of hindrances to the construction players compared to the positive consequences on the project success. The extension of time in delivering the project, the increased project costing and limited resource have hastened the project to achieve the project success. Currently, to facilitate the construction industry survival in this critical situation especially for the small and medium contractors' companies, CIDB has announced "CIDB Prihatin Initiative" with nine (9) schemes such as deferment on the levy payment, deferment of construction personnel skill training and fee payment for skill competency assessment. Also, the compulsory requirement for Covid-19 test is a burden to the contractors because of its cost, however, on 23rd June 2020, the government facilitate by CIDB and SOCSO (Social Security Organization)

has launched a new initiative to help the construction players on this issue by providing them with a free Covid-19 test for the foreign workers especially for the small and medium construction company.

Through all the discussion in this paper, it can be concluded that MCO has given a lot of negative impacts towards the project success whereby the contributing factors to project success such as time, cost and resource availability are affected by the MCO. With limited additional time and tight budget has caused stress among the contractors especially for the project that needs more than RM 100,000 additional cost to complete their project (Refer Table 1). In another view, MCO has taught people about the self-care in preventing the Covid-19 especially in term of regularly practising good hygiene and social distancing. At the same time, it was observed that the SOP compliance level amongst construction players is seen to be better and this new norm should be maintained in the construction industry to avoid the second wave of Covid-19 in Malaysia. For further works, this research will continue to be conducted on other construction players including the AEC (Architecture, Engineering and Construction) company in Malaysia to investigate the impact of MCO to their organization.

Conflict of Interest

The authors declare no conflict of interest.

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Strategic Model to Assess the Sustainability and Competitiveness of Focal Agri-Food Smes and their Supply Chains: A Vision Beyond COVID 19

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ABSTRACT

There have been disruptions in local and global food supply chains around the world due to the COVID-19 pandemic. It has led to rethink various aspects and to consider various trends in the food sector, encourage a more rapid transition and evolution to the Sustainable Supply Chain Management (SSCM), to counteract current problems and to help towards a more sustainable and competitive vision. However, there is a strategic disconnection in SSCM between sustainability and strategies related to competitive advantage. Therefore, the objective of this research is to propose a decision-making model to assess the sustainability and competitiveness strategically of a Mexican agri-food focal SME (Small and Medium-sized Enterprise) that leads its supply chain. It is validated with comparative analysis in the productive taro activity through the Analytic Hierarchy Process (AHP) that contributes to prevent or to face problems such as the COVID-19 pandemic and climate change. This research is based on a case study methodology divided into four stages. Three presented alternatives are assessed and compared by thirty-five criteria: a) A current situation without sustainability, b) Cost leadership strategy considering sustainability, and c) Differentiation strategy considering sustainability. The conclusions indicate more feasibility and compatibility to achieve sustainability with a differentiation strategy than with a cost leadership strategy. The current crisis should lead us to think beyond COVID-19, as we have more challenges ahead, such as climate change, environmental impacts, poverty, among other aspects that could cause instability around the world. Therefore, the current situation should be an impetus to further progress towards the 17 Sustainable Development Goals, in this case, through the theory of SSCM. That is why this model contributes strategically to the SSCM, to develop greater long-term resilience in the Mexican agri-food focal SMEs and their supply chains.

1. Introduction

Currently, there are disruptions in both local and global food supply chains around the world due to the pandemic [1]-[3] caused by the new coronavirus [4], better known as COVID 19. It has led to thinking in various scientific fields and everyday life, as in the present manuscript, which contemplates the acceleration of various changes to move towards Sustainable Supply Chain Management (SSCM) and competitiveness, especially in the food

sector. Some adversities that have placed Mexico as one of the countries at the most significant risk to COVID-19 are obesity and overweight [5], mainly caused by poor nutrition from ultra-processed foods [6].

Also, this pandemic has exposed social deficiencies in textile supply chains by the ease of firing employees who have been subcontracted, violating their labor rights [7]. Therefore, after COVID-19, there will be challenges, opportunities, and potential solutions in agri-food supply chains considering some sustainable aspects, among which climate change stands out [8]. A climate shock would place food supply chains in vulnerable circumstances,

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exacerbating poverty, food insecurity, and the impact on the environment [9] aspects considered by the SSCM.

However, there are few studies on SSCM, especially on its environmental and social aspects [10], [11]. There is little implementation of the SSCM theory in emerging economies [12], [13], as in Mexico [14]. The SSCM theory also has several theoretical gaps derived from the disconnection between sustainability and strategies related to competitive advantage, known as this combination as Sustainable Competitive Advantage (SCA). SCA is challenging to evaluate and measure since there is no factual theoretical basis [15]. The poor results of the implementation of sustainable strategies to improve competitiveness [16] make it difficult to introduce them into regular SSCM practice [17].

In emerging countries, the SSCM practices adoption does not necessarily imply improved cost performance or short-term profitability [18]. Likewise, a case was found where clients do not necessarily accept higher prices for acquiring sustainable products [17]. Therefore, the SSCM theory seems to be incompatible in some cases between the economic part and the social and environmental parts [17]. That is, if sustainability is considered together with Porter's cost leadership strategy [19], there may not be compatible. Hence, this discordance is reflected in the supply chains of both large, and Small and Medium Enterprises (SMEs), with an even greater emphasis on emerging countries such as Mexico. As a result, decision making becomes a challenge at the strategic level in SSCM, since there are no well-established metrics, as pointed out in the literature review [20]. Therefore, the objective of the research is to propose a decision-making model to assess the sustainability and competitiveness strategically of a Mexican agri-food focal SME that leads its supply chain, validated with comparative analysis in the productive taro activity through the Analytic Hierarchy Process (AHP) that contributes to prevent or face problems such as the COVID-19 pandemic and climate change. It is expected that the results of the strategic model contribute with knowledge at a strategic level to the SSCM, in order to understand the generic strategies and their relationship with sustainability, demonstrating their possible compatibilities.

2. Literature review

2.1. Sustainable Supply Chain Management

Sustainability is a term derived from Sustainable Development, being an increasingly important instrument for economic growth. Sustainable Development is defined as [21]:

"A development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [21].

Sustainability must be taken into account in the design of supply chains [22]. Certain aspects of Supply Chain Management (SCM) are related to the environmental, social, and economic aspects of Sustainable Development, conceptualizing SSCM as [10]:

"The strategic, transparent integration and achievement of an organization's social, environmental, and economic goals in the systemic coordination of key interorganizational business

processes for improving the long-term economic performance of the individual company and its supply chains" [10].

That is why SSCM is based on long-term partnerships [23], even if these are difficult to achieve [24] and also costly [17]. Likewise, the level of interest in SSCM practices by companies or organizations is different and depends on what they are producing [25]. To replace SCM with SSCM, companies or organizations need both conventional performance criteria and sustainability requirements [11]. Besides, as it is known, both SCM and SSCM have three levels of planning; strategic planning, tactical planning, and operational planning [26], so when sustainability is integrated into SCM, it causes changes at each level, making strategic planning more relevant.

2.2. Sustainable Supply Chain Management and Competitiveness

On the one hand, there are no signs where competitiveness is strategically considered within the central SSCM literature reviews [20], [23]. On the other hand, the theory of Creating Shared Value (CSV) [27] from the theory of Competitive Advantage [19] does not consider sustainability in-depth, nor does it consider external pressures. However, it has happened that legal norms and sanctions applied (external pressures) to companies become the primary motivations for companies to implement SSCM initiatives [28], which contradicts the internal motivation of the companies [27]. Furthermore, CSV, a relatively new theory, focuses more on large companies, even multinationals, leaving considerable research opportunities in SMEs.

Hence, this research proposes a model for Mexican agri-food focal SMEs that integrates sustainable and competitive strategies within the SSCM theory. These strategies will be based on Porter's two generic strategies [19]: 1) Cost leadership; consists of low costs and economies of scale, and 2) Differentiation; consists of being unique in some value need for clients. It is essential to clarify that it is challenging to achieve a low-cost and differentiation strategy simultaneously, although this does not mean that it is impossible [19].

2.3. Analytic Hierarchy Process and Supply Chains

The AHP is a general theory of measurement developed by Saaty in 1971-1975; this method is used to make a consistent measurement of physical and psychological events, giving them equal importance without sacrificing anything [29]. Therefore, the AHP is a technique for decision making where certain situations with ideas, feelings, and emotions are quantified, which affect the decision-making process, thus obtaining a numerical scale to prioritize the decision alternatives [30].

This tool has also been applied in various areas such as assessment of risk factors in agriculture [31]; natural resources management [32]; location of an SME [33]; benchmarking [34]; among others. According to the literature review [35], there are no applications of AHP for strategic decision-making in sustainable agri-food supply chain models.

2.4. The Sustainable Supply Chain and Mexican Agri-food SMEs

The percentage of SMEs in Mexico is 99.8%, contributing 34.7% to the Gross Domestic Product (GDP) and creating 73.8%

of jobs [36], [37]. The productivity of SMEs is at a lower level than expected, so their entry into the international market and their permanence in the local or national market is difficult [37] due to changes in globalization. Therefore, in order to improve the SMEs, it is necessary to provide strategies that contribute to the current economic panorama, since there are companies where a conservative attitude persists, waiting to introduce structural changes [38].

The performance of focal companies in encouraging sustainable supply chains is vital because they drive and govern the supply chain [23]. There are few studies of Mexican agri-food focus companies that lead a sustainable supply chain [14]. It is normal since, SSCM theory is in an early stage of research [11]. However, some research has been found in the Mexican agri-food sector that includes only aspects of sustainability without considering supply chains, where they show how to develop sustainable enterprises through local networks of eco-farmers [39]. Likewise, the implications of fair trade and inclusion of local people in cooperatives or farmers' associations, trying to connect producers directly with clients [40]. Other studies have a more theoretical scope, a model [41] and a methodological proposal [42], focusing on sustainable agri-food SMEs without considering supply chains. In other words, agribusinesses still individualize their efforts without realizing that they are part of a supply chain.

In Mexico, there are studies on Clean Production and SMEs that contribute to the theory of SSCM. These point out that SMEs mostly play the role of suppliers for large companies; that is, they are not leaders in supply chains, so they are not focal companies [43]- [46]. However, there are projects that try to include the local population in competitive businesses with environmental and social aspects [47], [48]. Nevertheless, according to a literature review in [14], all these attempts are still far from achieving sustainability [14].

2.5. The malanga (*Colocasia esculenta*) production

The malanga, taro or *Colocasia esculenta*, is a plant that is cultivated for its corms, which are used in human and animal food and has various industrial uses [49], [50].

There are several ways to transform malanga into food; regional nutritionists have even recommended it as a valuable food; however, more in-depth research is required [51]. One of the most remarkable ways to consume it is in the meal. The nutritional value that taro provides through a meal is highlighted in a study [52], where it is obtained that according to fiber fractions, the meal is an alternative for the elaboration of balanced foods.

The volume of national production in 2015 was 16,552,000 kilograms, equivalent to \$66,364,000 national current pesos, and the price was 15,800 Mexican pesos per thousand kilograms [53]. The leading producers are in the states of Oaxaca, Tabasco, and Veracruz [54]. Mexican malanga production is used for self-consumption and is sold to the domestic market [54] and the United States and Canada [54], [55].

3. Methodology

Several research methods are used in SSCM theory, as SSCM is at an early stage, these methods are seen as a complement to others to gain diverse theoretical perspectives [11]. This study is

mainly based on the case study methodology [56], to research a phenomenon in its context. It allows selecting and studying an economically successful Mexican agri-food focal SME within its productive activity to relate its situation to the theoretical gaps and thus propose a strategic decision-making model.

Three experts participate in the development of this methodology and model. They propose the following four methodological stages through Figure 1.

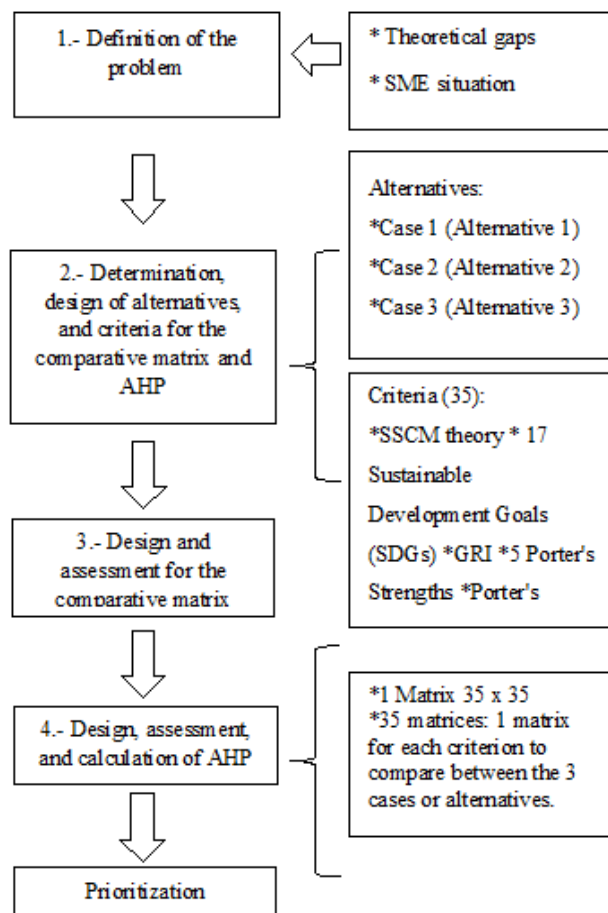


Figure 1: Methodological scheme.

Stage 1. Definition of the problem: It consists of creating a team of experts to know the essential characteristics of the company and to define the problem theoretically.

This research was carried out in a Mexican agri-food focal SME that leads its supply chain in the productive taro activity. This Veracruz-based company, the most economically successful one, is classified in Mexico as a medium-sized company by its number of employees [57], so it is also classified as an SME.

According to the information collected, this SME has been developed without any planning of strategies without considering competitive and sustainable strategies. The collaboration between the members of its supply chain is not ideal, so it is far from being a sustainable supply chain. This SME does not have a generic strategy, according to Porter's positioning matrix [19]. However, this company involuntarily competes with low prices to perform its exports; it is based on a cost leadership strategy. Its competitive situation is threatened when other competitors replace taro with

lower prices in the foreign market. For this reason, a model is designed to integrate strategies of competitiveness and sustainability, and then be assessed with the AHP.

