

**Restarting Manufacturing Industries Post Covid-19: A Mind Map Based Empirical
Investigation of the Associated Challenges in Business Continuity**

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Restarting Manufacturing Industries Post-COVID-19: A Mind Map-Based Empirical Investigation of the Associated Challenges in Business Continuity

Abstract

This research aims to identify the critical challenges associated with restarting manufacturing organizations post-coronavirus disease 2019 (COVID-19). We conducted an expert-based survey among various industry leaders of manufacturing organizations to capture a holistic view of business continuity plans and the associated challenges. The selected individuals are responsible for making business continuity policies and plans at their respective organizations. They were asked to reflect on their experience of the present-day challenges in managing business continuity in their organizations. Expert interviews were reflective and provided candid inputs. Consequently, the keywords of the experts' feedback were synthesized by using the mind map qualitative approach, which helps in the visualization of the critical challenges at an abstract level. Further, the interrelation between them and the significance of each critical challenge is evaluated using fuzzy theory with the Decision-making trial and evaluation laboratory (DEMATEL) technique. The findings of these evaluations will help to assess the existing policies/practices and to strengthen business continuity plans post-COVID-19. This study is a pioneering work that will help organizations to prepare action plans for kick-starting their broken down economic engines.

Keywords: COVID-19, coronavirus, business continuity, manufacturing, mind map, fuzzy, fuzzy DEMATEL, supply chain

1. Introduction

Most nations of the world today face the calamity caused by the COVID-19 pandemic. It has necessitated instant and coordinated response from society. Leaders all over the world are confronting twin apprehensions: how severely has the COVID-19 outbreak battered the economy and what actions should be undertaken to prepare for the possible challenges. Considering the global footprint of COVID-19, the World Health Organization (WHO) acknowledged it as a pandemic. This disease, which started in China, has spread across the world, causing countries to close their borders. Country administrations are imposing national quarantines on their people in different forms, which has created worldwide economic chaos (Kruger et al., 2020). The COVID-19 pandemic is taking a substantial toll on the worldwide economy (Gong et al., 2020; Ivanov, 2020; Nicola et al., 2020). The International Monetary Fund (IMF) has projected the global growth to drop considerably in the year 2020, calling it the worst year since the Great Depression (Ayittey et al., 2020; Gormsen and Koijen, 2020; Mendoza, 2020). Millions of people and their livelihoods are affected and jobs have been (Ayittey et al., 2020; Kartseva and Kuznetsova, 2020; Nicola et al., 2020).

Today, the entire world is struggling to control the pandemic (Ivanov, 2020; Nseobot et al., 2020; Sohrabi et al., 2020). The administrations have been taking series of speedy, all-inclusive, and effective preventive measures to contain the spread of the pandemic. Unfortunately, despite measures taken, the pandemic has gripped entire nations, creating unprecedented pressure on medical services (Galanakis, 2020; Rowan & Laffey, 2020). Besides, lockdowns in developing countries are even more catastrophic for socio-economic wellbeing since there is neither considerable assistance for small industries nor are there job loss welfare measures (Nseobot et al., 2020). With the surge in COVID-19 infections, towns are under lockdown, industries are shut down, and tourism and travel are frozen (Nicola et al., 2020). It is also expected that workforce layoffs will escalate. The situation is more critical in

developing countries, which are also fighting with the issues of the shortage of resources (Khan and Ghauri, 2020). Globally, various nations are facing a massive drop in GDP. Going forward, governments are thinking intensely about policies to partially lift lockdowns, which can help to restart economies while minimizing threat to human lives (Bénassy et al., 2020; Gilbert et al., 2020). Likewise, industries will need to figure out in what manner they should resume their set-ups while prioritize the safety of their workforce and dealing with the repercussions of lockdown and its immediate, near-term and long-term implications (Ivanov, 2020; Hudecheck et al., 2020). Thus, while the effect of COVID-19 on the international economy is at a nascent stage, there is a rising consciousness in business communities that organizations need to be equipped to deal with this pandemic in their backyards (Fadel et al., 2020; Koonin, 2020; Kruger et al., 2020).

Although the majority of nations and industries are still very much in the disaster-controlling phase of COVID-19, certain companies are planning to explore the policies that will help in restarting their businesses. While prioritizing the health and safety of the workforce and business continuity, they are reviewing the strategies to overcome the potential challenges. This involves considering what course corrections they must make by considering technical advances, changing consumer and worker behavior, the necessity for organizational swiftness and resilience, and the expanded role of leaders. Indeed, corporations should be assimilated into the administrative health contingency plan established by numerous nations, International Labour Organization, and WHO. Similar to earlier health crises, the COVID-19 outbreak has raised questions about preparation and emergency responses in a number of countries. In this catastrophe, what part can businesses play is a nerve-wracking question?

Kato and Charoenrat (2018) and Niemimaa et al. (2019) acknowledged that the identification of key risks and challenges is a significant part of business continuity planning. In this regard, it is crucial to review the business continuity plans considering the issues and challenges related to the COVID-19 (Koonin, 2020; Kruger et al., 2020). The COVID-19 pandemic is generating insecurity in the business environment, massive slowing of the supply chains, tumbling business assurance, and snowballing anxiety among consumer segments (Hudecheck et al., 2020; Ivanov, 2020; Rowan and Laffey, 2020). The overall consequence of the pandemic is impacting the manufacturing process of numerous industries (Nicola et al., 2020). Due to the COVID-19 outbreak, manufacturing operations worldwide are witnessing unforeseen disruption (Nicola et al., 2020). There is a need for organizations across the globe to be predictive and proactive in their decision-making for preserving business continuity as well as building enterprise resilience (Koonin, 2020; Kruger et al., 2020).

