

Critical Success Factors for Manufacturing Industries to Mitigate the Impact of COVID-19

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This paper identifies the critical success factors for the textile sector, one of the most significant parts of the manufacturing industry, to attain sustainability post COVID-19 pandemic and the potential critical success factors from it. The paper employs techniques like expert opinion, content analysis and SWOT analysis. The ISM-MICMAC approach is used to evaluate the inter-relation between the factors and compute personalized weights that enable to prioritize the critical success factors. The findings reveal that coordination among government-local authorities-health care centers is the key critical success factor with the highest driving and the least dependence power. Personnel hygiene awareness, workforce scheduling, and shop floor hygiene norms are the most dependent critical success factors.

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Introduction

An invisible enemy, COVID-19 has spread worldwide with a growing adverse impact on the global economy (Carlsson-Szlezak et al., 2020). Almost all nations halted their production activities by imposing a global lockdown to mitigate the risk of Coronavirus's spread (Lancet, 2020; Ivanov, 2020). It has the potential to collapse all sectors of the economy, and the manufacturing industry is no exception. The manufacturing industry can be severely affected due to the difficulties in importing raw materials, supply chain disruptions, labor migration, and reduced market demand (International Labor Organization, 2020; McKinsey and Company, 2020). Governments across the globe have extended the lockdown period to save lives; however, it has generated a new problem to save the economy from slipping into recession (Deloitte, 2020). This life

versus livelihood debate has put policymakers in a fix and creates an urgent need to develop a policy framework that can be implemented for the sector's economic sustainability.

From both economic and social point of view, the manufacturing industry is one of the most critical sectors that have been severely affected due to the COVID-19 pandemic. In this study, the textile sector (a highly labor dependent segment under the manufacturing industry) is considered as the unit of analysis. From the manufacture of raw material (fiber) to the final product (fabric), various activities are executed in the textile sector; the workers associated with this sector are also exposed to a wide variety of toxic substances. Apart from the textile manufacturing process, which is vast and highly hazardous for the workers' health, the organizational structure is also quite dreadful. The workers work in a group in different departments of a mill with inadequate precautionary measures are exposed to vapors of various volatile chemicals, the superheated steam, boiler's heat, fragments of fiber, and macroparticles of dyes; all make the workers engaged in the textile sector prone to severe lungs, kidney and heart-related diseases. The contagious spread of the COVID-19 virus via physical contact or aerosol transmission has further intensified these workers' physical distress. Respiratory deterioration, obstructive pneumonia, pleural or pericardial effusion, pulmonary embolism, and heart failure are the utmost symptoms of COVID-19 (Al-Shamsi et al., 2020, Li et al., 2020). The mortality rate of

Procurement of raw materials that are mostly import-driven, massive supply chain disruptions, and severe demand shocks have created irreparable damage.

COVID-19 infected patients with a history of lung, kidney, and heart ailments is also high. Thus, the onset of COVID-19 has not only affected the health and socioeconomics of the world society up to a large extent (Haleem et al., 2020) but has also led to a severe impact on the textile sector. Several other logistical challenges faced by this labor-intensive sector regarding the procurement of raw materials that are mostly import-driven, massive supply chain disruptions, and severe demand shocks have created irreparable damage. In the light of this, there is a need to investigate the critical success factors that can help policymakers and higher management to devise strategies to achieve the sustainability and boost the sector. The study identifies critical factors that can be most efficient in mitigating the risk and evaluates the interrelation between the factors which enable the decision-makers to prioritize and integrate these factors into their policy framework. The following research objectives are evaluated:

- To assess the textile sector's existing functioning and dynamics and overall functioning of the manufacturing industry as a whole.
- To identify critical success factors that could help mitigate the risk of

spread of Coronavirus, ensure the economic sustainability of the manufacturing industry, and safeguard social wellbeing.

To answer above listed research questions, an extensive literature review has been undertaken to find the critical success factors which can help stimulate the manufacturing industry. Further, Interpretive Structural Modelling (ISM)-MICMAC analysis has been used to find the interdependencies between these factors and compute the personalized weights of these factors that can enable the policymakers to prioritize among the critical success factors suggested in our study (Das et al., 2020; Mangla et al., 2018).