Stage 2. Determination, design of alternatives, and criteria for the comparative matrix and AHP: It consists of identifying the alternatives and criteria used in the AHP methodology. In this stage, the participation of experts is essential to provide feedback and consensus on the alternatives and criteria used in strategic, competitive, sustainable, and SSCM issues.

Stage 3. Design and assessment for the comparative matrix: It is a based analysis process on the logic of the experts, to compare two or more cases, to assimilate their reciprocal differences so that the attributes or criteria for comparing the case studies are established in [58], [59]. In this research, the case studies are considered as alternatives. Each attribute or criterion is assigned a weight or percentage value and then a value from 1 to 5 (1. Very low, 2. Low, 3. Medium, 4. High, 5. Very high) between each case and each criterion.

Stage 4. Design, assessment, and calculation of AHP: The matrix is designed to develop the calculations of AHP [60], the determined criteria are compared $A_1...A_n$ with their respective weights $w_1, ..., w_n$, this allows to formalize a square matrix, as shown in Figure 2:

$$A = \begin{matrix} & \begin{matrix} A_1 & A_2 & \dots & A_n \end{matrix} \\ \begin{matrix} A_1 \\ A_2 \\ \vdots \\ A_n \end{matrix} & \begin{matrix} w_1/w_1 & w_1/w_2 & \dots & w_1/w_n \\ w_2/w_1 & w_2/w_2 & & w_2/w_n \\ \vdots & \vdots & & \vdots \\ w_n/w_1 & w_n/w_2 & & w_n/w_n \end{matrix} \end{matrix}$$

Figure 2: Square matrix. Source: Saaty [60].

The Saaty scale is used to assign the weights for each criterion [61, 62], shown in Table 1.

Table 1: AHP Fundamental Scale. Source: Saaty [61], [62].

Intensity of importance	Definition	Explanation
1	Equally important.	Both elements contribute equally to ownership or judgment.
3	Moderately more important one element than the other.	Judgment and prior experience favor one element over the other.
5	Strongly more important one element than the other.	Judgment and prior experience favor one element over the other strongly.
7	Much more vital importance of one element over the other.	One element dominates strongly. Its dominance is proven in practice.
9	The extreme importance of one element over the other.	One element dominates the other with the most significant possible order of magnitude.

The values 2, 4, 6 and 8 are used when the degree of importance is intermediate between two odd numbers in the scale; and when the definition and explanation, is inverted, the reciprocal values of the scale are used (1/2, 1/3, 1/4, 1/5...1/9) [61], [62].

Then, Equation 1, because it is a reciprocal matrix, has positive inputs, that is, $aji = 1/aij$. So, if this matrix is multiplied by the transposition of the vector $wT = (w_1, \dots, w_n)$, the vector nw is obtained. In this way, Equation 1 is obtained:

$$Aw = nw \tag{1}$$

However, with the Saaty technique, it is only possible to work with a limited number of "n" criteria [61], [62]; for that reason, the Alonso and Lamata's technique [63], [64] is used since it allows to work with a matrix that has a more significant number of "n" criteria, allowing different degrees "α," to fulfill the requirement of consistency of the AHP technique.

3.1. Proposed model

Figure 3 shows the sequence of the proposed model, designed for SMEs through the productive taro activity, applied in a medium-sized company. This model, through the AHP technique, assesses the sustainability and competitiveness strategically of a Mexican agri-food focal SME that is the leader of its supply chain in the productive taro activity.

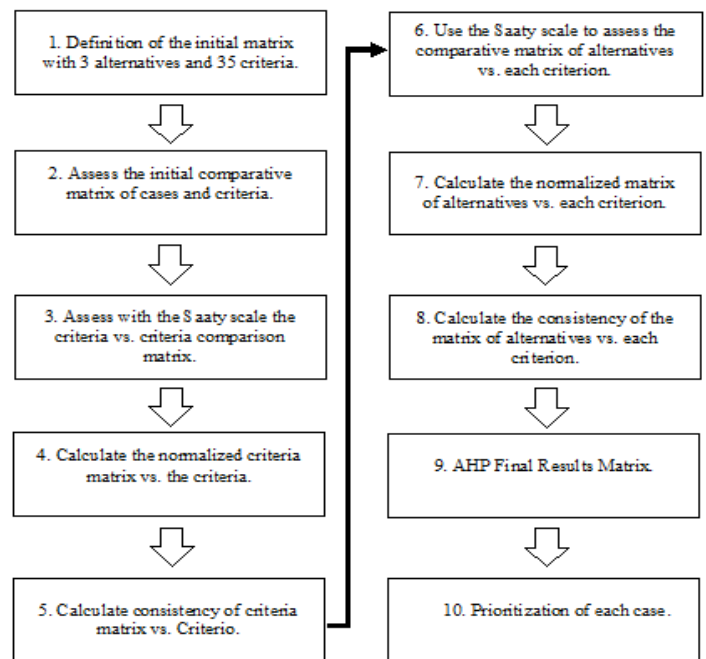


Table 2: Model alternatives or cases.

Alternatives (Cases)		
Alternative 1	Alternative 2	Alternative 3
a) The current state without sustainability (Case 1)	b) Cost leadership strategy with the possibility of sustainability (Case 2)	c) Differentiation strategy with the possibility of sustainability (Case 3)

Step 1. Definition of the initial matrix with three alternatives and 35 criteria.

Table 2 presents the three proposed alternatives, which represent three cases: a) case 1; it is the current state of the SME and its supply chain without considering sustainability, b) case 2; it is the strategy of cost leadership with the possibility of involving

sustainability and c) case 3; it is the strategy of differentiation with the possibility of involving sustainability. These last two alternatives are taken from Porter's two main generic strategies [19].

Table 3 shows the 35 criteria related to economic, competitive, environmental, social, and sustainable aspects from a strategic perspective. These criteria were determined and designed based on the five competitive forces [65], the Porter diamond [66], the SSCM theory [20], [23], the 17 Sustainable Development Goals [67] and the Sustainability Reporting Guidelines [68]. The authors selected these 35 criteria through an exhaustive analysis, representing the most updated and essential aspects of each theory. The theories reflected in these 35 criteria are SSCM, Competitive Advantage, and Sustainable Development.

Table 3: Classification of criteria.

Aspects	Criteria
Economic and competitive	C ₁ Scale Economies
	C ₂ Product differentiation
	C ₃ Brand positioning
	C ₄ Input differentiation
	C ₅ Impact of inputs on cost or differentiation
	C ₆ The relative price performance of substitutes
	C ₇ The propensity of buyers to substitute
	C ₈ High negotiating power of the buyer
	C ₉ Industry Rivalry (High, considering that the competition is international)
	C ₁₀ Low labor cost
	C ₁₁ Horizontal and vertical cooperation
	C ₁₂ Technology and Innovation
	C ₁₃ Administrative and production knowledge
	C ₁₄ Government policy (No intervention)
	C ₁₅ Consumer's level of acquisition
Environmental	C ₁₆ Materials
	C ₁₇ Energy
	C ₁₈ Water
	C ₁₉ Biodiversity
	C ₂₀ Emissions
	C ₂₁ Regulatory compliance and environmental standards
	C ₂₂ Supplier selection based on environmental performance
Social	C ₂₃ Labor Practices, Decent Work, Health and Safety at Work
	C ₂₄ Investment in training and education based on labor practices, human rights, and social impact
	C ₂₅ Diversity and equality of opportunity and redistribution
	C ₂₆ Supplier selection based on labor practices, human rights, and social impact

	C ₂₇	Child and forced labor
	C ₂₈	Rights of the indigenous population
	C ₂₉	Local communities
	C ₃₀	Fight against corruption
	C ₃₁	Regulatory compliance and social standards
	C ₃₂	Product Responsibility
	C ₃₃	Consumer Awareness of Sustainability
	C ₃₄	Food security, improved nutrition, and promotion of sustainable agriculture
	Sustainable	C ₃₅

Table 4 shows the initial matrix, which contains the three alternatives or cases, and the thirty-five criteria.

Table 4: Initial matrix.

Criteria	Alternatives (Cases)		
	a) Alternative 1 (Case 1)	b) Alternative 2 (Case 2)	c) Alternative 3 (Case 3)
	a) The current state without sustainability	b) Cost leadership strategy with the possibility of sustainability	(Case 2) c) Differentiation strategy with the possibility of sustainability
C ₁	Assessment 1/a	Assessment 1/b	Assessment 1/c
C ₂	Assessment 2/a	Assessment 2/b	Assessment 2/c
...
...
C ₃₅	Assessment 35/a	Assessment 35/b	Assessment 35/c

Step 2. Assess the initial comparative matrix of cases and criteria

In Table 5, the importance of each criterion is assessed according to a scale of 1 to 100 points, then the weight (percentage) of each criterion is calculated, and finally, the assessment is made between each case and each criterion, assigning values of 1, 2, 3, 4, and 5 (where 1 equals very low, 2 = low, 3 = medium, 4 = high, and 5 = very high).

Table 5: Initial assessment of cases and criteria.

Criteria	Alternatives (Cases)			Points for each criterion (From 1 to 100)	Weight (Percentage)
	a) Alternative 1 (Case 1)	b) Alternative 2 (Case 2)	c) Alternative 3 (Case 3)		
C ₁	Assessment 1/a	Assessment 1/b	Assessment 1/c		
C ₂	Assessment 2/a	Assessment 2/b	Assessment 2/c		
⋮		
⋮		
C ₃₅	Assessment 35/a	Assessment 35/b	Assessment 35/c		
				$\sum_{i=1}^{35} C_i$	$\sum_{i=1}^{35} C_i$

Step 3. Assess with the Saaty scale the criteria vs. criteria comparison matrix.

In Table 6, the criteria versus criteria assessment are made according to the Saaty scale [61], [62], taking as reference the weight (percentage) of Table 5.

Table 6: Assessment with Saaty scale [61], [62].

Criteria	Criteria			
	C ₁	C ₂	....	C ₃₅
C ₁	Saaty assessment w_1/w_1	Saaty assessment w_1/w_2	....	Saaty assessment w_1/w_{35}
C ₂	Saaty assessment w_2/w_1	Saaty assessment w_2/w_2	....	Saaty assessment w_2/w_{35}
⋮	⋮	⋮	⋮
⋮	⋮	⋮	⋮
C ₃₅	Saaty assessment w_{35}/w_1	Saaty assessment w_{35}/w_2	....	Saaty assessment w_{35}/w_{35}
	$\sum_{i=1}^n C_1$	$\sum_{i=1}^n C_2$	....	$\sum_{i=1}^n C_{35}$

Step 4. Calculate the normalized criteria matrix vs. the criteria.

Performing the normalization of Table 6, each assessment is divided by the total sum of each criterion. Once the normalization is done, the next step is to calculate the weighting of each criterion, which is obtained by averaging each criterion, see Table 7.

Table 7: Normalized matrix.

Criteria	Criteria				Weighting
	C ₁	C ₂	...	C ₃₅	
C ₁	(Saaty assessment w_1/w_1)/ $(\sum_{i=1}^n C_1)$	(Saaty assessment w_1/w_2)/ $(\sum_{i=1}^n C_2)$	...	(Saaty assessment w_1/w_{35})/ $(\sum_{i=1}^n C_{35})$	Row average C ₁
C ₂	(Saaty assessment w_2/w_1)/ $(\sum_{i=1}^n C_1)$	(Saaty assessment w_2/w_2)/ $(\sum_{i=1}^n C_2)$	...	(Saaty assessment w_2/w_{35})/ $(\sum_{i=1}^n C_{35})$	Row average C ₂
⋮	⋮	⋮	...	⋮	⋮
⋮	⋮	⋮	...	⋮	⋮
C ₃₅	(Saaty assessment w_{35}/w_1)/ $(\sum_{i=1}^n C_1)$	(Saaty assessment w_{35}/w_2)/ $(\sum_{i=1}^n C_2)$	...	(Saaty assessment w_{35}/w_{35})/ $(\sum_{i=1}^n C_{35})$	Row average C ₃₅

Step 5. Calculate consistency of criteria matrix vs. criteria

Multiply the evaluated matrix (Table 6) by the weighting vector in Table 7, then add the products to obtain the λ_{max} "o" nmax, which indicates if there is consistency in the matrix, according to α [63], [64].

Step 6. Use the Saaty scale to assess the comparative matrix of alternatives vs. each criterion.

In Table 8, each alternative is evaluated and compared with the alternative of each criterion. In this case, 35 matrices will be obtained, representing each criterion; each matrix is 3x3.

Table 8: Assessment with Saaty scale [61], [62].

Criterion C ₁			
Alternatives vs. alternatives comparison matrix (3x3)			
Alternatives	a) Alternative 1 (Case 1)	b) Alternative 2 (Case 2)	c) Alternative 3 (Case 3)
Alternative 1 (Case 1)	Saaty assessment w_1/w_1	Saaty assessment w_1/w_2	Saaty assessment w_1/w_3
Alternative 2 (Case 2)	Saaty assessment w_2/w_1	Saaty assessment w_2/w_2	Saaty assessment w_2/w_3
Alternative 3 (Case 3)	Saaty assessment w_3/w_1	Saaty assessment w_3/w_2	Saaty assessment w_3/w_3
Total (Sum)	$\sum_{i=1}^n C_1$	$\sum_{i=1}^n C_2$	$\sum_{i=1}^n C_3$

Step 7. Calculate the normalized matrix of alternatives vs. each criterion.

This normalization consists of dividing each assessment by the sums in Table 8, then averaging the normalization of each alternative, to obtain the weighting, as shown in Table 9.

Table 9: Normalized matrix.