The primary focus in the present-day situation is on understanding and adjusting to the incredibly disturbed state of affairs (Dun and Bradstreet, 2020; Ranney et al., 2020). The manufacturing sector is vital to the continual progression of the nation's economy. Industries all over the world are struggling to manage their operations and supply chains in face of the interruptions posed by the coronavirus (Ivanov, 2020). It has exposed the vulnerabilities of several establishments, chiefly those who have a high dependence on long supply chains (Dun & Bradstreet, 2020; Koonin, 2020; Nicola et al., 2020; Wuest et al., 2020). The virus could turn out to be a black swan event, which may force governments to transmute their strategies and operating plans (Ivanov, 2020). Koonin (2020) and Kruger et al. (2020) have highlighted that companies that regularly examine and update their pandemic management plan can minimize their losses considerably.

The review of existing plans would also play a crucial part in protecting workforces and consumers' wellbeing and safety and curtail the adverse influence of a pandemic on society

and economy (Adams and Walls, 2020; Ivanov, 2020; Koonin, 2020). From the aforementioned studies, it is apparent that there is a great need to review the challenges associated with business continuity of organizations post-COVID-19. Driven by this need, this research aims to answer two research questions. Firstly, what are the key challenges associated with the starting of the operations in the post-COVID-19 restart of companies? Secondly, the evaluation of interrelation and the significance of the identified challenges using appropriate statistical methods.

To answer these questions, firstly, an endeavor is made to identify the critical challenges associated with the restarting of operations post-COVID-19 pandemic. This is carried out by a literature review and one-to-one interviews with experts using qualitative research methodology. Secondly, the significance of each critical risk and the interrelation between them is evaluated using the fuzzy DEMATEL technique. This research uses the fuzzy DEMATEL process (Kumar and Dash, 2016; Kumar and Dash, 2017; Kumar et al., 2018; Ahuja et al., 2019) for establishing the interrelation between the identified challenges in revising business continuity plans. This is possibly the utmost demanding task that administrations face today: to create a responsible business restart plan.

This research work is structured as follows. The literature review and validation of the challenges are done in section 2. The overview of the research methodology is given in section 3, followed by the results, analysis, and discussions in section 4. Finally, conclusions that summarize contributions, limitations, and directions for future research are given in section 5.

2. Literature Review and Expert Validation of Business Continuity Challenges Post-COVID-19

This section encompasses literature on challenges associated with restarting manufacturing industries post-COVID-19 and their validation by experts. In the first part of this section, existing literature on COVID-19 and its associated challenges are reviewed, this laying a foundation to build a primary thought process. Secondly, affinity data of expert feedback was collected for the identified challenges using a Likert scale of 0 to 4, where 0 means no affinity and 4 means very high affinity with the restart of the manufacturing organizations post-COVID-19. The validation of the work was done through the confirmation of $n = 52$ industry leaders of the identified challenges in ensuring the meaningfulness and trustworthiness of findings before proceeding to further analysis. The identified experts are responsible for making business continuity policies and plans in their respective organizations. The overview of challenges posed by COVID-19 in the domains of socioeconomic condition, health and wellness, organizational and human dynamics, supply chain and logistics, financial, demand environment, emergency preparedness, communication, and business model aspects along with the mean score and standard deviation of experts' feedback (scale 0–4) is presented in Table 1.

Table 1: Overview of the challenges affecting the restart of business post-COVID-19

S. No	Challenges	Mean score	Standard deviation	Overview	Sources
1	Health and wellness	3.85	0.23	Challenges related to physical, mental, and social wellbeing, i.e., minimizing exposure to COVID-19, safety, respiratory hygiene, identification of sick individuals, history of travel to COVID-19-affected areas, lack of societal cohesion, post-traumatic stress disorder (PTSD), and anxiety disorders	Ayittey et al., 2020; Bénassy et al., 2020; Fadel et al., 2020; Galanakis, 2020; Gong et al., 2020; Gormsen and Koijen, 2020; Gilbert et al., 2020; Kartseva and Kuznetsova, 2020; Koonin, 2020; Kruger et al., 2020; Mendoza, 2020; Nicola et al., 2020; Rowan and Laffey, 2020; Sohrabi et al., 2020
2	Organizational and human dynamics	3.73	0.34	Maintaining appropriate physical distancing, contact with contaminated surfaces, workplace safety management, rules and procedures, including work from home, workplace guidance, awareness, and training	Bénassy et al., 2020; Gong et al., 2020; Hafiz et al., 2020; Hudecheck et al., 2020; Kartseva and Kuznetsova, 2020; Kruger et al., 2020; Mendoza, 2020; Nicola et al., 2020
3	Supply chain & logistics	3.65	0.29	Challenges related to sourcing of raw materials, processing, just-in-time manufacturing, inventory, packaging, storage, supply chain visibility, import/export, and port restrictions, distribution while managing the unpredictability and disruptions posed by COVID-19	Ayittey et al., 2020; Bénassy et al., 2020; Dun & Bradstreet, 2020; Galanakis, 2020; Gong et al., 2020; Gormsen and Koijen, 2020 al., 2020; Gilbert et al., 2020; Hafiz et al., 2020; Hudecheck et al., 2020; Ivanov, 2020; Mendoza, 2020; Nicola et al., 2020; Rowan and Laffey, 2020; Sohrabi et al., 2020; Shao, 2020; Wuest et al., 2020)
4	Financial	3.59	0.18	Challenges related to the management of the cash flow, working capital, budget, capital expenditures, payments, unforeseen expenses, lack of fiscal and monetary capacity, and low revenues during COVID-19 pandemic	Ayittey et al., 2020; Bénassy et al., 2020; Gong et al., 2020; Gilbert et al., 2020; Hafiz et al., 2020; Ivanov, 2020; Kruger et al., 2020; Kartseva and Kuznetsova, 2020; Mendoza, 2020; Nicola et al., 2020; Rowan and Laffey, 2020; Sohrabi et al., 2020; Shao, 2020
5	Demand environment	3.62	0.25	Manging demand shocks, both positive and negative, as organizations and their suppliers respond to changing needs, consumption, and spending patterns of global customers in the unpredictable and disruptive	Ayittey et al., 2020; Bénassy et al., 2020; Galanakis, 2020; Gong et al., 2020; Gormsen and Koijen, 2020; Hafiz et al., 2020; Mendoza, 2020; Nicola et al., 2020