Literature Review

Approximately 70% of overall textile manufacturing workers engaged in spinning, dyeing, and finishing departments are profoundly affected due to curbs imposed during the lockdown period. Besides, transportation and shops being closed, even the distributors and consumers were severely affected. Lack of protective equipment, insufficient ventilation, inadequate working procedure, and ineffective environmental control systems are frequent causes of new cases of occupational contact infections for textile workers (Gallagher et al, 2012).

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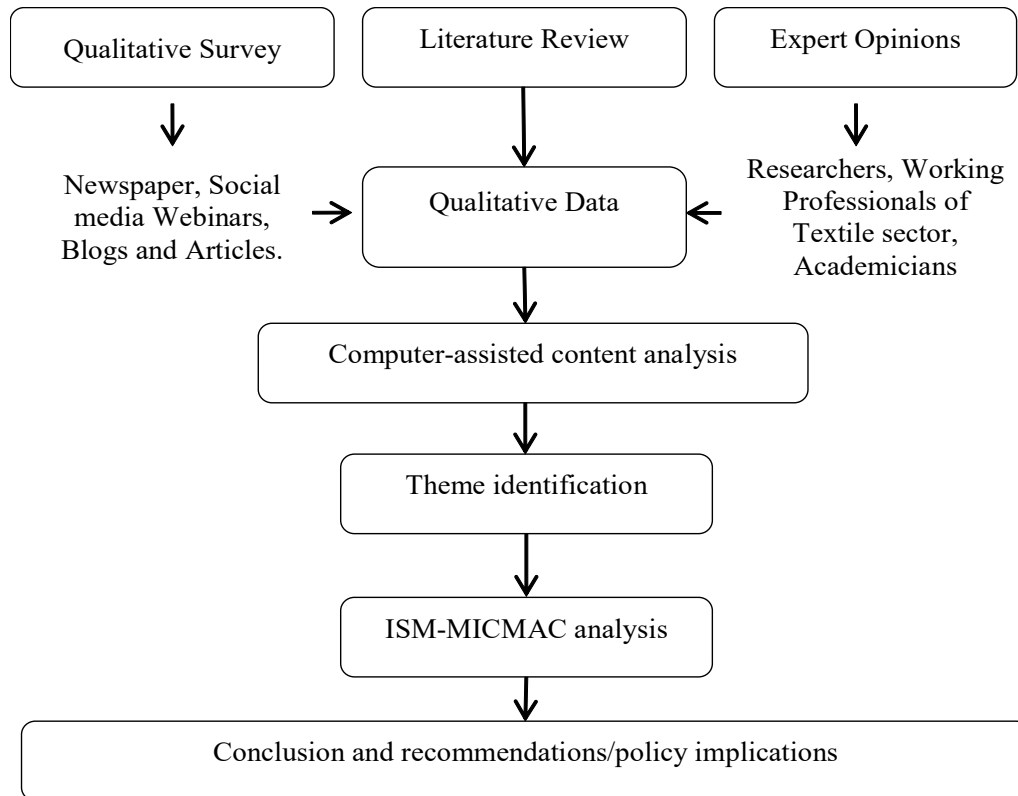
All textile industries the worldwide have halted operations in the lockdown period, affecting the export of yarn, fabric, and other raw materials (Pratheesh & Arumugasamy, 2020). The magnitude of the economy's downturn will depend on the duration of the lockdown period and the severity of the health crisis. As a preliminary precaution against the physical contact or aerosol transmission of the virus, it is suggested that it be curbed through social distancing and effective use of personal protective equipment (Cook, 2020). However, there is an urgent need to understand the industry-specific critical success factors that can help to mitigate the risk of further spread of the virus among textile clusters and other allied sectors, which have been captured in our study through a detailed methodology as presented in the next section.

Methodology

The research methodology framework has been illustrated in Fig. 1 that summarizes the structure of our study.

In the initial stages, the research team conducted several brainstorming sessions with the textile sector experts, qualitative surveys, and an extensive literature review. A total of 25 interactions were conducted using video conferencing. The sample included two senior managers, three assistant managers, five executives, three academicians, four research professionals of textile technology, and eight shop floor workers from Indian textile firms. The qualitative data on the impact of the COVID-19 pandemic is also collected through online resources such as

Fig. 1 Integrated ISM-MICMAC Based Research Methodology



newspapers, social media, webinars, blogs, and articles. After the data collection process, a qualitative analysis was carried out using Excel and NVIVO-11. The ten critical success factors are proposed after considering the literature review, content analysis, and expert opinions. Finally, ISM-MICMAC analysis is carried out for the ranking and interrelationship of proposed critical success factors from the COVID-19 pandemic.