Criterion C ₁				
Normalized matrix (3x3)				
Alternatives	Alternative 1 (Case 1)	Alternative 2 (Case 2)	Alternative 3 (Case 3)	Average Vector C ₁ /A _n
Alternative 1 (Case 1)	(Saaty assessment w_1/w_1)/ $(\sum_{i=1}^n C_1)$	(Saaty assessment w_1/w_2)/ $(\sum_{i=1}^n C_2)$	(Saaty assessment w_1/w_3)/ $(\sum_{i=1}^n C_3)$	Row average Alternative 1 (C ₁ /A ₁)
Alternative 2 (Case 2)	(Saaty assessment w_2/w_1)/ $(\sum_{i=1}^n C_1)$	(Saaty assessment w_2/w_2)/ $(\sum_{i=1}^n C_2)$	(Saaty assessment w_2/w_3)/ $(\sum_{i=1}^n C_3)$	Row average Alternative 2 (C ₁ /A ₂)
Alternative 3 (Case 3)	(Saaty assessment w_3/w_1)/ $(\sum_{i=1}^n C_1)$	(Saaty assessment w_3/w_2)/ $(\sum_{i=1}^n C_2)$	(Saaty assessment w_3/w_3)/ $(\sum_{i=1}^n C_3)$	Row average Alternative 3 (C ₁ /A ₃)

Step 8. Calculate the consistency of the matrix of alternatives vs. each criterion

This calculation is done in the same way as in step 5. The matrix in Table 8 is taken by the average vector in Table 9. This procedure is done for all 35 criteria.

Step 9. AHP Final Results Matrix.

Making this matrix, only the average vectors of the 35 matrices calculated in step 7 are taken, and finally, the weights of step 4 are taken from Table 10.

Step 10. Prioritization of each case.

It is the last step in our proposed model to obtain the prioritization of each case or alternative. First, each of the average vectors of each alternative is multiplied by the weighting with the same criterion, resulting in 35 products. Then, the resulting products are added up to obtain the prioritization of each alternative (Table 10).

Table 10: Normalized matrix (3x3).

Criteria/Cases (Alternatives)	Alternative 1 (Case 1)	Alternative 2 (Case 2)	Alternative 3 (Case 3)	Weighting
C ₁	Average Vector C ₁ /A ₁	Average Vector C ₁ /A ₂	Average Vector C ₁ /A ₃	Weighting C ₁
C ₂	⋮	⋮	⋮	Weighting C ₂
⋮	⋮	⋮	⋮	⋮
⋮	⋮	⋮	⋮	⋮

C ₃₅	Average Vector C ₃₅ /A ₁	Average Vector C ₃₅ /A ₂	Average Vector C ₃₅ /A ₃	Weighting C ₃₅
Prioritization	Prioritization 1	Prioritization 2	Prioritization 3	

4. Results

Table 11 shows the comparative matrix of the three alternatives against the thirty-five criteria. This table is the beginning of the application of the AHP technique.

Table 11: Initial comparative matrix of cases and criteria.

Criteria		Alternatives (Cases)			Points for each criterion (From 1 to 100)	Weight (Percentage)
		a) The current state without sustainability (Case 1)	b) Cost leadership strategy with the possibility of sustainability (Case 2)	c) Differentiation strategy with the possibility of sustainability (Case 3)		
C ₁	Scale Economies	3	3	1	66	2.84%
C ₂	Product differentiation	1	1	5	66	2.84%
C ₃	Brand positioning	1	3	5	60	2.58%
C ₄	Input differentiation	1	3	5	40	1.72%
C ₅	Impact of inputs on cost or differentiation	1	4	4	40	1.72%
C ₆	The relative price performance of substitutes	1	3	3	62	2.67%
C ₇	The propensity of buyers to substitute	1	1	5	75	3.23%
C ₈	High negotiating power of the buyer	1	1	5	80	3.44%
C ₉	Industry Rivalry (High, considering that the competition is international)	1	1	5	80	3.44%
C ₁₀	Low labor cost	2	3	3	38	1.64%
C ₁₁	Horizontal and vertical cooperation	1	2	5	90	3.87%
C ₁₂	Technology and Innovation	2	3	5	72	3.10%
C ₁₃	Administrative and production knowledge	2	3	5	73	3.14%
C ₁₄	Government policy (No intervention)	3	2	5	79	3.40%
C ₁₅	Consumer's level of acquisition	1	2	5	81	3.49%
C ₁₆	Materials	1	2	5	45	1.94%
C ₁₇	Energy	1	2	5	68	2.93%
C ₁₈	Water	1	2	5	67	2.88%
C ₁₉	Biodiversity	2	2	5	56	2.41%
C ₂₀	Emissions	2	2	5	57	2.45%
C ₂₁	Regulatory compliance and environmental standards	2	3	5	89	3.83%
C ₂₂	Supplier selection based on environmental performance	1	2	5	90	3.87%
C ₂₃	Labor Practices, Decent Work, Health and Safety at Work	2	3	5	40	1.72%
C ₂₄	Investment in training and education based on labor practices, human rights, and social impact	1	3	5	39	1.68%
C ₂₅	Diversity and equality of opportunity and redistribution	1	3	5	41	1.76%
C ₂₆	Supplier selection based on labor practices, human rights, and social impact	1	3	5	90	3.87%
C ₂₇	Child and forced labor	4	4	5	57	2.45%
C ₂₈	Rights of the indigenous population	3	3	5	56	2.41%
C ₂₉	Local communities	3	3	5	53	2.28%
C ₃₀	Fight against corruption	2	3	5	67	2.88%
C ₃₁	Regulatory compliance and social standards	2	3	5	89	3.83%
C ₃₂	Product Responsibility	3	3	5	68	2.93%
C ₃₃	Consumer Awareness of Sustainability	1	2	5	85	3.66%
C ₃₄	Food security, improved nutrition, and promotion of sustainable agriculture	3	3	4	67	2.88%
C ₃₅	Partnerships to Achieve the Goals: Strengthening the Means of Implementation and Revitalizing the Global Partnership for Sustainable Development	1	2	4	97	4.18%
					2323	100%

Continuing with the AHP technique, it is essential to know the consistency of the matrix. Since it is too large (35 x 35), it requires using the Alonso and Lamata's consistency criteria [63], [64], where λ_{max} is considered to accept or reject the consistency. According to calculations made with an α of 0.1, λ_{max} has a value of 38,845, which indicates that this matrix has an adequate consistency, allowing the continuation of the AHP technique.

In Table 12, the comparison between the alternatives is made according to criterion 1 (C1), then it is normalized (average vector); this procedure is performed for the 35 criteria.

Table 12: Comparative matrix of cases for each criterion.

Criterion C1: Scale Economies				Normalized matrix			
Alternatives	Case 1 (Alternative 1)	Case 2 (Alternative 2)	Case 3 (Alternative 3)	Case 1	Case 2	Case 3	Average Vector
Case 1 (Alternative 1)	1	1	5	4/9	4/9	4/9	0.45
Case 2 (Alternative 2)	1	1	5	4/9	4/9	4/9	0.45
Case 3 (Alternative 3)	1/5	1/5	1	0.09	0.09	0.09	0.09
Total ($\sum_{i=1}^n C_i$)	2.20	2.20	11.00				

In Table 13, the final result of AHP can be seen, where the weights of the 35 x 35 matrix and the average vectors of the 35 comparative matrices of the three cases by criterion are shown. The final result is the prioritization of each case. This prioritization can be interpreted as the final assessment or evaluation that each case has according to the 35 criteria.

Case 1 (alternative 1) has a low value (9.49%) because its current situation is casual, here there are no defined strategies, the collaboration of the supply chain is not ideal, sustainability is not contemplated, among other aspects defined in stage 1.

While case 2 (alternative 2), with the strategy of cost leadership with the possibility of sustainability, shows a percentage of 17.30%. Based on the current situation, this percentage indicates that the combination of this strategy with sustainability would be more challenging to carry out compared to case 3. It does not mean that it is impossible, but it would be more challenging to shift to sustainability. It is difficult for organizations to compete with unsustainable low-cost products in the foreign market in the current situation, making it somewhat unfeasible to have this strategy along with sustainability. It could increase their costs and lead to unequal competition.

Finally, case 3 (alternative 3), referring to the strategy of differentiation with the possibility of sustainability, has the highest value (73.21%). It indicates better compatibility and strategic feasibility between competitiveness and sustainability. It is because sustainability could be more easily aligned while providing a competitive advantage. However, a more significant challenge to achieving full sustainability can be seen in the supply chain of this SME because it is in the agri-food sector. If it goes more in-depth at the farmer level, it is difficult to achieve 100 %

sustainability because it would need to reach a natural ecosystem to do so [69].

Table 13: AHP final results.

Criteria Cases (Alternatives)	Case 1 (Alternative 1)	Case 2 (Alternative 2)	Case 3 (Alternative 3)	Weighting
C ₁	0.4545	0.4545	0.0909	0.0178
C ₂	0.0909	0.0909	0.8182	0.0178
C ₃	0.0612	0.2157	0.7231	0.0106
C ₄	0.0612	0.2157	0.7231	0.0050
C ₅	0.0667	0.4667	0.4667	0.0050
C ₆	0.0909	0.4545	0.4545	0.0110
C ₇	0.0909	0.0909	0.8182	0.0362
C ₈	0.0909	0.0909	0.8182	0.0391
C ₉	0.0909	0.0909	0.8182	0.0391
C ₁₀	0.1429	0.4286	0.4286	0.0044
C ₁₁	0.0685	0.1549	0.7766	0.0737
C ₁₂	0.0833	0.1932	0.7235	0.0339
C ₁₃	0.0833	0.1932	0.7235	0.0350
C ₁₄	0.1932	0.0833	0.7235	0.0374
C ₁₅	0.0685	0.1549	0.7766	0.0414
C ₁₆	0.0685	0.1549	0.7766	0.0058
C ₁₇	0.0685	0.1549	0.7766	0.0209
C ₁₈	0.0685	0.1549	0.7766	0.0192
C ₁₉	0.1111	0.1111	0.7778	0.0095
C ₂₀	0.1111	0.1111	0.7778	0.0097
C ₂₁	0.0833	0.1932	0.7235	0.0665
C ₂₂	0.0685	0.1549	0.7766	0.0737
C ₂₃	0.0833	0.1932	0.7235	0.0050
C ₂₄	0.0612	0.2157	0.7231	0.0046
C ₂₅	0.0612	0.2157	0.7231	0.0056
C ₂₆	0.0612	0.2157	0.7231	0.0737
C ₂₇	0.2000	0.2000	0.6000	0.0097
C ₂₈	0.1429	0.1429	0.7143	0.0091
C ₂₉	0.1429	0.1429	0.7143	0.0087
C ₃₀	0.0833	0.1932	0.7235	0.0192
C ₃₁	0.0833	0.1932	0.7235	0.0665
C ₃₂	0.1429	0.1429	0.7143	0.0209
C ₃₃	0.0685	0.1549	0.7766	0.0632
C ₃₄	0.2000	0.2000	0.6000	0.0192
C ₃₅	0.0833	0.1932	0.7235	0.0823
Prioritization	0.0949	0.1730	0.7321	1

5. Discussion

This study shows that there are more compatibility and feasibility between the differentiation strategy and sustainability, causing at the same time a competitive advantage. While some strategic incompatibilities can be observed with the cost leadership strategy and sustainability, the effects are presented in the costs and, consequently, the competitiveness. It coincides that SSCM practices do not necessarily reduce costs related to sustainability [17], [18].

The proposed model shows a high degree of difficulty in assessing sustainability and competitiveness strategically. It was validated through a Mexican agri-food focal SME. The model demonstrates that it is possible a large number of criteria for decision-making, considering Alonso and Lamata's terms [63], [64]. To carry out this assessment, it is necessary to have an in-depth and particular knowledge of the company's situation, its environment, and its supply chain. It agrees that particular circumstances of each supply chain must be assessed, considering all factors, both internal and external, which may vary over time [20].

Everything indicates that the effects of the COVID-19 pandemic will drive and accelerate a change in people's eating habits [70], prioritizing consumption in local food supply chains [71]. All of the above, together with climate change and its effects [8], [9], as well as changes in the governmental agendas of various countries due to the COVID-19 pandemic [1], such as Mexico, would lead to an increase of SSCM practices in local, national and international food sector.

The COVID-19 pandemic can be taken as a reference for issues such as food insecurity and ultra-processed food products that affect the health and welfare of people. The crisis that has brought this pandemic should lead us to think further, as we have more challenges ahead, such as climate change, environmental impacts, poverty, among other aspects that could cause instability around the world. Thus, the current situation should be a lesson on what is wrong, and an impetus to further progress towards the 17 Sustainable Development Goals, in this case, through the SSCM theory. The SSCM must continue to evolve in order to improve food supply chains, so this model contributes to the strategic planning of the SSCM in order to develop greater long-term resilience in Mexican agri-food SMEs.

6. Conclusions

This study finds more feasibility and compatibility to achieve sustainability with a differentiation strategy than with a cost leadership strategy. As could be seen, strategies have an essential role in promoting sustainability and competitiveness. Therefore, they must be considered in SSCM's strategic planning and tactical and operational planning, aligning them and fitting them to the core business of the focal companies and the supply chain members. It is also found that the proposed strategic initiatives in SSCM would lead to a competitive advantage due to the difficulty of replicating them.

The proposed model provides support to assess and develop the sustainable and competitive part of the strategic planning in SSCM, without running the economic risks that an

implementation represents. It highlights how complex it may be to assess an SME and its supply chain strategically due to the high number of criteria used, but at the same time, these criteria provide important aspects for decision making.

This strategic model contributes to prevent or face problems such as the COVID-19 pandemic and climate change, providing knowledge to the SSCM. It is designed to apply to both small and medium-sized focal companies that lead their supply chain in the food sector, considering sustainability and competitiveness strategically through specific metrics.

In future research, it is intended to apply the model to more small and medium Mexican agri-food companies that lead their supply chains to carry out comparative case studies to contribute knowledge to the SSCM theory and, at the same time to continue executing and improving the proposed model.

Conflict of Interest

The authors declare no conflict of interest.

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Resilience Assessment of System Process Through Fuzzy Logic: Case of COVID-19 Context

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ABSTRACT

The present work is undertaken as part of research studies aiming to provide sociotechnical systems with a decision-making tool that supports them in assessing the resilience of their processes. The ultimate objective is to fix the identified imperfections in order to steadily gain strength and effectiveness to cope with new and existing threats and challenges. In that respect, this paper presents a framework called 3R process whose goal is to calculate the resilience score for a process based on several parameters and grade it on the resilience scale. In order to achieve this, a fuzzy model has been put in place and graphic user interfaces have been designed so that the 3R process becomes an integral part of daily working practices. Finally, a real case company example in the context of COVID-19 is exposed towards putting into practice the proposed model.