				business environment posed by COVID-19.	
6	Emergency preparedness	3.56	0.35	Preparedness planning to respond effectively to outbreaks and epidemics, i.e., medical responsiveness, rules and procedures, quarantine facilities	Bénassy et al., 2020; Fadel et al., 2020; Galanakis, 2020; Gong et al., 2020; Gormsen and Koijen, 2020; Gilbert et al., 2020; Hafiz et al., 2020; Mendoza, 2020; Qing et al., 2020; Rowan and Laffey, 2020; Sohrabi et al., 2020; Shao,2020
7	Business model	3.68	0.28	Challenges in the development of new business models to create new customer value, safety requirements, distribution channels while enabling new revenue schemes in the altered competitive landscape	Mendoza, 2020; Nicola et al., 2020
8	Communication	3.43	0.23	Communicate simply and frequently with all stakeholders and acknowledgment of the difficult situation	Bénassy et al., 2020; Galanakis, 2020; Gormsen and Koijen, 2020; Hafiz et al., 2020; Mendoza, 2020; Nicola et al., 2020; Rowan and Laffey, 2020

Occupational safety and health standards necessitate companies to ensure adequate organizational as well as emergency controls to offer employees a safe and healthy workplace that is free from hazards (Ghahramani and Salminen, 2019). Barbieri et al. (2020) highlight that there is a direct correlation between exposure to transferrable viruses and the physical proximity of workers. Consequently, in Italy, approximately 67% of manufacturing workforce is under high risk of infection by COVID-19 (Barbieri et al., 2020), which poses the challenge of enforcing organizational and emergency controls. Likewise, Baker et al. (2020) highlight that nearly 26.7 million workers in the USA have exposure to the COVID-19 at least once a month. Accordingly, the administration faces the challenge of improving organizational and emergency controls that may minimize the threat of Coronavirus or its dispersion in the workplace.

In line with Baker et al. (2020), Dyal (2020) highlights that improvement in physical distance, personal hygiene, along with disinfection and adequate training may reduce the risks posed by COVID-19 in the manufacturing sector. As the outbreak of COVID-19 is increasing rapidly, businesses across the globe are facing the challenge to swiftly fine-tune their processes to myriad situations that can affect their business continuity. Health and wellness have been brought to the forefront of corporate priorities, and this development is in line with Gong et al. (2020) and Koonin (2020). Viruses and other forms of biological catastrophes are real global threats to operational continuity. Employees older than 60 years of age and people with medical complications like hypertension, heart problems, breathing illness/asthma, tumors, or diabetes are at advanced risk for increasing serious complications to fellow employees (Carlos et al., 2020). Besides, there are challenges of social distancing in common areas, which are also highlighted by Gilbert et al. (2020) and Fadel et al. (2020).

Araz et al. (2020) highlight that the dispersal of COVID-19 is leading to the breakdown of numerous global supply chains. Likewise, Linton and Vakil (2020) highlight supply chain-related challenges in approximately 1,000 global organizations. With a huge number of industrial units shut down worldwide, supply chains have been affected around the globe. Because COVID-19 has led to lockdowns, and logistics service providers can no longer flawlessly transport goods across borders (Dun & Bradstreet, 2020; Nicola et al., 2020; Wuest et al., 2020). COVID-19 is a supply shock as well as a demand shock. Both facets will impact international business markets. Baldwin and Tomiura (2020) highlight that approximately 55% of supply and demand, 60% of manufacturing, and 50% of manufacturing exports across China, Korea, Japan, USA, and Germany, are affected by the COVID-19, which poses challenges for the demand environment, supply chain, financial as well as business model issues. In such circumstances, the manufacturing sector is hit by the disruptions in supply chain, hindering production, as well as the shocks on the demand side.

Businesses all over the world are stressed to manage their operations and fragile supply chains due to the interruptions posed by the COVID-19 (Ivanov, 2020). It has revealed the vulnerabilities of several organizations, predominantly those who have a great dependence on longer supply chains and just-in-time supplies (Dun & Bradstreet, 2020; Koonin, 2020; Nicola et al., 2020; Wuest et al., 2020). Fernandes (2020) also highlighted that approximately 75% of the American organizations face the challenge of supply chain disruptions due to a shortage of raw materials as well as final parts. This is exacerbated by the scarcity of freight options to ship products across the globe.

The disruption in the supply chain and demand environment will also pose the challenge of increase in the cost of business for the manufacturing sector (Fernandes, 2020). Besides, Kuckertz et al. (2020) highlight the issues of cash flow, working capital, budget, capital expenditures, payments, lack of fiscal and monetary capacity, and low revenues that are being faced by small- and medium-scale organizations during COVID-19 pandemic. Likewise, Nicola et al. (2020), in the research of socio-economic implications of COVID-19, point out that approximately 80% of the respondents anticipate a decline in financial turnover. Furthermore, approximately 98% of the respondents expect negative growth during the current pandemic, leading to the huge financial as well as business model challenges (Nicola et al., 2020). This is also triggered by the changes in the consumption and spending patterns of global customers as well as new safety requirements posed by COVID-19.