Content Analysis

The interviews and qualitative data were typed for coding. The text in Hindi

language was translated into English using trained translators. First, descriptive coding was undertaken to identify significant themes (Miles et al., 2014). The word cloud of essential themes is generated using NVIVO-11, and that is presented in Fig. 2.

Fig. 2 shows that health care management, hygiene factor, coordination, environmental issues, digitization, innovation, medical audit, and a pandemic are essential themes emerged from the qualitative data. In the word cloud analysis, the larger the word's size, the higher are the frequency in qualitative data.

equipment, isolation of the finishing department from the other departments to avoid passage of any accidental infection and ensure consumer safety.

CSF 2: Innovation & Promotion: With the inception of COVID-19, apart from delivering essential items such as face masks and shields, personnel protective equipment, and face wipes, there is a need to develop and innovate new product lines (Wadho & Chaudhry, 2020). Firms should revolutionize to cater to the surge in demand for a diverse range of medical textiles soon, such as anti-microbial / anti-viral/ anti-bacteria textile products; water repellents, hydrophilic, wrinkle-free, anti-odor, anti-sweating, anti-pilling textile material (Chachra, 2020).

CSF 3: External Medical Audit: The hazardous elements in textile shop floor led to chronic diseases (Wang et al., 2005), which significantly impact worker's health during COVID-19 infection. Worker's health issues do not only influence their family members, but industrial production is also affected. Hence, the government medical teams are highly recommended to survey workers' physical health and take necessary action at the primary level of disease.

CSF 4: Digitization; The textile sector is highly dynamic as a function of time in terms of style, color, and texture. Thus, the corresponding supply chain must be a rapid supply of the correct product in the right quantity at the time of demand for a fair price (Backs et al., 2020). During the COVID-19 pandemic, the textile

supply chain has been crippled as it was an antiquated system. Still, numerous textile companies have retained the traditional supply chain. The competition is increasing in the textile sector due to globalization and digitization. The three primary benefits of digitizing are transparency at each level, speed, and worth price. Many steps are involved in the procurement and delivery of items like to run with face to face, gathering and paper-based signature. Digitization in the supply chain can eliminate face to face interaction, and then a business may run on the path of growth during and after the pandemic.

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CSF 5: Coordination: Coordination among government, local authorities, and health care centers is beneficial to minimize the spreading of epidemic disease (Kim & Liu, 2012; Maneesh & El Alaoui, 2020). The government's role is crucial in the prevention of the epidemic situation by imposing a lockdown (Moser & Yared, 2020). Public support for the government is also crucial (Paek et al., 2008). The workplace stakeholders like workers, managers and labor unions have a significant role in mitigating the epidemic at the workplace. The implementation of the guidelines provided by the government and local authorities, seeking the help of the labor union to create safe workplace infrastructure, regular training on prevention measures by the local health center, help to minimize the

spreading of an epidemic in the workplace and to continue operations of the textile sector.

CSF 6: Health Care Management: A substantial restriction is necessary to reduce the impact of COVID-19 and other health-related diseases for legislation and implementation rules to control infections (Chung, 2016). ‘The best way to control a hazard is to eliminate it,’ the substitution is preferable to administration control and personal protective equipment. Workers have a financial need when they are infected. This need can be fulfilled with medical compensation. Hence, adequate health care management should be established in the textile sector to give some relief during the textile workers’ crucial period.

CSF 7: Facility: There are several issues, such as lack of proper illumination and ventilation, which worsens the working conditions of the laborers in the mill. The excruciating process involves burning coal, and the emission of steam further intensifies the temperature at the workplace, which makes it painful for the workers.

The COVID-19 crisis further risks the lives of these workers. Thus, there is a need to develop a facility that can help lower pandemic threats. For example, Vardhman Textile Limited has developed excellent facilities for production activities and excellent residential facilities for employees, which helped Vardhman continue the production process under the norms of the government (Krar, 2020). At the time of developing the facilities,

firms should consider the following essential attributes of hygiene: periodic sanitization of the machinery, proper ventilation and illumination, installing dehumidifiers and regular maintenance of washing department (since these areas are relatively more humid), provide hot air tumble for drying of garments to disinfect them further. Attendance of employees should be done using face recognition machines instead of punching a card on the biometric machine (Cirrincione, 2020).