1. Introduction

In an increasingly uncertain and volatile world, sociotechnical systems, which are complex systems incorporating technical (machines and technology that provide an authentic link between the user input and the system's output) and social (people and society) systems that both have interactions between them, and those interactions are a key factor in the success or failure of system performance [1], are bending over backwards to become more resilient in order to be able to react to change as quickly as possible and to treat challenges and mistakes as a learning opportunity. An obvious case in point is the Nokia organization. This company, at one point, had 32% of the global market share in smartphones and mobile phones [2]. However, as it is well known, Nokia fell from grace with respect to the mobile phones market. They misread the North American market and they did not respond correctly when Apple and Samsung introduced new products and it took them too long to catch up. Eventually, they had to sell their mobile phone business to Microsoft, and effectively had to exit the mobile phone market, which they dominated only a few years earlier. Nevertheless, what makes Nokia such an interesting case of resilient organization is that despite the fact that Nokia made a mistake, it has been putting back together an organization. They

refocused on their core transmission on business, they have been thinking how to position their navigational services and connecting with other organizations to produce new software, new kinds of handsets. The organization did not fall apart and was able to remake itself. In fact, their stock price, from the time they sold the business to Microsoft to recently, doubled. Indeed, what is important for every system is to develop resilience capabilities such as the ability to sense what is happening out in its environment and to compare that with what is done inside the organization, and, as necessary make the changes [3]. The question now being asked is how a system can assess its own resilience level so it can take stock of its strengths and weaknesses, threats and opportunities in terms of dealing with disturbances and returning to normal function.

In fact, several attempts have been made to find new approaches and frameworks that help in the resilience assessment. Amongst these, there are methods established to evaluate resilience of critical infrastructures, such as defining a generalized index that serves for quantifying the resilience under various scenarios [4], or designing a quantitative method to assess distinct elements in a critical infrastructure system [5].

Furthermore, different frameworks were proposed for the assessment of supply chain resilience, for example, elaborating an assessment model in order to measure organizational, business and labor resilience performance of supply chain [6], or developing a

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framework that integrates the concepts of resilience with risk management techniques in order to understand how a supply chain reacts to disruptions as a function of time [7].

Idem for urban communities as establishing a methodology for evaluating the earthquake resilience [8], or putting into place a workbook that helps urban areas incorporate resilience thinking into their planning practice [9], and so forth.

Moreover, measuring and quantifying resilience has proved challenging and research works in this field are not so numerous. However, some researchers have sought to contribute to fill this gap by developing methods aimed at calculating resilience. For example, we can find quantitative models explaining how to compute resilience of manufacturing [10] or nuclear power [11] plants, physical networks [12], mass railway transportation [13], and the list goes on.

In this same perspective, the 3R process dedicated to assigning a resilience level to sociotechnical system processes is described in this paper. This framework is based on the resilience scale [14], a scoring system, which is composed of five echelons: 0.Unconscious (Processes belonging to this category have no resilience processes associated with them), 1.Informed (These processes are warned of resilience without any elaborated resilience processes), 2.Aspiring (These processes are beginners and try to set up resilience processes), 3.Progressing (These processes overcome less serious disruptions within a reasonable time. However, the consequences can be more devastating in serious situations), 4.Expert (For this kind of processes, the anticipated situations are perfectly manageable. As per the unforeseen situations, they try to adapt to changes), and which aims to assess the level of resilience of a given process. The present work will go beyond this qualitative description to find out how this scale can be used by a sociotechnical system in order to assess the resilience of its own processes by attributing a resilience score to each process.

For this purpose, the first section will be devoted to the selection of needed indicators. This step is of such importance since the indicators provide the necessary information for decision-making and constitute a basis for our calculation model. However, in order to be able to accomplish these missions, the indicators should be relevant. This means that they should be specific so that the results can be clearly identified, measurable and quantified, practical and useable, available (it should be possible to collect the data), be transparent in methodology and selection and well-grounded in scientifically [15]. After this, the “3R” process will be defined in the second section. This method relies mainly on three concepts, which are (1) resources that can be considered, among others (time, budget, regulations...) as a constraint that may limit the achievement of the process objective [16], (2) risks, which are undesirable events that may happen several times can have a negative impact on the process [17], (3) Resilience, which is the ability of a system to manage disturbances and to adapt to changes without ceasing the activity[18]. In this section, a model explaining extensively the 3R process that is divided into two steps (Definition of parameters and resilience assessment) will be derived, the way of calculating the resilience score using fuzzy logic, a procedure that has already proved its effectiveness in many fields, will be explicitly shown, and graphic

user interfaces will be developed. Then, a real case company example in the context of COVID-19 is presented in the penultimate section. The purpose is to check the reliability of the proposed method through assessing the resilience of a process of a huge company in face of this exceptional crisis. At the end of this paper, conclusions and opportunities for further work will be exposed.

2. Selection of indicators

The role of resilience processes is to ensure the continued availability of resources, in case of disruptions, in order to avoid failures. This objective can be achieved through resistance, recovery, and anticipation [19]. Thus, the selection of indicators will be in relation with these three missions.

As per resistance, a variety of metrics can be considered [20]:

- The meantime between failures (MTBF), which indicates the expected time between consecutive failures.
- The operational availability that expresses the percentage of time a process is available to users.
- The operational reliability, which is defined as the ability of a process to operate at the normal service level for a specified period of time.
- The Maximum Tolerable Period of Disruption (MTPD) that measures the time for which a process can be available before entirely stopping the system activity. It depends on the system business objectives and thus determined by the organization. The importance of this indicator lies in the fact that it has an impact on the recovery metrics [21]. Furthermore, the MTPD is identified as one of the inputs used to prepare the response plans [22].

In the light of the foregoing, the MTPD is picked up and the criticality of processes will be defined according to the value of MTPD.

Table 1: The selected indicators

Resilience process mission	Indicator	Description
Resistance	MTPD	Time after which operations of the site are critically impacted, in case of a full process unavailability.
Recovery	RT	Time required for the system to resume normal operation after a disruption.
Anticipation	WIT	The time needed to implement an anticipated workaround for a disturbance.
Anticipation	WMTTL	The period during which a workaround perform normally.

Regarding recovery, the following metrics can be listed [23]:

- Recovery Point Objective (RPO) describes the period of time in which data must be restored after a disruption.
- Recovery Time Objective (RTO) is the period during which the system must recover.

- Mean Down Time (MDT) is the mean time that a system is not operational.
- Recovery time, which is the time it takes for a process to return to normal operation after a failure is occurred. It is shown in a research work about the relationship between recovery and resilience that the recovery time depends on, among others, the resilience of the system and the scale of the perturbation [24]. It is considered also as the period within which it takes a system to return to a stable state [25]. This metric is chosen as one of the parameters used to define the process criticality.

As for anticipation, the notion of “workaround” is addressed. It may be defined, according to the Cambridge Dictionary, as “a way of dealing with a problem or making something work despite the problem, without completely solving it”. In other words, it is an alternative solution, which allows continuing the operation in short term. For instance, we can define, as workaround, for raw material shortage, borrowing from the stock of another plant. In terms of indicators, Workaround Implementation Time (WIT) and Workaround Maximum Tolerable Time Length (WMTTL) are selected. WIT is the amount of time it takes to implement an anticipated workaround for the present situation, and WMTTL is the absolute maximum length of time for which an implemented workaround can be maintained.

The featured indicators are presented in the table 1.

3. 3R process

The 3R process is a novel method and an instrument for decision-making aimed at assessing the resilience of sociotechnical systems processes. This process is built on three essential concepts: Resource, Risk, and Resilience, and is conducted in two stages, which are the definition of parameters and the resilience assessment. A model of the 3R process is proposed in figure 1.

This begins with the selection of a sociotechnical system process for which resilience will be assessed. Thereafter, the concerned resource is identified. This latter may fall under one of the following categories: (1) Infrastructures (Buildings, Racks, Dock lanes, Doors...), (2) Devices/Equipment (Pick-to-light, Conveyer Belt, Tape machine, Forklift...), (3) People (Management, Certified staff, External Human Resources...), (4) IT/Hardware (Computer, Printer, Server, Network...), (5) IT/Software (ERP, Local applications...), (6) Consumables (Box, Plastic film, Labels, Pallet...), (7) Utilities (Electricity, Water, Stream, Gas...). Then, a potential risk that threaten the selected resource is chosen. In general, there are six types of risks: (1) General resources (All risks directly impacting facilities and services (Supplier Bankrupt, Power outage...), (2) Internal staff (All events impacting human resources (Loss of key personnel, Strike, Epidemic...)), (3) IT (All incidents concerning data and IT resources availability (Virus, Hacking...)), (4) Natural disaster (All incidents with natural causes (Earthquake, flood, hurricane...)), (5) Regulation (All incidents impacting the authorization to make business (Lawsuit, Customs issue...), (6) Social (External) (All personal incidents external to the system (Riots, Terrorism, Bomb Threat)).

When this is done, the next step is to define parameters. The aim is to attribute values to the four indicators detailed in the previous section. For each one, time ranges should be defined and the process criticality level should be identified based on these intervals. As regards WIT and WMTTL, before proceeding with this exercise, the existence of workarounds should be checked, and if not found, workarounds must be put in place.

The criticality level helps determine the priority ranking of processes as per their potential risk of failures. In the present work, five process criticality levels are considered: (1) Very low, (2) Low, (3) Medium, (4) High, (5) Very high. An example of intervals for the selected indicators (MTPD, RT, WIT, and WMTTL) is given in the tables below.

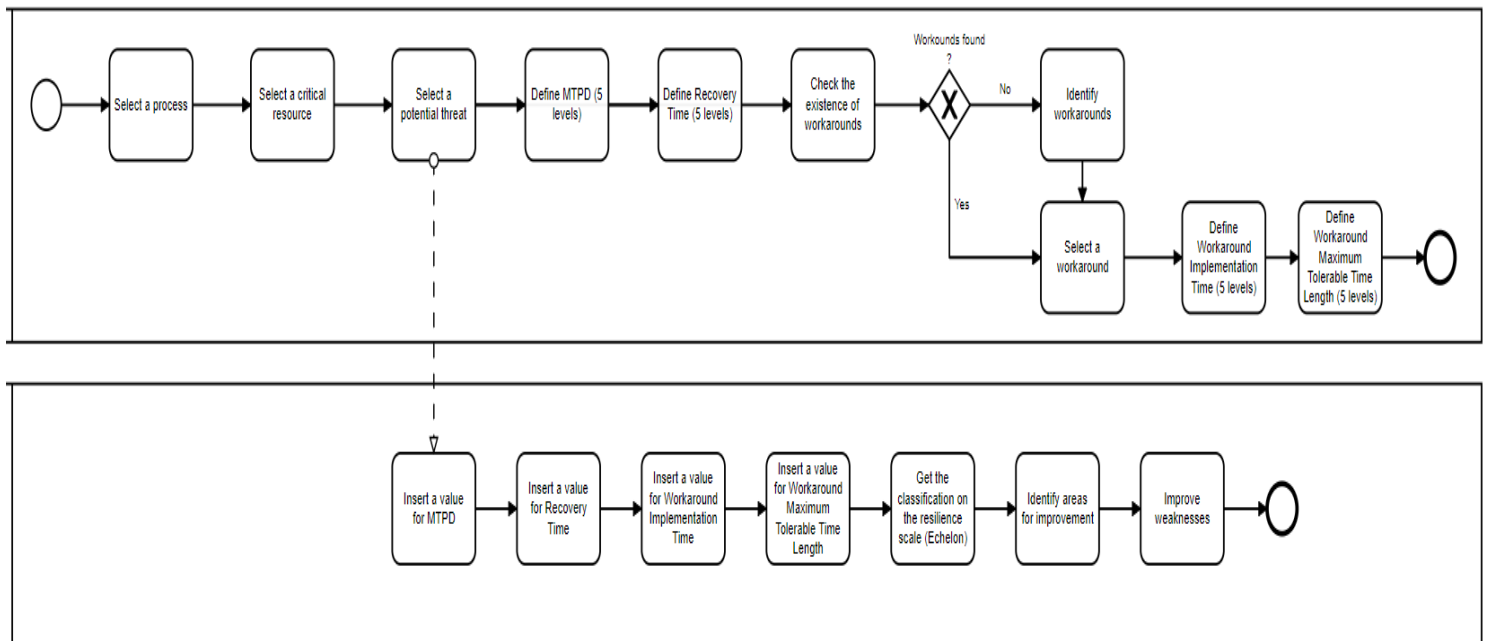


Figure 1: 3R process model

Table 2: The process criticality levels for MTPD

Level	Process criticality	Description	Comment
5	Very high	MTPD < 4h	The risk of failure is very high since the process can carry on functioning only 4 hours during the disturbance before completely ceasing its activity.
4	High	4h ≤ MTPD < 1 day	The risk of failure is high since the process can carry on functioning between 4 hours and 1 day during the disturbance before completely ceasing its activity.
3	Medium	1 day ≤ MTPD < 3 days	The risk of failure is medium since the process can carry on functioning between 1 day and 3 days during the disturbance before completely ceasing its activity.
2	Low	3 days ≤ MTPD < 5 days	The risk of failure is low since the process can carry on functioning between 3 and 5 days during the disturbance before completely ceasing its activity.
1	Very low	5 days ≤ MTPD < 1 week	The risk of failure is very low since the process can carry on functioning between 5 days and 1 week during the disturbance before completely ceasing its activity. This is a sufficient time for the process to recover.

Table 3: The process criticality levels for RT

Level	Process criticality	Description	Comment
1	Very low	RT < 1 day	The risk brought about by the disruption is very low since the process can recover in less than 1 day.
2	Low	1 day ≤ RT < 3 days	The risk brought about by the disruption is low since the process can recover in a period of time between 1 day and 3 days.
3	Medium	3 days ≤ RT < 5 days	The risk brought about by the disruption is medium since the process can only recover in a period of time between 3 and 5 days.
4	High	5 days ≤ RT < 1 week	The risk brought about by the disruption is high since the process can only recover in a period of time between 5 and 7 days.
5	Very high	1 week ≤ RT	The risk brought about by the disruption is very high since the process can only recover in more than 1 week.