2.1 Literature gaps and research objectives

The review of the extant literature highlights the role of COVID-19 in affecting the business continuity of the numerous organizations. Prominent scholars have also highlighted the challenges in health and wellness, organizational and human dynamics, supply chain and logistics, financial, demand environment, emergency preparedness, business model, and communication (Table 1). As industries navigate uncharted and choppy waters, business leaders might want to contemplate how they can prepare their establishments to face the disruptions (Adams and Walls, 2020; Dun and Bradstreet, 2020; Gates, 2020). Also, Kato and Charoenrat (2018) and Niemimaa et al. (2019) acknowledge that identifying key risks and challenges is a significant part of business continuity planning. Building upon this, Koonin (2020) and Kruger et al. (2020) indicate the need to identify and validate the business continuity challenges during COVID-19. However, it is important to note that most of the existing work in this area is at an abstract level, lacks rigor, and lacks empirical testing and validation. Furthermore, very few studies focus on the challenges associated with the restarting of

manufacturing industries post-COVID-19. Based on this identified gap, the objectives of this research are as follows:

- Identifying the critical challenges associated with the restarting of manufacturing operations post-COVID-19
- Evaluating the significance of each critical challenge and the interrelation between them

The next section explains the methodology of analysis used to achieve the research objectives.

3. Research Methodology

The main objective of this study is to determine the critical challenges associated with the restarting of manufacturing units post-COVID-19. Identifying the critical challenges and understanding the interrelation between them would help to revise the business continuity plans and to make appropriate decisions ensuring preparedness of the manufacturing unit post-COVID-19. This research employs a two-phased approach. In the first phase, an expert survey among $n = 52$ industry leaders and policymakers primarily from India, Bangladesh, Indonesia, USA, Brazil, and Indonesia is carried out to capture their views on the challenges associated with restarting manufacturing organizations post-COVID-19. The sample for this study involved 52 experts from 45 industries in the COVID-19-affected nations who are working towards business continuity in respective organizations. The experts were carefully selected from professional networks and databases of the ministries of the industrial promotion of the surveyed countries. The average revenue and workforce of the represented businesses in 2018 were USD 5 million and 1,640 employees, respectively. Given the novel nature of this investigation, the research methodology and sample size are satisfactory and in line with the demands of research pragmatism (Buchholz et al., 2009). An expert survey has been used in this study bearing in mind the possible problems in the collection of the data the pandemic and the novel nature of the work. This is significant because very few establishments have executed a business continuity plan in the disruptive environment posed by COVID-19. All the chosen experts hold at least a bachelor's degree and are involved in implementing business continuity frameworks. The first round of interviews was conducted one to one over telephone/online Zoom platform/Google Meet. The virtual interactions lasted from 20 minutes to 30 minutes per expert, where experts were asked to share their perspectives on the challenges mentioned in Table 1.

The virtual interactions helped in rephrasing and restating the critical issues for evaluating the accuracy of the information. Interviews were reflective and provided genuine inputs. As the respondents were highly experienced and senior professionals in the industry, we followed certain protocols. For instance, at first, we sent e-mails to the identified experts to explain to them the objective of the study and requested them to contribute by providing a suitable time for the interaction. At the end of the first round of the survey, the response data was compiled to make a mind map of the experts' feedback on the critical challenges identified in Table 1, i.e., for the restart of the companies post-COVID-19. The mind map thus generated is shown in Figure 2.

To evaluate the interrelation between the parameters and to study the significance of each identified challenge, the DEMATEL technique—developed by Gabus and Fontela (1972) at the Geneva Research Center of the Battelle Memorial Institute—was used. Diagraphs, which are typically the outcome of this technique, help in visualizing and understanding the interdependency between variables. The AHP methodology is useful for computing the weight of the criteria (Saaty, 1990; Dağdeviren and Yüksel, 2008; Kumar and Dash, 2016). Also, the

AHP methodology reveals better results than the other knowledge-based decision methodologies, i.e., ANP, TOPSIS, and ELECTRE (Harputlugil et al., 2011). Also, it is comparatively easier to understand and apply (Mangla et al., 2015). However, the application of AHP also poses some limitations to the subjectivity of human judgments (Abdullah and Najib, 2016; Mangla et al., 2016). Since the perception of decision-makers varies for a particular query, fuzzy judgment scale is adopted while collecting the responses. This would benefit from capturing the ambiguity in decision making (Van Laarhoven and Pedrycz, 1983). It may be noted that the organizations in other sectors can implement a similar approach. This method is used in various decision-making techniques like line balancing, supplier selection, performance evaluation, service evaluation, sustainable production, etc. (Ertuğrul and Karakaşoğlu, 2009; Avikal et al., 2014; Abdullah and Najib, 2016; Mangla et al., 2016). The typical steps involved in the empirical investigation of risks associated with the restart of business in manufacturing organizations post-COVID-19 are shown in Figure 1.

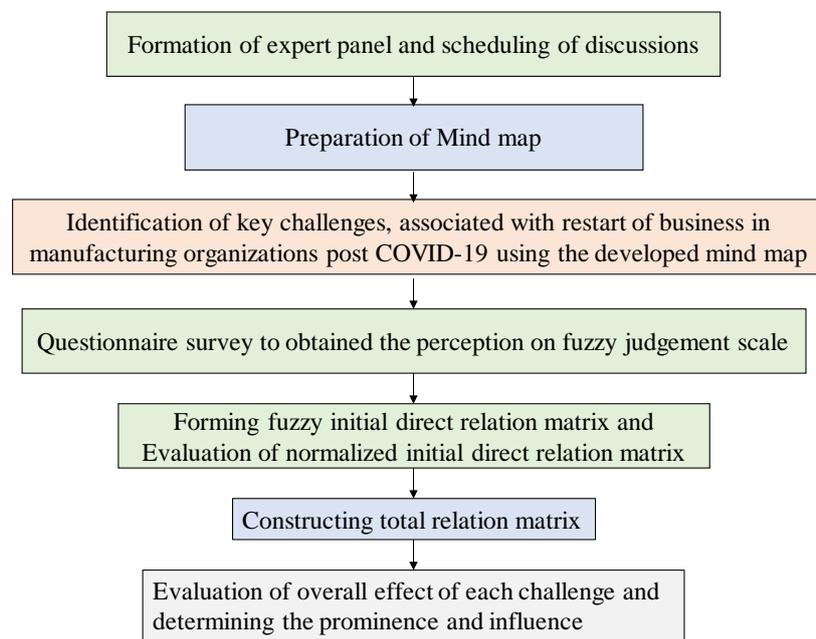


Figure 1. Schematic illustration of the steps involved in identifying prominent key challenges

As mentioned in the previous sections, a preliminary survey was conducted to prepare a mind map that depicts the vital challenges (Figure 1). Subsequently, an expert panel was constituted by identifying the resource persons involved in the management activities of a manufacturing unit. The perception of each decision-maker on the identified key challenges was collected. The key challenges include health and wellness, organizational and human dynamics, supply chain and logistics, financial, demand environment, emergency preparedness, communication, and business models.