These labor-intensive firms should bear the short-term expenses of providing the workers with necessities of food, water, electricity, and livelihood security.

CSF 8: Work floor Scheduling: The textile sector comprises spinning mills with different spindle capacity. For the resumption of services post lockdown, these labor-intensive firms should bear the short-term expenses of providing the workers with necessities of food, water, electricity, and livelihood security. Work floor scheduling plays a crucial role in eliminating the risk of spreading the virus in the enclosed workspaces. The workers can perform better if initiatives like the assignment of staggered working hours, allotment of different lunch timings in multiple batches, permission for a lunch break in the assigned time slot only are taken. It should also be ensured that the division of batches should be made as per the production line. For smooth functioning, workers’ seating on the odd-even rule basis should be introduced to

maintain optimal distance between two workstations (World Health Organization, 2020a; Whitworth, 2020).

CSF 9: Labor Management: Numerous textile workers had lost their source of income due to the COVID-19 pandemic outbreak. Some workers had not paid by the mill, so they have been forced into bonded debt (Nagaraj & Srivastava, 2020). In the context of such a catastrophic impact of this pandemic on the livelihood of workers, mill management must follow the guidelines issued by the government that direct employees to pay wages without any deduction during the lockdown period (Ministry of Home Affairs, 2020). Government support is required for a small manufacturer to pay worker's wages (Bhattacharjee, 2020). In addition to this, various work setup through staggered shift hours or alternate working day needs to be explored to minimize the spread of the virus due to floor congestion.

CSF 10: Shop floor Hygiene Norms: Outlets/shops are an essential element of the supply chain to distribute the product from the manufacturing mill. They are a mediator between manufacturing and consumer, therefore boost the product demand. Various advisories issued for outlets/shops are as follows: 1) Check body temperature of a customer at the entry gate by thermal scanning thermometer; 2) Put alcohol-based hand sanitizer and make people disinfect their shoes by using potassium permanganate solution at entry gate; 3) Handover facemasks to each customer; 4) Mark on the floor for social distancing; 5) Shop

floors must be sanitized after a regular interval (Zhai et al., 2020; Arshiya & Agarwal, 2020).

The list of COVID-19 critical success factors for the manufacturing sector is provided in Table 1.

Interpretive Structural Modelling using ISM-MICMAC Analysis

ISM can be used as a systematic tool to identify contextual interactions among considered elements associated with the problem/issue to be analyzed. For the ISM-MICMAC analysis, data are collected from 12 textile sector experts.

Step 1: Determination of Critical Success Factors: In our study, we have identified ten critical success factors which would be essential for mitigating the impact of the pandemic on the textile sector. These critical success factors have been identified based on the literature review and opinion of experts from various fields.

Step 2: Determining the Contextual Relationship Between Identified Factors: The expert group consisted of policymakers, academicians, industry experts, and researchers. Depending on the responses received, the causal relationship between the identified factors was established.

Step 3: Constructing the Structural Self-interaction Matrix (SSIM): Responses of the experts were collated, which helped in determining the relationship between two pairs of critical