Table 4: The process criticality levels for WIT

Level	Process criticality	Description	Comment
1	Very low	WIT < 1 day	The risk of failure is very low since the anticipated workaround can be implemented in less than 1 day.
2	Low	1 day ≤ WIT < 3 days	The risk of failure is low since the anticipated workaround can be implemented in a period of time between 1 day and 3 days.
3	Medium	3 days ≤ WIT < 5 days	The risk of failure is medium since the anticipated workaround can be implemented only in a period of time between 3 and 5 days.
4	High	5 days ≤ WIT < 1 week	The risk of failure is high since the anticipated workaround can be implemented only in a period of time between 5 and 7 days.
5	Very high	1 week ≤ WIT	The risk of failure is very high since the anticipated workaround can be implemented only in more than 1 week.

Table 5: The process criticality levels for WMTTL

Level	Process criticality	Description	Comment
5	Very high	WMTTL < 1 day	The risk of failure is very high since the anticipated workaround can be maintained only for less than 1 day.
4	High	1 day ≤ WMTTL < 3 days	The risk of failure is high since the anticipated workaround can be maintained only for a period of time between 1 day and 3 days.
3	Medium	3 days ≤ WMTTL < 5 days	The risk of failure is medium since the anticipated workaround can be maintained only for a period of time between 3 and 5 days.
2	Low	5 days ≤ WMTTL < 1 week	The risk of failure is low since the anticipated workaround can be maintained for a period of time between 5 and 7 days.
1	Very low	1 week ≤ WMTTL	The risk of failure is very low since the anticipated workaround can be maintained for more than 1 week.

Table 6: The process criticality levels for the selected indicators

Indicator	Criticality level				
	Very low	Low	Medium	High	Very high
MTPD (days)	[5, 7[	[3, 5[	[1, 3[	[1/6, 1[	[0, 1/6[
RT (days)	[0, 1[	[1, 3[	[3, 5[	[5, 7[	[7, +∞[
WIT (days)	[0, 1[	[1, 3[	[3, 5[	[5, 7[	[7, +∞[
WMTTL (days)	[7, +∞[	[5, 7[	[3, 5[	[1, 3[	[0, 1[

Table 7: Definition of parameters: Example of application

Action	Description
Select a process	Quality Control. It includes : - Raw material control - Finished goods and components control - Microbiology control
Select a resource	The critical resources for this process are: - Infrastructure: Light, air conditioning, fume hood, microlab, raw material sampling booth... - Equipment: Component control equipment, finished goods and packaging control equipment, raw material and assay control equipment, micro control equipment... - People: raw material and assay control: Basic chemical knowledge, micro control: micro knowledge.
Select a threat	The potential threats for this process are: Lab unavailable, reagent supply shortage, scanners or printers unavailable, more than half of the team missing, equipment unavailable...
Define MTPD (Five levels)	Cf. Table 6
Define recovery time (Five levels)	Cf. Table 6
Check the existence of workarounds	If No → Identify workarounds If Yes → Select a workaround
Identify workarounds	- Lab unavailable → Externalization of quality control to another plant. - More than half of the team missing → Borrow people from production department. - Reagent supply shortage → Borrow from another plant. - Equipment unavailable → Delegate part of the activity to another plant.
Select a workaround	Select one of the workarounds already identified
Define WIT (Five levels)	Cf. Table 6
Define WMTTL (Five levels)	Cf. Table 6

The process criticality levels for the four selected metrics are gathered in table 6 (1/6 day stands for 4 hours)

An example of application of the first part of the 3R process model is given in the process analysis template hereafter (table 7).

The second and most important step of the 3R process model is “resilience assessment”. Its aim is to explain how to rate sociotechnical system processes on the resilience scale. In figure 1, it can be noticed that this part consists in determining inputs in order to obtain the echelon at the output. This will help the process identify the areas for improvement and afterwards overcome weaknesses.

In order to design the 3R process model, fuzzy logic will be used. This is an approach of data mining, which enables the modelling of a decision process in a situation of uncertain reasoning or incomplete information [26]. A fuzzy inference system (FIS) is defined as a system that uses fuzzy membership functions to make a decision [27]. In our case, Mamdani approach is adopted. This is a nonlinear mapping process on the base of fuzzy logic, which involves three components: fuzzification, inference rules, and defuzzification. The proposed fuzzy model is implemented using the programming language python, which is versatile and easy to use with a large and rich library.

The first step in the fuzzy model is to import scikit-fuzzy, which is a fuzzy logic Python package, using the following code block:

```
import numpy as np
import skfuzzy as fuzz
from skfuzzy import control as ctrl
```

Afterwards, the inputs (MTPD, Recovery time (RT), Workaround implementation time (WIT), Workaround maximum tolerable time length (WMTTL)) and the output (Echelon) should be defined. Values included between 0 and 8 for the inputs according to Table 6, and 0 and 5 for the output according to the resilience scale (5 echelons (0, 1, 2, 3 and 4)). The code portion is inserted hereunder:

```
MTPD = ctrl.Antecedent(np.arange(8), 'MTPD')
WIT = ctrl.Antecedent(np.arange(8), 'WIT')
WMTTL = ctrl.Antecedent(np.arange(8), 'WMTTL')
RT = ctrl.Antecedent(np.arange(8), 'RT')
Echelon = ctrl.Consequent(np.arange(0, 5, 1), 'echelon')
```

Next, auto-membership function should be populated (Five intervals). Membership functions are used in fuzzy systems to represent input values. The code snippet is added below:

```
MTPD.automf(5)
WIT.automf(5)
WMTTL.automf(5)
RT.automf(5)
```

Then, membership functions are built based on resilience scale and table 6. Our choice was to go with the triangular membership functions (trimf) that are frequently used in many applications of fuzzy sets owing to their simplicity and which are suitable in this case (because they are defined by a lower limit a, an upper limit b,

and a value m, where $a < m < b$) [28], [29]. The functions are shown hereafter

```
Echelon['Unconscious'] = fuzz.trimf(Echelon.universe, [0, 0, 1])
Echelon['Informed'] = fuzz.trimf(Echelon.universe, [1, 1, 2])
Echelon['Aspiring'] = fuzz.trimf(Echelon.universe, [2, 2, 3])
Echelon['Progressing'] = fuzz.trimf(Echelon.universe, [3, 3, 4])
Echelon['Expert'] = fuzz.trimf(Echelon.universe, [4, 4, 5])
MTPD['Very high'] = fuzz.trimf(MTPD.universe, [0, 0, 0.16])
MTPD['High'] = fuzz.trimf(MTPD.universe, [0.16, 0.16, 1])
MTPD['Medium'] = fuzz.trimf(MTPD.universe, [1, 3, 3])
MTPD['Low'] = fuzz.trimf(MTPD.universe, [3, 5, 5])
MTPD['Very low'] = fuzz.trimf(MTPD.universe, [5, 7, 7])
WIT['Very low'] = fuzz.trimf(WIT.universe, [0, 0, 1])
WIT['Low'] = fuzz.trimf(WIT.universe, [1, 1, 3])
WIT['Medium'] = fuzz.trimf(WIT.universe, [3, 3, 5])
WIT['High'] = fuzz.trimf(WIT.universe, [5, 5, 7])
WIT['Very high'] = fuzz.trimf(WIT.universe, [7, 7, 8])
WMTTL['Very high'] = fuzz.trimf(WMTTL.universe, [0, 0, 1])
WMTTL['High'] = fuzz.trimf(WMTTL.universe, [1, 1, 3])
WMTTL['Medium'] = fuzz.trimf(WMTTL.universe, [3, 3, 5])
WMTTL['Low'] = fuzz.trimf(WMTTL.universe, [5, 5, 7])
WMTTL['Very low'] = fuzz.trimf(WMTTL.universe, [7, 7, 8])
RT['Very low'] = fuzz.trimf(RT.universe, [0, 0, 1])
RT['Low'] = fuzz.trimf(RT.universe, [1, 1, 3])
RT['Medium'] = fuzz.trimf(RT.universe, [3, 3, 5])
RT['High'] = fuzz.trimf(RT.universe, [5, 5, 7])
RT['Very high'] = fuzz.trimf(RT.universe, [7, 7, 8])
```

Thereafter, fuzzy rules are defined in order to express pieces of knowledge. Given the large number of identified rules, a few examples are provided in the table hereunder:

Table 8: Examples of Fuzzy rules

Example 1						
MTPD = Very low & RT = Very low						
Echelon		WIT				
		Very low	Low	Medium	High	Very high
WMTTL	Very low	Expert	Expert	Expert	Progressing	Progressing
	Low	Expert	Expert	Expert	Progressing	Progressing
	Medium	Expert	Expert	Progressing	Progressing	Progressing
	High	Progressing	Progressing	Progressing	Progressing	Progressing
	Very high	Progressing	Progressing	Progressing	Progressing	Progressing
Example 2						
MTPD = Very low & RT = High						
Echelon		WIT				
		Very low	Low	Medium	High	Very high
WMTTL	Very low	Progressing	Aspiring	Aspiring	Aspiring	Aspiring

	Low	Aspiring	Aspiring	Aspiring	Aspiring	Aspiring
	Medium	Aspiring	Aspiring	Aspiring	Aspiring	Aspiring
	High	Aspiring	Aspiring	Aspiring	Aspiring	Aspiring
	Very high	Aspiring	Aspiring	Aspiring	Aspiring	Aspiring
Example 3						
MTPD = High & RT = High						
Echelon		WIT				
		Very low	Low	Medium	High	Very high
WMTTL	Very low	Informed	Informed	Informed	Informed	Informed
	Low	Informed	Informed	Informed	Informed	Informed
	Medium	Informed	Informed	Informed	Informed	Informed
	High	Informed	Informed	Informed	Unconscious	Unconscious
	Very high	Informed	Informed	Informed	Unconscious	Unconscious

Table 9: Values of inputs

Indicator	Value	Level	Interpretation
MTPD	3	Medium	The process can resist for 3 days before failing to function. Then, its criticality is medium.
WIT	5	High	It takes 5 days to implement the anticipated workaround. This is a long response time to the perturbation.
WMTTL	1	High	The implemented workaround can remain operational for one day, which is not sufficient.
RT	7	Very high	The process can reach its normal functioning within 7 days. This means that the duration of the disturbance lasts for a long time.

In example 1, MTPD and RT are very low, which means that the two first missions of resilience process (resistance and recovery) are perfectly fulfilled. It remains to be seen if the last mission (anticipation) is also fully accomplished or not. Accordingly, the output (Echelon) will oscillate between progressing and expert.

In example 2, the RT decreases, which conveys a much-needed effort to enhance recovery, and thus the process climbs down in the resilience scale from progressing to aspiring. It cannot be informed or unconscious because the resilience process is already set up with at least one mission that really holds water (resistance).

Regarding the last example, MTPD and RT are high, which is to say that resistance and recovery of the process are weak. Therefore, depending on the performance of anticipation, the echelon varies between informed and unconscious.

Subsequently, a control system (a nonlinear Single Input-Single Output (SISO) discrete-time process based on a set of rules [30]) is created using the code block hereunder

```
resiliencescale_ctrl = ctrl.ControlSystem ([rule1, rule2, ..., rule n])
```

Later, this control system is simulated through specifying the inputs. The table hereafter gathers the values attributed to the four indicators in the present example.

```
resiliencescale.input ['MTPD'] = 3
resiliencescale.input ['WIT'] = 5
```

```
resiliencescale.input ['WMTTL'] = 1
resiliencescale.input ['RT'] = 7
resiliencescale.compute ()
```

Finally, simulation results is visualized (cf. Code blow& figure 2)

```
print (resiliencescale.output['echelon'])
Echelon.view(sim=resiliencescale)
```

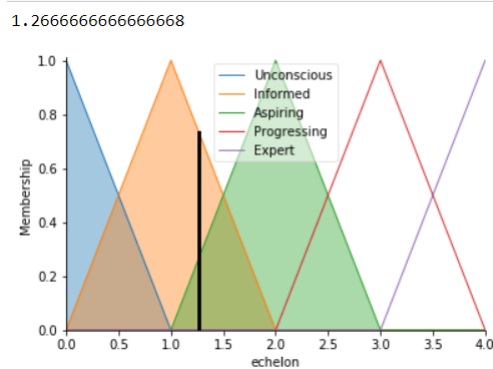


Figure 2: Simulation results

According to the plot above, the resilience echelon is about 1.27. That is to say, by referring to the resilience scale, the process