4. Results, Analysis, and Discussions

4.1 Mind map analysis

At the end of the first phase of the survey, the keywords of the expert's feedback about the challenges associated with restarting manufacturing industries post-COVID-19 were summarized in a mind map (Figure 2).

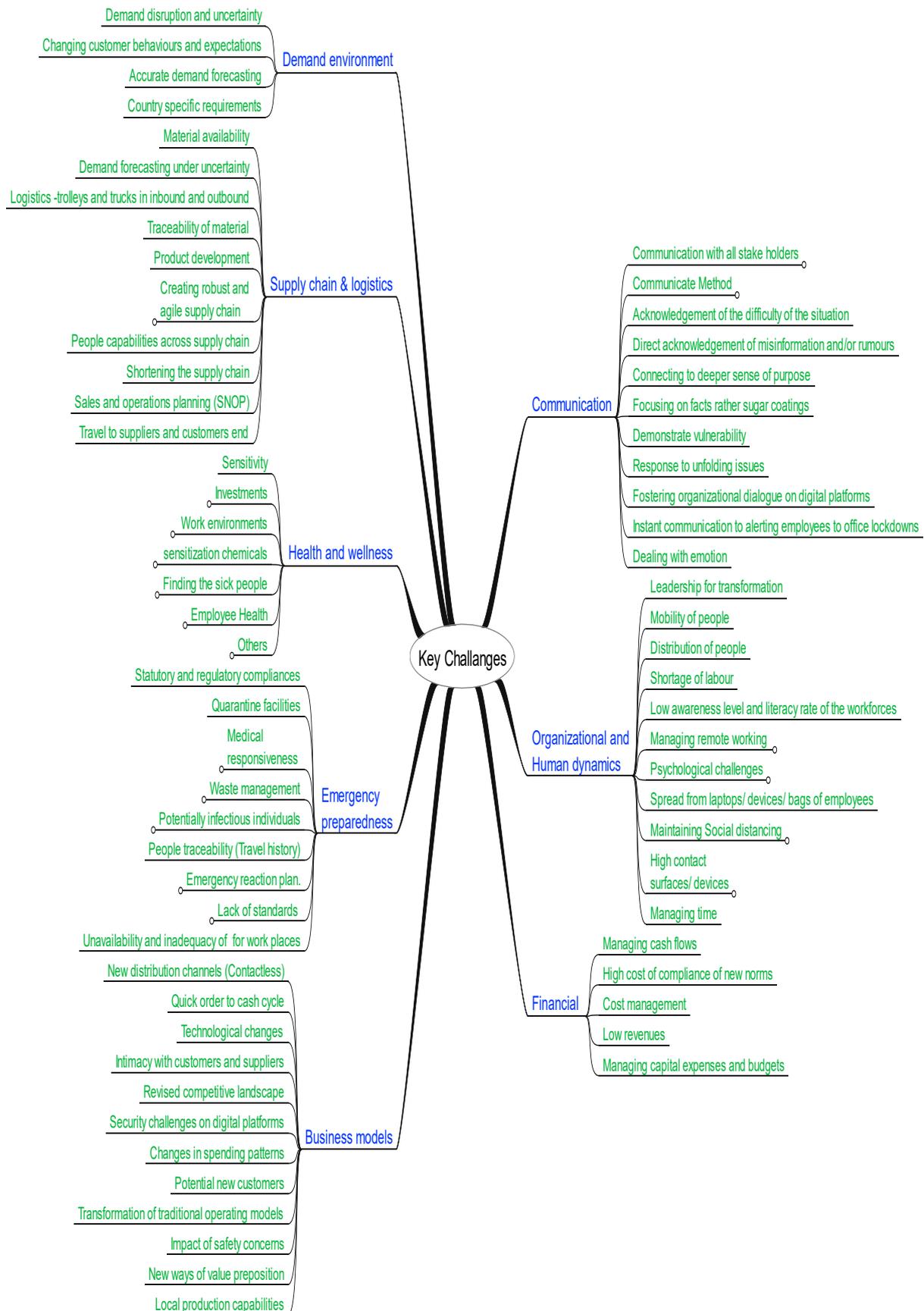


Figure 2: Mind map of experts’ feedback on the critical challenges associated with the restart of companies post-COVID -19 pandemic

4.1.1 Discussion of mind map analysis

Post-COVID-19, organizations need to address the fragility of the current supply chains, which is observed during this lockdown period. The susceptibility and risks for organizations are evident from the long supply chains, long lead times, and inflexibilities. Therefore, there is a great need for shorter and leaner supply chains that are synchronized from customers to suppliers. The volatility and uncertainty of demand and supply require more transparency and visibility across all elements of the supply chain. Organizations are dealing with a variety of financial complications in the face of the unpredictable COVID-19 pandemic and its impact on businesses of all the sizes.

In the face of a crisis, specifically, where the business situation is fluctuating daily, constant monitoring of developments and swift response to changes are particularly significant for the industry. Public and private corporations must endure to produce or deliver their services, but with thoughtfulness from the employee-wellbeing perspective. There is no “one-size-fits-all” method to deal with this situation as each business may have its unique operating needs. As per experts, this involves better detection and surveillance of illness among employees and visitors coming to the workplace. Furthermore, these resources help in the identification of high-risk groups and isolation based on the risk severity by providing proper personal protective equipment (PPE). Organizations need support from administrations to get individuals back to workplaces. Also, organizations need to start planning their budgets and provide investments for building better and more elaborate infrastructure to manage and rapidly react to health issues. Soliciting direct feedback and ideas from workforces, especially on sanitization issues at the workplace, might help further minimize the menaces of transmission of the coronavirus.