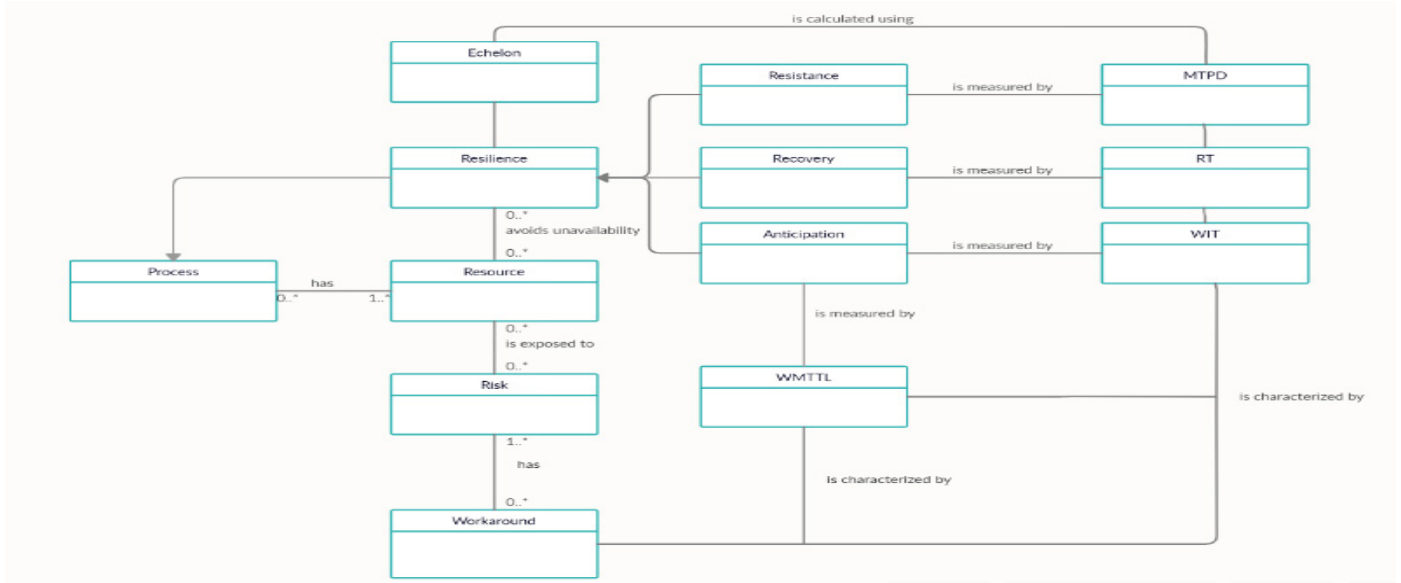


Figure 3: A conceptual metamodel representing the 3R process

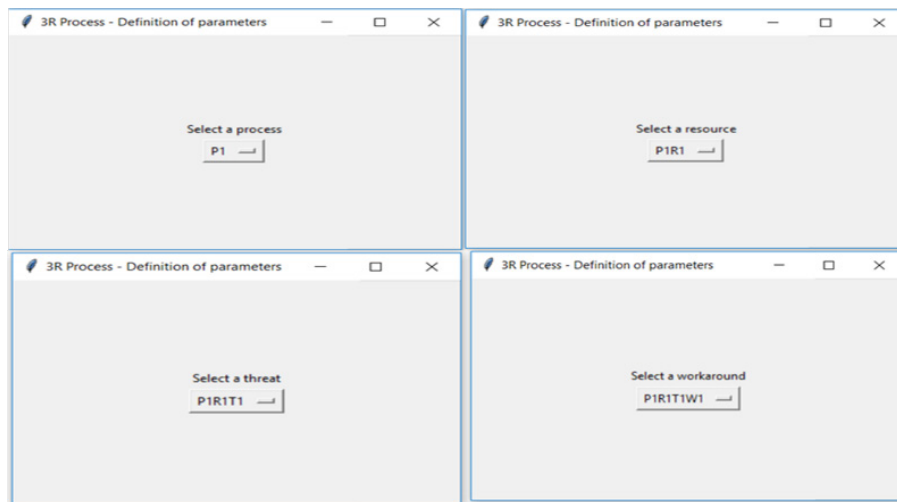


Figure 4: Definition of parameters – User interfaces

under study is informed. It is poorly developed with regard to resilience. An associated resilience process must be set up in order to enhance its resilience. The aim is to improve:

- the resistance of the process and its resource to the disruption through increasing the MTPD
- the recovery through the reduction of the recovery time (RT)
- the anticipation through putting in place well elaborate workarounds, reducing WIT and increasing WMTTL for each workaround.

In order to make this model usable for sociotechnical systems and a core part of their processes, a user interface should be designed. For this purpose, a model is elaborated using UML language (Cf. figure 3).

As can be seen, the metamodel illustrated by figure 3 formulates the following points:

- A process has one or more resources.
- A resource is exposed to one or more risks.

- A risk can have one or several identified workarounds. It may also have no created workarounds.
- There are processes called resilience processes.
- The existence of resilience processes in the sociotechnical systems help avoiding unavailability of resources.
- An echelon (Resilience score) is attributed to each process of the sociotechnical system based on the existence of associated resilience processes.
- The missions of resilience processes are resistance, recovery and anticipation.
- Resistance is measured using MTPD.
- Recovery is measured using RT.
- Anticipation is measured using WIT and WMTTL. These two indicators characterize workarounds.
- The echelon is calculated through MTPD, RT, WIT and WMTTL.

Firstly, the database should be populated with the list of all the processes in a sociotechnical system. Then, for each process, the critical resources should be identified. After this, the potential threats should be presented for each resource. Next, the verification should be carried out, for each risk, to ensure that anticipated workarounds are available. If this is not the case, workarounds should be developed to compensate for the lack. Thereafter, criticality levels (Very high, high, Medium, Low, Very low) should be determined for MTPD, RT, WIT and WMTTL.

In the second place, the parameters can be defined via the user interfaces dedicated for this purpose and which are developed using the framework Tkinter of Python (cf. figure 4)

Then, based on the chosen criteria, the resilience of the selected process can be assessed. Figure 5 illustrates that values of the indicators MTPD, RT, WIT and WMTTL should be inserted to get the resilience score of the process.

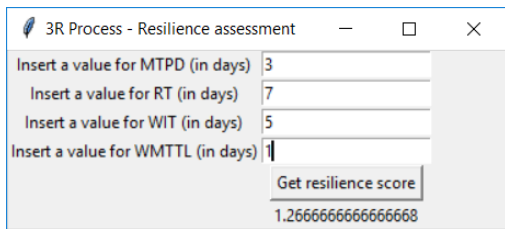


Figure 5. User interface corresponding to resilience assessment

It is clear that for the selected combination ((Process(P1), Resource(P1R1), Threat (P1R1T1), Workaround (P1R1T1W1)), the resilience score is 1.27. That is to say, according to the resilience scale, the process P1 is informed and there is no elaborated resilience process associated with it. The first thing to be done is to try to enhance the resistance of the process/resource to the risk P1R1T1 through increasing the MTPD in order to avoid

the activity interruption and at the same time attempt to recover more quickly. Furthermore, the workaround implementation time should be sharply reduced and the functioning of the workaround P1R1T1W1 should last longer at least until recovery.

On the basis of the given example, the 3R process can be considered as a decision-making tool that helps sociotechnical systems assess their processes as per resilience and hence identify improvement opportunities with the aim of building a system capable of weathering the continuing uncertainty surrounding business environment nowadays.

4. A real case company example – COVID-19 context

COVID-19 is having an unprecedented impact on sociotechnical systems (societies, companies...) and people’s lives and will continue to do so into the foreseeable future. Since the first day, the selected company, which is one of the largest and best-known enterprises operating in the cosmetics sector, has been working on the COVID-19 outbreak in order to ensure its employees’ safety. Country by country as well as globally, the evolution of the situation has been carefully monitored and decisive measures to limit everyone’s risk to exposure have been taken. In order to evaluate the resilience of the company processes against this worldwide crisis, the 3R process method will be applied.

First, the physical distribution process (PDP) is chosen as an example. It is a part of the supply chain organization. Its aim is to ensure that the service to the consumer required by the business is met at the best possible costs by optimizing the inbound (reception and returns), internal (putaway and replenishment) and outbound (order preparation and shipping) physical flows whilst guaranteeing quality and safety in a sustainable environment. The table below summarizes all the crisis phases that the PDP has passed through.

Table 10: PDP behavior during pandemic phases

Crisis step	Events / Country decisions	Supply Chain Impact	PDP Impact	Risk	Workaround
Before outbreak	Pre epidemic decisions	Localize Goods close to the market	Increase pallets to Customer & International Affiliates	Storage saturation	Increase storage capacity (internal or external)
Before outbreak	Pre epidemic decisions	Business Continuity Plans (BCP) & Secondary backup Distribution Center (DC)	Secondary DC carry additional stock	Storage Saturations/Unable to move product systematically	Work with IT to prioritize Storage location creation needed and Catalog extension; Identify key 3PLs that can support pop-up DCs where needed
Before outbreak & Outbreak phase	Epidemic decisions	Lead-time increase	Transport capacity	Lack of carriers and freight-forwarders capacity	Give to suppliers mid-term visibility in order to book slots and capacity + alert Transportation Team if no positive answer from freight-forwarders
Before outbreak &	Epidemic decisions	Costs increase	Transportation costs increase	Spot extra charges for airfreight but also risk on road and sea freight	Inform Transportation Team about requests from freight-forwarders especially for intercontinental flows (sea freight, rail freight & airfreight)

Outbreak phase					
Outbreak phase	Shops closing by authorities without proper anticipation / Population confined at home	Order delivery not possible as shops are closed	Unusual amount of parcels returns to DCs: Cancellation of orders that could've begun picking	Return area capacity saturation unable to manage the flow	Define in advance how to manage this unusual return flow: resize return area / outsource?
Outbreak phase	Shops closing by authorities without proper anticipation / Population confined at home	Customer orders in portfolio not relevant.	Unusual amount of parcels returns to DCs	Useless workload in picking Return area capacity saturation	Verify if customer can still receive goods / reprocessing order portfolio (cancel useless orders)
Outbreak phase	Shops closing by authorities without proper anticipation / Population confined at home	Massive slowdown of order and still inbound flows to come	Increase of pallets to store	storage saturation/"lack of work" for labor on-site	Increase storage capacity (internal or external) Release time while communicating retention bonus plan for future Reduce shift hours throughout day
Outbreak phase	Shops closing by authorities without proper anticipation / Population confined at home	Online orders booming	Increase of e-commerce orders	Capacity (preparation and delivery)	Labor share where sites are in close proximity Work through weekends
Outbreak phase	School closing	Part of employee obliged to stay at home to baby-sit the children	Part of employee in home office / not working (if home office not feasible)	Capability reduction	Identify what are the key processes, the key customers that have to be prioritized: Set-up daycare alternative & reimbursement : alternate shift schedules
Outbreak phase	Health and Safety instructions		Temperature measurement before entering for all employees => delays in workers' access to the DC	Capability reduction	Several simultaneous controls or with thermal camera Verify temperature measurement system data privacy compliancy
Outbreak phase	Health and Safety instructions		Disable fingerprint access control	Less access control	Replaced by personal cards
Outbreak phase	Health and Safety instructions		Flexibility or workforce reduction to	Capability reduction	Extra hours/ Extra shifts

			lower people concentration. Keep a minimum distance of 1 m from other operators. Canteen flow regulation.		
Outbreak phase	Health and Safety instructions		A Covid-19 case confirmed for a DC employee	Capability reduction	Identify what are the key processes, the key customers that have to be prioritized; Shutdown area for 3 hours, neighborhood survey & sanitize area; If site is shutdown, go to secondary DC; Have approved sanitation suppliers confirmed for cleaning support
Outbreak phase	3PL crisis management	Ensure 3PLs follow Health and Safety instructions and have a strong crisis management internally		capability reduction / lock down due to inappropriate actions	Ask 3PL to present measures activated and BCP action plan
Outbreak phase	Stop of none essential activity / epidemic situation in the DC	DC Lock down	Stock not available and shipping stopped		Define heroes products Map heroes products stocks positions worldwide Map twins heroes products worldwide Prepare process to use these twins products
Outbreak phase	DC closed due to government regulation	DC Lock down	Stock not available and shipping stopped	Unable to load products	Prepare list of key SKUs; Preload trailers where items have sufficient coverage based on risk of local government shutdown
Restart period	confine constraints removal	Orders pic	Huge activity at restart	Unable to meet demand	Prepare additional locations for preparation; Offer retention bonus for temporary employees based on seniority

As mentioned previously, the first step of the 3R process method is the definition of parameters. For such needs, the human factor is picked up as a resource. Then, the threat chosen, based on

the table above, is capability reduction due to school closing. Finally, the workaround selected is alternating shift schedules. As per the four indicators, they are determined as follows (table 11)

Table 11: The four indicators time ranges for PDP

MTPD			
Level	Process criticality	Description	Comment
5	Very high	$MTPD < 1 \text{ month}$	The risk of failure is very high since the PDP can handle the capability reduction only for less than 1 month before completely ceasing its activity.
4	High	$1 \text{ month} \leq MTPD < 3 \text{ months}$	The risk of failure is high since the PDP can handle the capability reduction only for a period of time between 1 month and 3 months before completely ceasing its activity.
3	Medium	$3 \text{ months} \leq MTPD < 5 \text{ months}$	The risk of failure is medium since the PDP can handle the capability reduction only for a period of time between 3 and 5 months before completely ceasing its activity.
2	Low	$5 \text{ months} \leq MTPD < 9 \text{ months}$	The risk of failure is low since the PDP can handle the capability reduction for a period of time between 5 and 9 months before completely ceasing its activity.

1	Very low	$MTPD \geq 9$ months	The risk of failure is very low since the PDP can handle the capability reduction for more than 9 months before completely ceasing its activity. This is a sufficient time for the process to recover.
RT			
Level	Process criticality	Description	Comment
1	Very low	$RT < 1$ month	The risk brought about by the disruption is very low since the process can recover in less than 1 month.
2	Low	$1 \text{ month} \leq RT < 3$ months	The risk brought about by the disruption is low since the process can recover in a period of time between 1 month and 3 months.
3	Medium	$3 \text{ months} \leq RT < 5$ months	The risk brought about by the disruption is medium since the process can only recover in a period of time between 3 and 5 months.
4	High	$5 \text{ months} \leq RT < 12$ months	The risk brought about by the disruption is high since the process can only recover in a period of time between 5 and 12 months.
5	Very high	$1 \text{ year} \leq RT$	The risk brought about by the disruption is very high since the process can only recover in more than 1 year.
WIT			
Level	Process criticality	Description	Comment
1	Very low	$WIT < 1$ month	The risk of failure is very low since the anticipated workaround can be implemented in less than 1 month.
2	Low	$1 \text{ month} \leq WIT < 3$ months	The risk of failure is low since the anticipated workaround can be implemented in a period of time between 1 month and 3 months.
3	Medium	$3 \text{ months} \leq WIT < 5$ months	The risk of failure is medium since the anticipated workaround can be implemented only in a period of time between 3 and 5 months.
4	High	$5 \text{ days} \leq WIT < 9$ months	The risk of failure is high since the anticipated workaround can be implemented only in a period of time between 5 and 9 months.
5	Very high	$9 \text{ months} \leq WIT$	The risk of failure is very high since the anticipated workaround can be implemented only in more than 9 months.
WMTTL			
Level	Process criticality	Description	Comment
5	Very high	$WMTTL < 1$ month	The risk of failure is very high since the anticipated workaround can be maintained only for less than 1 month.
4	High	$1 \text{ month} \leq WMTTL < 3$ months	The risk of failure is high since the anticipated workaround can be maintained only for a period of time between 1 month and 3 months.
3	Medium	$3 \text{ months} \leq WMTTL < 5$ months	The risk of failure is medium since the anticipated workaround can be maintained only for a period of time between 3 and 5 months.
2	Low	$5 \text{ months} \leq WMTTL < 9$ months	The risk of failure is low since the anticipated workaround can be maintained for a period of time between 5 and 9 months.
1	Very low	$9 \text{ months} \leq WMTTL$	The risk of failure is very low since the anticipated workaround can be maintained for more than 9 months.

Afterwards, the second step, which is the resilience assessment, should be initiated. Therefore, the inputs are specified in the table below.

Table 12: Specification of inputs

Input	Value (in months)	PDP criticality level
MTPD	12	Very low
RT	Uncertain (Given the fact that there is no visibility concerning the	Very high

	termination of the crisis). For calculation purposes, 12 is taken as value.	
WIT	4	Medium
WMTTL	8	Low

By using the 3R process tool, the plot below (figure 6) is obtained.

By inference, the physical distribution process is aspiring. In fact, the Novel Coronavirus outbreak has some particularities that differentiate it from other disruptions. As a result, the

corresponding resilience process is not yet completely set up. The resistance mission is functioning very well and the anticipation mission is under development. However, the recovery mission is still very ambiguous.

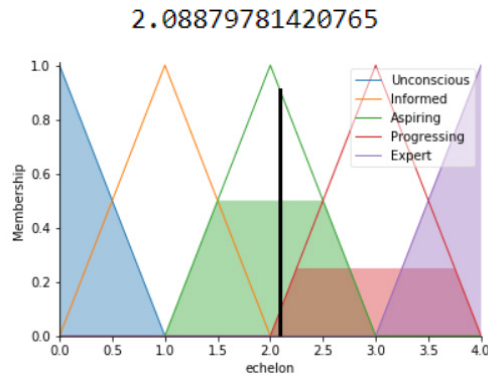


Figure 6: Simulation results for PDP

5. Conclusion

The presented work pointed out a method that can be used by sociotechnical systems to evaluate the resilience of their processes. First and foremost, the resilience scale with its five echelons (0. Unconscious, 1. Informed, 2. Aspired, 3. Progressing, 4. Expert) and three missions (resistance, recovery and anticipation) was introduced. Then, indicators related to these missions have been outlined (MTPD for resistance, RT for recovery, WIT and WMTTL for anticipation). Afterwards, the 3R process was detailed. The 3Rs stand for Resource, Risk and Resilience. This framework is divided into two parts, the first one is the definition of parameters, which consists in determining process criticality levels according on the four selected indicators. Time ranges are defined for the metrics and for each process, critical resources, potential risks and anticipated workarounds are selected and resilience is evaluated for all possible combinations. As for the second part, it is about the resilience assessment. In order to calculate the resilience score (echelon) and rank the process on the resilience scale, fuzzy logic has been used. A fuzzy model has been elaborated and user interfaces have been developed in order to enable decision makers to evaluate their systems and build their resilience. In short, the major advantages of this process are summarized as follows. First, this is a generic method that can apply to any system and help it to define the key indicators, related to resistance (MTPD), recovery (RT) and anticipation (WIT and WMTTL): the three functions of a resilience process, and identify plausible workarounds. Second, it provides a resilience score and a rating as per the resilience scale, which can be useful for detecting and improving weaknesses and also increasing strength and effectiveness to deal with adverse events. Finally, by applying fuzzy logic in the 3R process, the vagueness and uncertainty faced can be overcome. In the last section, a study has been conducted to look at the impact of the COVID19 sanitary crisis on a real case company example and how resilience plays a crucial role in preventing the worst from happening and resuming gradually the normal course of events. In fact, the exposed real case study shows that the pandemic situation has negatively affected the functioning of the studied process. In the aftermath, the process works on improving its resilience, especially, the recovery mission. In the future work, attempts will be made to establish

new methods serving to evaluate the resilience of sociotechnical system processes and enhance it.

Conflict of Interest

The authors declare no conflict of interest.

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Approach to a Logistic Model to Reduce Costs for Delivery at Home of a Seller of Supplies in Times of Coronavirus

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ABSTRACT

Logistics is a science and art that has been widely used by large commercial chains, whose main objectives focus on the distribution of products or services. This understanding has generated various logistics studies directed towards those businesses, without considering that science can also be applied to small or medium enterprises.

The present study initially executes a bibliographic review of multiple works done by several authors that confirm that studies related to the field of logistics can be aimed at any organization. The theoretical investigation of this study is therefore widely supported.

This work is focused on helping a small enterprise continue offering its services during the pandemic caused by the worldwide presence of COVID-19. Hence, the purpose of this research is to present a logistics model that will allow a small supermarket to continue its commercial activities in Quito, Ecuador, in compliance with diverse regulations issued by the Ecuadorian Government. The logistical model uses the methodology called savings method developed by Clarke and Wright.

The designed model produces as a main outcome the establishment of short-distance home delivery routes of provision to customers by the supermarket, thereby achieving significant savings in time and money. Additionally, the design and implementation of the model can serve as an example to be replicated in similar businesses.

1. Introduction

The logistics service well thought out is vital for the survival of a small, medium, or large enterprise. On many occasions, logistics has been visualized as the last link of the delivery of any product or service. Generally, it is the client who must go to a store to use a particular service or purchase a good [1].

However, this thought necessarily had to be reconsidered due to a worldwide health problem, which required looking at businesses from another perspective, forcing companies to modify their ways of doing businesses. Otherwise, they ran the risk of being pushed out of the market from not adapting to the policies issued by the local and national governments which affect the inhabitants of the city of Quito, Ecuador.

For this reason, a small supply chain has had to adapt to the policies and conditions issued by these organizations, which state

that the enterprise could work only by home delivery while the government prohibits on-site service at their facilities. Therefore, in accordance with mandated policies, a logistics model was designed for home delivery by looking for a way to reach customers at minimal cost and adapting the enterprise's activities to an integration process necessary for its commercial survival [2].

With these considerations, the supermarket object of study could choose to halt its activities and possibly resume them when the health situation caused by the pandemic has finished, or continue working while adapting them to the state's policies [3]. These realities demonstrated the need to find a solution by characterizing and identifying the logistical management of the provision of the supermarket services in its work context in Quito, Ecuador. The study, carried out with the support of the business owner, has the following objectives: highlighting the logistical routes applicable for this business-type, based primarily on innovation; and the work-family subsistence of those who are involved directly in these activities [4].

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This study is organized into several sections that present the bibliographic review, the methodology applied, the results achieved, and finally, the conclusions based on the total research carried out.

2. Literature review

Logistics in business is a novelty derived from the concept that it adds value to essential products or services for customer satisfaction and sales [5]. Conversely, for other authors, by citing the American Production and Inventory Control Society (APICS), the term logistics is considered the art and science of obtaining, manufacturing and distributing material and products at a place and in adequate quantities [6]. Therefore, logistics can be considered a science that combines the art of satisfying clients at the moment and placetheydesire.

Logistics is big business in the United States of America. In that country, it represents 8 to 9 % of the Gross Domestic Product (GDP), and this percentage is growing [6]. In Europe, the logistics sector in 2018 represented 8% GDP in most of the countries from the European Union [7].

The use of logistics in any production or service chain is always going to be related to its costs. For example, in the United States, Japan, and Europe, the logistics costs represent under 10% GDP, while in Mexico it represents 13.5% GDP. In India and China it represents 17% and 22% GDP, respectively [8]. In general, in the first world countries, it is noticed in efficient use of their transport systems, including maritime systems, while in the third world countries, it is more common to see a high degree of bureaucracy, as well as inefficiency [8].

According to the Inter-American Development Bank (DIB), in Latin America, the inefficiency of supply chains, and logistics performance in particular hinders competitiveness. Currently, logistics costs represent between 18% and 35% of final product value, which exceeds the percentage registered by the member countries of the Organization for Economic Cooperation and Development (OECD), which is 8% [9]. Additionally, the logistics costs in Latin America and the Caribbean are between 50% and 100% of those of the countries from the OECD [9].

In Ecuador, specifically in Quito, according to a study done by the Municipality of the Metropolitan District of the city, the costs associated with logistics represent between 50% and 60% of the costs incurred by enterprises in production or generation of services [10]. This represents a reasonable limit that halts home delivery in general. Only an approximate percentage of 5% of organizations provide this kind of service [11]. Under this perspective, it is feasible to establish a logistics model that fits the required conditions, which can be used and applied by the supermarket without generating high costs that would increase substantial economic losses for the business.

The logistics model has been studied based on many aspects, for example, the study made in 2014 [9], in which it is established an analysis of the provision of home health services in the Cauca

valley in Colombia [4]. In this research, the authors are focused on showing a diagnosis for the institutions authorized by the Ministry of Health of that country, which objective is to characterize how the home health care providers (HHC) make logistical decisions associated with the service delivery process and identify opportunities for improvement and research. The diagnosis of that model is based on the application of a semi-structured survey, which evaluated six work axis and the maturity degree of the service processes, by showing in its results that it is required more integral management with the logistics decisions and supported on the knowledge of the epidemiologic and demographic profile of the population served [4].

In 2018, in Mexico, the logistics related to the means of transportation and local development of an exporting organization of table grape was studied; this study is characterized by determining the critical processes in the enterprise operation by looking for ways to develop management efficiency mechanisms to meet market demands in product delivery times to customers with minimal operation costs, but without establishing a specific model to comply with [12].

In a study, a logistic model is proposed to reduce the costs of the furniture painting sub-process, whose central objective is to minimize reprocessing and reduce its costs. This is achieved by identifying the behavior of the costs incurred in production through the use of tools and techniques that add value to the products and by increasing the profit margin as those tools are used [2].

In 2017, a compilation of logistic models is presented to solve problems related to integration, coordination, sustainability, and mobility that arise in the urban distribution of goods; specifically focused on an update of scientific literature with a subsequent categorization of the models and techniques used so that in the future the solutions presented would be implemented [13]. Another study called personalization degree of logistic services: service and performance priorities is presented. The authors focus their research efforts on analyzing the relationship between the types of logistic services required and the supply chain priorities, generating two hypotheses related to this study, which result in a significant association between the variables studied [14].

Another author conducted a logistics study in small and medium-sized companies in the state of Jalisco-Mexico [15], whose focus is on determining knowledge of the logistical state in the business sector of the area of study, which describes the main problems that affect logistics performance and, therefore, the export efficiency of the state. The obtained results indicate that there is an association between logistics and export business efficiency in the state previously mentioned [15]. Additionally, the executed work describes the logistical problem is in its primary nodes, customs, carriers, and customs agents. Identifying the primary type of problem defined in this study has a cultural nature because work is not done as an integrated system; each node is seen as unique and essential throughout the value chain,

without understanding that it generates a high cost in the export efficiency of the state [15].

One of the few studies made for small and medium-sized companies (SMEs) in Mexico seeks to strengthen the importance of their competitive position through a conceptual model of logistical management via control of the variables involved [16]. It achieves a conceptual reference for SMEs so that they can reach logistical performance according to their needs by integrating resources, skills, and systems and allowing them to accomplish a competitive advantage regarding other companies [16].

In studies carried out in 2019, other authors analyzed the evaluation of the supply chain by considering the direct relationship between a logistical field and the supply chain, and presenting an evaluation model related to companies of the metalworking sector. The model elaborated comprises five aspects: supply, storage, inventory management, distribution, transportation and/or reverse logistics [17]. These factors include a set of variables that evaluate the planning, execution, measurement, and control of the supply chain management. The conclusion was that in the metalworking sector, due to its sustained growth over time, it is necessary to continuously optimize and improve its processes through permanent monitoring, which facilitates the operational processes that actively contribute to an even more significant growth of this type of organization [17].

The lines above have presented various studies carried out by authors who have executed research work in Latin American countries, who present various scientific analyses related to the logistics field. Logistics, in being a science, can be used anywhere in the world and in any labor field [13]. Ecuador is not exempt from such analyses. The research executed by different authors is mainly focused on theoretical works. Some of them study reverse logistics as a differentiation strategy for dynamic markets, highlighting a qualitative-theoretical, historical-logical, analytical-synthetic, and inductive-deductive approach; they seek in this way to highlight that companies that have applied reverse logistics have improved their competitiveness by reducing costs [18].

Their credibility is reflected in the market due to their efforts to minimize the environmental footprint; concluding that the application of the practices covered by reverse logistics increases the possibilities of differentiation from the competition, since it generates trust and security in consumers [18]. Additionally, other authors present a logistics study in a textile company, analyzing the processes that show the most significant difficulties, in which they focus on the processes of production, logistics, and sales, via the use of documentary tools that identify elements that will allow them to recognize logistical processes for companies in the textile sector that contribute to improving the competitiveness of the sector in general, and present as a result a documentary study that facilitates the improvement of processes through strategic decision making [19].

A similar study to those previously mentioned deals with the evolution of digital information in commercial and integral logistics. The research objective of this work was to review the best catalog for searches, trends, and behavior of scientific production over the years by using web tools such as the Scielo catalog, Scopus, and Redalyc; and by specifying trends through Google Trends and Publish or Perish software, presenting a compendium of relevant logistical studies [20].

A document called Research in Logistics and Transport was elaborated, which was based on comparing Ecuador with other countries from the Andean region (Bolivia, Colombia, and Peru) with regards to studies carried out that concern this topic. The comparison looks at competitive aspects of the countries, and relates each one of the points found as relevant factors to identify which country within the Andean region has the most significant development and research concerning logistics and transport [21].

Logistics can be applied to any labor or scientific field. Thus many people consider it a factor that generates competitive advantage [21]. Under this premise, a study focused on the cosmetics and personal care products industry is analyzed. In that study, the authors present a methodological proposal where they analyze factors and variables that characterize this commercial sector and allow the use of the logistics processes and resources in this type of enterprise by practically and directly explaining how these factors should be used along with their variables [22]. In a different approach, the existing relationship between logistics and the environment was studied through content analysis published with relation to logistical studies and supply chain done between 2005 and 2015, while concluding that it is necessary to design support tools for the inclusion of new processes in logistical issues [23].

The research results of a study that relates supplier management to supply chain management show the proposed model that address an existing relationship between an adequate search of suppliers and a strict control of the supply compliance, by providing vital input to generate efficient strategies in this field, and by collaborating on agreements with the suppliers [24].