Inspiring good sanitation practices extends beyond internal workforce. Companies that rely on recruitment services for temporary workforce should make sure that those firms are also taking suitable sanitation measures. There are also potential risks of fake self-declaration of good health by employees, especially by persons who have visited COVID-19 hot spots. This needs a stringent employee sickness surveillance process. Besides, companies should connect openly and frequently with the employees through the exchange of updated information about the pandemic, which is in line with the conclusive remarks of De Flamingh & Fairhall (2020). Most of the experts indicated that frequently communicating with the workforce about organizational guidelines and measures associated with hygiene, occupational travel, isolation, remotely work, wellbeing and safety measures, and visitor screening is an effective way to demonstrate to employees that the organization is monitoring the situation and working to keep its employees safe.

Consistent communication helps not only to train workforces on best practices but also to dissipate myths and baseless rumors on COVID-19 and its impact on the workplace. Besides, companies that do not communicate with their workforce may be perceived as ill-equipped to manage the outbreak and uncaring about the health and safety of their employees. Such businesses may also experience workforce absenteeism. Management teams must be given the authority to act quickly and conclusively in response to rapidly fluctuating information and environments—they must possess the agility to make amendments alongside passing time and changing commercial requirements (Pearce et al., 2020). Various experts spoke about the challenges in maintaining plummeting output due to limited workforce during the pandemic as the spread of the virus will lead to illness among employees.

One of the big issues the leaders of organizations may face is achieving an equilibrium between being an inspiring and empathetic leader and continuing to thrust on performance. Striking this

balance while getting things done and running the business as usual may be the most challenging issue for an organization. Furthermore, responding to the numerous queries from executives and frontline supervisors when no perfect solution exists is also one of the challenging issues identified through these virtual discussions. Shop floor management needs a complete rethinking. Most of the experts indicated that all contact points like elevator buttons, handrails, handles and call buttons, escalator handrails, public counters, intercom systems, printers and scanners, frequently touched areas like tabletops, chair handles, pens, diary files, keyboards, mouse, mouse pads, tea/coffee-dispensing machines, toilet pots, commodes, commode lids, showers, taps and fittings, soap dispensers, safety equipment/computers/testing should be identified and new protocols should be put in place.

The at-risk places include canteens, tea points, restrooms, locker rooms, common walkways, crèches, entrance queus, exit/attendance swiping, shift beginning/ending meetings, pantry, water tanks, break-in shop floors, exercise before the start of the shift, driver rooms, elevators, security guard booths, entrance lobbies, corridors, and staircases—these areas need to be taken care of in the planning of the workplace. Companies should also evaluate their existing cleaning processes to ensure that frequently touched surfaces are regularly sanitized. It is also important that the housekeeping staff is appropriately trained to sanitize commonly touched areas, and they have suitable PPEs to avoid getting affected while cleaning.

A person's ability to foresee the impact of his/her behavior is crucial for the control of the virus, and the lack of knowledge is a critical risk. To contain the spread effectively, people's adherence to the standards and new norms is essential, which is fundamentally affected by their knowledge, attitudes, and adherence. In such scenarios, we will need to find new ways of management, online meetings, and reviews and for providing coaching and engagement of people (Santosh 2020). The international economy is still incredibly integrated, and most nations and businesses depend on vendors for their operations.

4.2 Evaluation of the interrelations and significance of the challenges

The information collected from various decision-makers is used to determine the interdependency of each identified challenge, as mentioned in Figure 1. The different steps involved in the evaluation of interrelation between the challenges using the fuzzy DEMATEL technique are detailed next, with a simultaneous discussion of the results.

Step 1: Collection of responses from experts and converting them into a fuzzy scale

The perception related to the interdependency of each factor, corresponding to various experts from the manufacturing industry, was collected on a linguistic scale. The linguistic scale contains five different categories that can distinguish the interdependence among the key challenges. The collected linguistic scale judgment was converted into trapezoidal fuzzy weights. The linguistic scale adopted in this current study and its corresponding fuzzy weights is shown in Table 2, which is adapted from the study of Luthra et al. (2016). The collected responses from the experts and the corresponding fuzzy judgmental scores are shown in Table 3 and Table 4, respectively.

Table 2: Fuzzy linguistic scale adopted in this study

Crisp	Linguistic score	Explanation	Equivalent fuzzy trapezoidal weight
0	O	No influence	(0, 0, 0.1, 0.2)
1	VL	Very low influence	(0.1, 0.2, 0.3, 0.4)
2	L	Low influence	(0.3, 0.4, 0.5, 0.6)
3	H	High influence	(0.5, 0.6, 0.7, 0.8)
4	VH	Very high influence	(0.7, 0.8, 0.9, 1)

Table 3: Interdependency of each challenge over the other on a linguistic scale

	A	B	C	D	E	F	G	H
A	O	VH	H	L	H	H	H	L
B	L	O	H	H	L	H	H	L
C	VH	H	O	VH	H	L	L	VH
D	H	H	VH	O	L	H	L	H
E	VL	H	VH	VH	O	L	L	VH
F	H	L	L	L	VL	O	H	L
G	H	H	L	L	VL	H	O	L
H	H	H	H	H	H	VL	L	O

Note: The challenges corresponding to the alphabets are as follows: A = supply chain and logistics; B = organizational and human dynamics; C = health and wellness; D = business models; E = demand environment; F = emergency preparedness; G = communication; H = Finance.