Finally, it is useful to address a study that performs a competitive diagnostic of the logistical point of view in the central geographical zone of Ecuador. The authors consider the implementation of integral logistics as a competitive advantage in the current global environment. Moreover, they establish that the management of retail stores contributes to cost-reduction if operations are simplified and information flow is improved [25].

When analyzing each of the works presented by the diverse research to which we refer, a high percentage of conceptual studies based on theories applicable to the logistics field are evidenced. However, they do not specify the concrete application of any methodology that allows companies to make practical decisions in the field. This does not mean there is an inability to apply those studies, rather that they leave open the real possibility of using them in different organizations that require it. Based on

what was analyzed, the study presented below describes how a small supermarket can avoid stopping the sale of its products to customers that request home delivery, by finding efficient routes through the interpretation of a methodology that allows savings in time and cost.

It is important to note that the model designed was structured for a small supply delivery business which lacks the logistical infrastructure owned by medium and giant supermarket chains. The study generates practical-scientific knowledge that can be replicated by other similar organizational structures.

3. Methodology

From the regulations issued by control entities in Ecuador due to the type-2 coronavirus that causes severe acute respiratory syndrome SARS-CoV-2-COVID-19 [26], the sales percentages, in most business, have decreased significantly. Given this situation, among the decrees issued by the Ecuadorian state, the possibility of executing door-to-door sale of food and supplies made by small supermarkets and/or grocery stores was defined by decree number 1052, issued by the Presidency of the Republic of Ecuador [3]. Hence, the study carried out is focused on establishing a logistical model that prioritizes the delivery of supplies or provisions to residential complexes located in the sector known as La Vicentina, in order for the SME to cover the largest number of clients in unique places.

Faced with the present situation, a model of logistical transportation was designed, by using the savings method authored by Clarke and Wright which has persisted for many years [27].

Clarke and Wright’s model has been one of the most implemented algorithms to solve the vehicle route problem method (VRP), and it consists in doing a limited exploration of the search space and giving an acceptable quality solution in a moderate time. The algorithm is developed starting from a solution with two routes (0,..., i,...,0) y (0,..., j,...,0), which can be combined by generating a single route (0,..., i, j,...,0) [28].

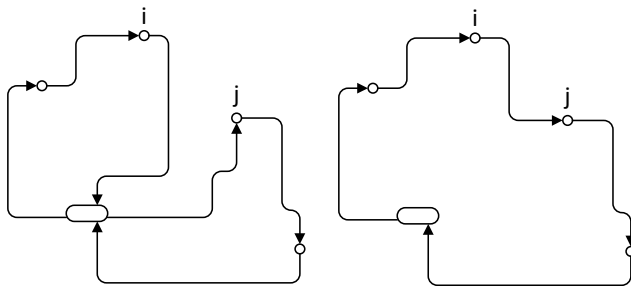


Figure 1: Clarke and Wright’s algorithm

Clarke and Wright’s method details a very flexible procedure that allows the management of a wide range of practical constraints, and whose resolution on a computer is relatively fast [28]. This method applies to the designed model because the comparisons of the optimal results in small problems, such as in

this study case, have shown that the effectiveness of its application generates solutions at 2% of the optimum on average [5].

The objective of using the savings method is to minimize the total distance covered by the vehicles and indirectly minimize the number of vehicles required to make local stops [5]. The logic of the applied model is mainly based on the fact the small supermarket has only one available vehicle. Therefore, by using Clarke and Wright’s algorithm, the mathematical model only considers the existence of a central warehouse as the starting point for all deliveries. The objective function of the proposed model is determined by:

Minimize:

$$\sum_{i \in V} \sum_{j \in V} C_{ij} X_{ij}$$

The constraints applicable to the proposed model are specified by:

$$\sum_{i \in V} X_{ij} = 1, \quad \forall j \in V \setminus \{0\}$$

$$\sum_{j \in V} X_{ij} = 1, \quad \forall i \in V \setminus \{0\}$$

$$\sum_{i \in V} X_{i0} = k$$

$$\sum_{j \in V} X_{j0} = k$$

$$\sum_{i \notin S} \sum_{j \in S} X_{ij} \geq r(S), \forall S \subset V \setminus \{0\}, S \neq \emptyset$$

$$X_{ij} \in \{0,1\}, \forall i, j \in V$$

Constraint number 5 impedes the presence of subtours, where $r(S)$ is the number of vehicles required to meet the demand in S .

Constraints numbers 5 and 6 have cardinalities that grow exponentially with n , thus, they are replaced with a family of constraints with polynomial cardinality [28]. For the study case, they were set according to the following:

$$u_i - u_j + Q_{ij} \leq Q - d_j$$

Considering that $d_i + d_j \leq Q$

Therefore: $d_i \leq u_i \leq Q$

where:

V: node set $V = \{V_0, V_1, V_2, \dots, V_n\}$, V_0 is the warehouse

A: edge set $A = \{(i, j) : i, j \in V, i \neq j\}$

d_i : node demand i

k : number of available vehicles

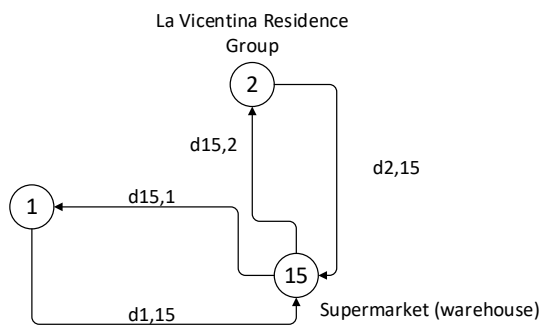
Q : vehicle capacity

By mathematically setting the model design, it is possible to verify that its theoretical characteristics are necessary and ideal to establishing a pattern on which the vehicle belonging to the business returns to its facilities only when it has made all the deliveries. The designed model establishes that this delivery is adapted to the needs of the businesses that are the objects of study, and it can be used for a long time [27]. Considering the opinion of an epidemiological expert whose statements say that the SARS-Cov2 virus will remain for an indefinite time, forcing businesses and people to adapt to living with it, if desired the world economy and its activities to be regularized [29]. In such circumstances, the savings method for the programming and route design is adjusted to the supermarket's needs, by seeking the maximum savings in cost and distances to cover.

Subsequently, and with the theoretical support provided below, with the help of Google Maps, it is possible to visualize the specific places where supplies and provisions are to be delivered, which are identified numerically with small blue circles, as shown in Figure 2.



Figure 2: locations of delivery sites

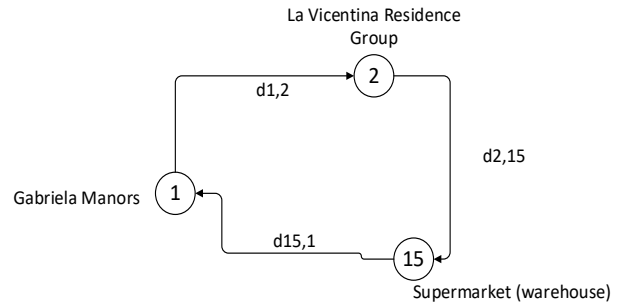


Initial route: route distance= $d_{15,1} + d_{1,15} + d_{15,2} + d_{2,15}$

Figure 3: the maximum distance route

Initially, with the help of a single vehicle, by simulating covering each stop and immediately returning to the supermarket, identified as number 15, the route to be covered would result in the maximum distance experienced for the delivery of supplies, as is represented in Figure 3.

Nevertheless, when considering the saving of minimizing the distance that must be covered, the vehicle can combine a route or many routes, which would be found by algebraically subtracting the initial distance with the proposal represented in Figure 4:



Combination of two stops= $d_{15,1} + d_{1,2} + d_{2,15}$

By carrying out the algebraic operation of the operations previously defined in Figures 2 and 3, a savings value of $Z = d_{15,1} + d_{2,15} - d_{1,2}$ would be obtained. This calculation is performed for all pairs of stops. The pair of stops with the highest savings value is selected for the respective combination.

This process is a continuous combination because, to combine single stops as in the previous case, the process can add another stop on a route that already contains multiple stops. For example, if point 7 were inserted between stops 1 and 2 where those points are on the same route, the value to be saved would be expressed as follows: $Z = d_{15,7} + d_{7,15} + d_{1,2} - d_{1,7} - d_{2,7}$. On the other hand, if stop seven were inserted after the last stop, point 2, the value of the route savings would be: $Z = d_{2,15} - d_{2,7} + d_{15,7}$. By contrast, if stop 7 were inserted before stop 1, the value of the savings would be: $Z = d_{7,15} - d_{7,1} + d_{1,15}$. These savings calculations are repeated as progress is made in solving the problem. With this procedure, the highest savings value identifies the stop that should be considered for inclusion in a route.

If a particular stop, due to some circumstance or constraint, cannot be included, such as the route being excessively long or the capacity of the sole vehicle being exceeded, the stop with the next highest savings value is considered for inclusion; in the same way, this process would be repeated until all points or stops have been considered. This argument is supported due the strength of the method is the ability to simultaneously assign a stop to a specific route and place it in an area in the sequence of the route. In such circumstances, before accepting a stop on a route, the route must be provided with the new stop [5].

Therefore, the use of the only available vehicle by the supermarket must be programmed to send all orders for the week according to the schedule issued by government-controlled entities (06h00-13h00). Such orders can only be complied with by having only one departure in the morning and returning after all deliveries have been made. It is important to note that the dispatchers will be fed before and/or after the delivery of all the provision requests, considering that there is no constraint on this

issue. The average driving speed is 50 km/h, in compliance with the maximum speed limit allowed within the city of Quito. Additionally, the calculation of the costs related to the dispatches – based on the salaries or wages of the staff that make the deliveries, the budget for the purchase of supplies and provisions to be delivered, fuel consumption, and car maintenance costs – equates to an economic value of USD 5.50 per kilometer driven.

The model is posed in the software Logware Version 5.0 for Windows, which is formed by a collection of useful programs to analyze a wide variety of issues related to the management of logistic supply chains. The software has a module named “Route” that allows the user to determine the shortest route in a route network and to input multiple constraints based on the designed model.

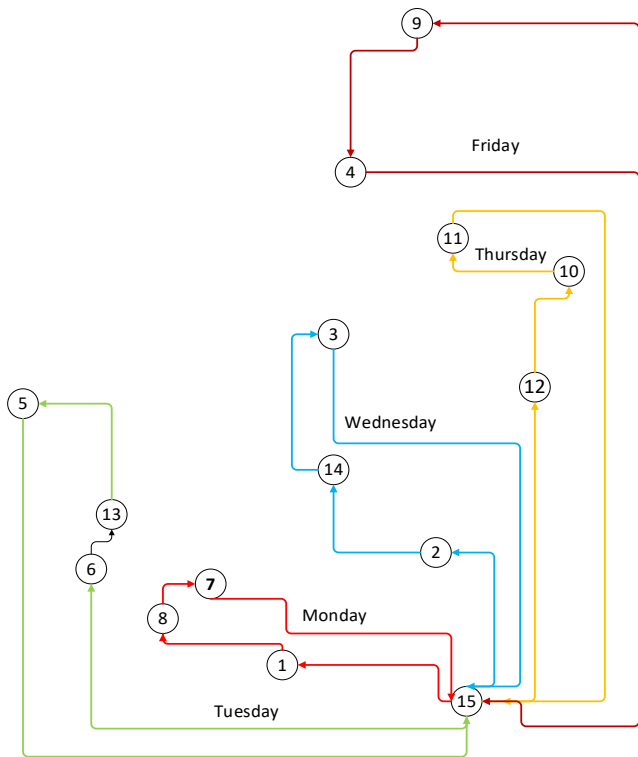


Figure 5: delivery provision routes

When these data were input into this software, and after several ride simulations, the feasible sequences to be implemented were found according to the details in Table 1.

When carrying out the respective work in Logware through the use of the “Route” software which allows the user to consider several additional constraints within savings assessment, enter the respective data, and execute route simulations the feasible sequences to be implemented were found, and are detailed in Table 1.

According to the data found and the determined economic value based on kilometers driven, the weekly cost for home delivery of provisions is USD 206.30. The graphical representation of the routes is illustrated in Figure 5.

Table 1: Optimal Routes to deliver provisions

Route	Sequence	Start Time	End Time	Route Distance (km.)	Route Time (hours)	Delivery Weight (pounds)	Truck size (pounds)
Monday	15,1,8,7,15	08:00	11:00	6.32	3:00	750	1000
Tuesday	15,6,13,5,15	08:00	11:30	7.55	3:30	775	1000
Wednesday	15,2,14,3,15	08:00	11:30	6.83	3:30	790	1000
Thursday	15,12,10,11,15	08:00	12:30	8.05	4:30	900	1000
Friday	15,9,4,15	08:00	12:00	8.76	4:00	810	1000
TOTAL				37.51	17.9	4,025	

Source: Logware for Windows

4. Conclusion

The result achieved with this study provides an opportunity for a small supermarket to be able to continue with its work by delivering provisions at home in its direct area of influence while covering the largest number of customers through direct delivery in residential complexes. The model reflects the optimal weekly routes that the supermarket under study must use in order to comply with its customer’s orders and thereby achieve significant savings in time and related costs.

This model was developed using the “savings method” logistics methodology through the Route module of the software program Logware, which facilitated running various simulations of routes that could potentially be applied. This software allows the user to find the shortest driven route in a route network, while making it possible to cover those distances at lower costs than empirical methods. The ideal route found shows that the transport of provisions can be performed weekly by covering a total distance of 37.51 kilometers at a cost of USD 206.30.

The results achieved enabled the supermarket to continue working in compliance with the requirements of the state control authorities of Ecuador, while also allowing a certain number of collaborators to keep their jobs and continue working during a difficult time for labor and economy. The formulation of the logistics model designed by using the savings method made it possible to form a model that has a sequential distribution of daily routes, thus facilitating the identification of additional constraints that could be used in the future to determine certain possible events that may be studied. It is important to mention that the model proposed for the supply business can be replicated by similar businesses, or by commercial establishments that want to make home deliveries while optimizing time and money.

The future work to perform is the determination and allocation of routes to new customers, considering especially that the global health problem will not be easily solvable in the short term, and that this model will allow the supermarket to increase its number of customers.

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