Table 4. Fuzzy relation matrix of interdependency between parameters

	A				B					H			
A	0	0	0.1	0.2	0.7	0.8	0.9	1	.....	0.3	0.4	0.5	0.6
B	0.3	0.4	0.5	0.6	0	0	0.1	0.2	.....	0.3	0.4	0.5	0.6
C	0.7	0.8	0.9	1	0.5	0.6	0.7	0.8	.....	0.7	0.8	0.9	1
D	0.5	0.6	0.7	0.8	0.5	0.6	0.7	0.8	.....	0.5	0.6	0.7	0.8
E	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	.....	0.7	0.8	0.9	1
F	0.5	0.6	0.7	0.8	0.3	0.4	0.5	0.6	.....	0.3	0.4	0.5	0.6
G	0.5	0.6	0.7	0.8	0.5	0.6	0.7	0.8	.....	0.3	0.4	0.5	0.6
H	0.5	0.6	0.7	0.8	0.5	0.6	0.7	0.8	.....	0	0	0.1	0.2

Step 2: Constructing fuzzy initial direct relation matrix

The equivalent fuzzy numbers were converted into crisp ratings using a defuzzification technique. This study considered the bisection of the area method to convert the equivalent trapezoidal weights into crisp numbers. Since the expert panel comprised several people, an average fuzzy matrix was constructed by considering the response of all the experts from various manufacturing companies (Table 5).

Table 5. Fuzzy initial direct relation matrix

	A	B	C	D	E	F	G	H
A	0.08	0.85	0.65	0.45	0.65	0.65	0.65	0.45
B	0.45	0.08	0.65	0.65	0.45	0.65	0.65	0.45
C	0.85	0.65	0.08	0.85	0.65	0.45	0.45	0.85
D	0.65	0.65	0.85	0.08	0.45	0.65	0.45	0.65
E	0.25	0.65	0.85	0.85	0.08	0.45	0.45	0.85
F	0.65	0.45	0.45	0.45	0.25	0.08	0.65	0.45
G	0.65	0.65	0.45	0.45	0.25	0.65	0.08	0.45
H	0.65	0.65	0.65	0.65	0.65	0.25	0.45	0.08

Step 3: Evaluating the normalized initial direct relation matrix

The initial direction relation matrix can be obtained mathematically using Equation 3 and Equation 4 (Luthra et al. 2016).

$$m = \min \left[\frac{1}{\max \sum_{j=1}^n |a_{ij}|}, \frac{1}{\max \sum_{i=1}^n |a_{ij}|} \right] \quad (3)$$

$$D = m \times A \quad (4)$$

Where A is the fuzzy initial direct relation matrix.

The fuzzy normalized direct relation matrix, thus obtained is shown in Table 6.

Table 6. Fuzzy normalized initial direct relation matrix

	A	B	C	D	E	F	G	H
A	0.02	0.18	0.13	0.09	0.13	0.13	0.13	0.09
B	0.09	0.02	0.13	0.13	0.09	0.13	0.13	0.09
C	0.18	0.13	0.02	0.18	0.13	0.09	0.09	0.18
D	0.13	0.13	0.18	0.02	0.09	0.13	0.09	0.13
E	0.05	0.13	0.18	0.18	0.02	0.09	0.09	0.18
F	0.13	0.09	0.09	0.09	0.05	0.02	0.13	0.09
G	0.13	0.13	0.09	0.09	0.05	0.13	0.02	0.09
H	0.13	0.13	0.13	0.13	0.13	0.05	0.09	0.02

Step 4: Constructing a total relation matrix

A total relation matrix can be formulated using Equation 5.

$$T = D(I - D)^{-1} \quad (5)$$

where I is the identity matrix and T is the total relation matrix.

The obtained total relation matrix is shown in Table 7.

Table 7: Fuzzy total direct relation matrix

A	B	C	D	E	F	G	H
0.755	0.953	0.917	0.855	0.733	0.796	0.794	0.819
0.771	0.746	0.852	0.824	0.647	0.740	0.738	0.759
0.970	1.002	0.895	0.999	0.800	0.825	0.824	0.962
0.875	0.929	0.961	0.791	0.709	0.800	0.766	0.863
0.811	0.933	0.970	0.941	0.642	0.767	0.766	0.907
0.709	0.717	0.712	0.687	0.533	0.547	0.652	0.660
0.737	0.782	0.744	0.717	0.557	0.681	0.573	0.688
0.816	0.873	0.873	0.844	0.701	0.683	0.715	0.706

Step 6: Evaluation of the overall effect of each challenge

In this step, the overall effect of each identified challenge is evaluated, which is achieved by evaluating the sum of each row and columns, respectively. This can be expressed mathematically using Equation 6 and Equation 7.

$$R = \left\{ \sum_{j=1}^n t_{ij} \right\}_{n \times 1} \quad (6)$$

$$C = \left\{ \sum_{i=1}^n t_{ij} \right\}_{n \times 1} \quad (7)$$

where R represents the effect of i on j and C represents the effect experienced by j due to i .

The evaluated attributes are presented in Table 8 and the interrelation between the parameters is presented in Figure 3. The conclusive remarks drawn are discussed in section 6.

Table 8. Prominence and influence of each success factor

	Fuzzy DEMATEL					Cause/Effect
	Parameter	D	R	D + R	D - R	
Supply chain & logistics	A	6.63	6.45	13.07	0.18	Cause
Organizational and human dynamics	B	6.08	6.94	13.02	-0.86	Effect
Health and wellness	C	7.28	6.93	14.21	0.35	Cause
Business models	D	6.70	6.66	13.36	0.03	Cause
Demand environment	E	6.74	5.33	12.07	1.41	Cause
Emergency preparedness	F	5.22	5.84	11.07	-0.62	Effect
Communication	G	5.48	5.83	11.32	-0.35	Effect
Finance	H	6.22	6.37	12.58	-0.15	Effect

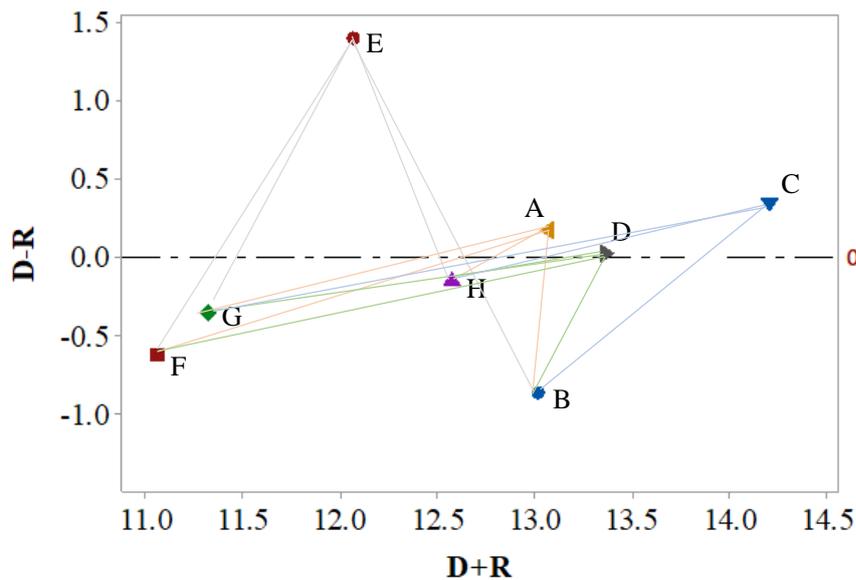


Figure 3. Diagraph showing the impact of each success factor on the other

5. Discussion

Our analysis highlights the increasing importance of health and wellness in the priorities of organizations. This factor leads to a strong effect in the areas of emergency preparedness, communication, and finance. Companies have to urgently rewrite their business continuity manuals and disaster recovery plans to overcome the challenges posed by COVID-19, which may create medical emergencies that can suddenly disrupt business operations and have significant financial implications. Health and wellness factor has a strong correlation with communication strategies for both internal and external stakeholders. Experts indicate the need for businesses to improve their communication modes, content, and frequency of messaging in response to health emergencies. This requires much more sensitivity in handling and much

more focused messages to provide appropriate information while eliminating the risk of panic and misinformation. The use of social media and mass communication channels may enhance effective communication. Organizations also feel that they need to build stronger communication channels with local health authorities and public administration. Health and wellness priority also influences financial conditions. On the one hand, the impact on demand and supply is causing revenues to drop, and on the other, the new regulations and compliances are expected to increase costs. Preparedness for dealing with emergencies requires finances for building infrastructure and providing equipment.

Uncertainty around supply chain and logistics is also seen to be significantly affecting other challenges. This uncertainty will not only affect the demand environment, causing demand volatility, but also financial implications of delayed deliveries, emergency procurements, and logistical costs. Supply chain concerns cast an important influence on organization design and overall human dynamics. Effective management of supply chain uncertainty requires the reskilling of people to deal with cross-functional issues. New culture with more cross-functional teams and problem-solving may emerge. The integrated supply chain is expected to emerge with an impact on organizational and human dynamics. Demand environment management under uncertainty may influence finances being diverted towards better and faster demand forecasting solutions. Real-time forecasting with predictive capabilities may require the reskilling of human resources and the culture of cooperation and trust. Business models also affect supply chain operations, organizations, and human dynamics and finance significantly. Like supply chains, evolving business models may require more cross-functional roles and responsibilities. Faster response times and quick decision-making would help to break organization silos and decentralize decision-making.

5.1 Contribution to practice

This study lays down a comprehensive list of issues and challenges that may be immensely useful to industries in the preparation of their reaction plans and restart plans. Careful use of the factors highlighted in this study will eliminate, largely, the possibility of industry executives missing out key factors, which can be disastrous for preparedness and execution of a robust factory restart. This study can, therefore, also be used by practitioners as an excellent checklist for their reaction plans.

5.2 Contribution to society

This study can help public administration and officials to understand the need for proper preparedness by industries before restart to eliminate problems. This study can educate the officials who are making public policy and guidelines, including all important factors in their policies, and help them appreciate the correlations between the various factors. They can guide the failed and struggling restarting attempts while learning from the successful ones, thereby avoiding the substantial negative impact of this pandemic on society.

6. Conclusion

This research started with an objective to identify the key challenges associated with restarting manufacturing organizations post-COVID-19 lockdown. The key challenges are identified using a literature review, and the perception of industry leaders on the interrelation between them is collected on a verbal scale. Later, an expert survey with industry leaders working towards the restart of manufacturing organizations is conducted to learn the perception of decision-makers on a verbal scale. Since the perception of decision-makers varies widely, the

concept of fuzzy is fused with the philosophy of the DEMATEL technique to evaluate the significance of each criterion and to gauge the interrelation between them. From the findings of the study, it can be conclusively stated that the main challenges for organizations in post-COVID-19 time are related to health and wellness preparedness, managing supply chain volatility, reducing cost, managing during the volatile demand environment, and dealing with emerging business models as per the hierarchy. These challenges undoubtedly have a significant effect on how organizations are structured and managed, the overall culture and behaviors, and interactions of human resources. These will also lead to a new mindset and perception of business continuity and emergency preparedness spending. They may also affect the overall financial situation and the way companies communicate within and outside the organization. Therefore, our study indicates that the organizations in the post-COVID era have to prepare themselves for new challenges and have to evolve new solutions to these challenges.

Governments and industries are currently preparing to kick-start the battered economic engine. This study addresses the need for providing guidance and an initial framework for these industries to have a successful restart. This study depended heavily on the views of experts and rigorous analysis of perceived cause-and-effect relationships. As organizations restart, they may provide real-time and actual data, and visibility, on the various issues and challenges that they face, which may open up a need for further analysis and study of correlations in a more objective manner. The factors may need regrouping, and new cause-and-effect relationships may emerge. More studies may be needed to evaluate the relative effectiveness of the measures adopted by various organizations in different environments.

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