Table 1 List of COVID-19 Critical Success Factors For The Manufacturing Industry

Factor	Critical success factor	Explanation	References
CSF1	Personnel hygiene awareness	Promote awareness among the workers to maintain optimal social distancing at work, adoption of compulsory masking policy, and compliance with other hygiene regulations.	Bedford et al., (2020); World Health Organization (2020b)
CSF2	Innovation & Promotion	Resumption of the production process through an innovative product line.	Chachra, (2020); Wadho and Chaudhry (2020)
CSF3	External medical audit	Physical health verification/certification of workers by govt. medical team	Storrs (1986); Wang et al., (2005); Stahlmann et al., (2006); Tounsadi et al., (2020)
CSF4	Digitization	Transforming the information of every step of supply and product into digital format	Backs et al., (2020); Pratheesh & Arumugasamy (2020)
CSF5	Coordination	The Coordination of the textile sector with the government, local authority, labor unions, and local health care centers	Paek et al., (2008); Kim & Liu (2012); Maneesh and ElAlaoui (2020); Moser & Yared (2020); Perez & Ross (2020)
CSF6	Health care management system	Implementing rules to mitigate pandemic outbreak and other health issues and providing medical compensation	Wilkinson & McGechaen, (1996); Hatch et al., (2003); Chung (2016)
CSF7	Facility	Precautionary measures and facility development to safeguard workers from being infected.	Cirincione et al. (2020)
CSF8	Workforce scheduling	The work floor scheduling plays a crucial role in eliminating the risk of the spread of the virus in these enclosed workspaces.	Whitworth (2020); World Health Organization, (2020a)
CSF9	Labor management	All workers managed in such a way that all workers can be engaged in their work.	Bhattacharjee (2020); Ministry of Home Affairs (2020); Nagaraj et al. (2020)
CSF10	Shop floor hygiene norms	Guidelines issued for outlets/shops to mitigate the impact of COVID-19	Arshiya & Agarwal (2020); Zhai et al., (2020)

Table 2 Structural Self-interaction Matrix

Factor	Critical success factor	CSF1	CSF2	CSF3	CSF4	CSF5	CSF6	CSF7	CSF8	CSF9	CSF10
CSF1	Personnel hygiene awareness	X									
CSF2	Innovation & Promotion		X	A	X	A	A	V	V	X	V
CSF3	External medical audit		X	A	X	A	A	V	V	X	V
CSF4	Digitization			X	X	A	A	V	V	X	V
CSF5	Coordination					X	V	V	V	V	V
CSF6	Health care management system						X	V	V	V	V
CSF7	Facility							V	O	A	X
CSF8	Workforce scheduling							X	X	A	O
CSF9	Labor management									X	V
CSF10	Shop floor hygiene norms										X

success factors. A structural matrix was formed based on an established relationship, using the letters **V, A, O, X**. Each of these letters signify the nature of the relationship between the factors which are enumerated below:

V - critical success factor i will influence critical success factor j

A - critical success factor will influence critical success factor

O - no relationship between the critical success factors.

X - critical success factor influences critical success factor and vice versa

Based on the above criteria, Structural Self-interaction Matrix (SSIM) is formed, as shown in Table 2. An overview of Table 2 helps us identify the nature of the relationship between the critical success factors considered in our study.

Step 4: Developing The Initial Reachability Matrix: The Initial Reachability Matrix is a binary matrix wherein V,A,O,X elements of Structural Self-interaction Matrix (SSIM) are replaced by 0 and 1 based on the following rules:

- When **(i, j)** in the SSIM is V, then in the reachability matrix is replaced by 1 and by 0.
- When in the SSIM is A, then in the reachability matrix is replaced by 0 and by 1.
- When in the SSIM is X, then in the reachability matrix is replaced by 1 and by 1.
- When in the SSIM is O, then in the reachability matrix is replaced by 0 and by 0

Table 3 Initial Reachability Matrix

Factor	CSF1	CSF2	CSF3	CSF4	CSF5	CSF6	CSF7	CSF8	CSF9	CSF10
Personnel hygiene awareness	1	1	0	1	0	0	1	1	1	1
Innovation & Promotion	1	1	0	1	0	0	1	1	1	1
External medical audit	1	1	1	1	0	0	1	1	1	1
Digitization	1	1	0	1	0	0	1	1	1	1
Coordination	1	1	1	1	1	1	1	1	1	1
Health care management system	1	1	1	1	0	1	1	1	1	1
Facility	0	0	0	0	0	0	1	0	0	1
Workforce scheduling	0	0	0	0	0	0	0	1	0	0
Labor management	1	1	0	1	0	0	1	1	1	1
Shop floor hygiene norms	0	0	0	0	0	0	1	0	0	1

Based on the above convention, the Initial Reachability Matrix of our analysis is shown in Table 3.

Step 5: Development of Final Reachability Matrix

The final Reachability Matrix is obtained after the transitivity check on the initial Reachability Matrix. It is used to check the presence of any indirect relationship. This check is performed on entries with zero (0) in the Initial Reachability Matrix.

The final Reachability Matrix gives us the driving power and dependency of each critical success factor. Driving power for each critical success factor is the total number of critical success factors (including itself) that it influences and is calculated through a horizontal summation of the effect of one critical success factor on other critical success factors. On the other hand, dependence is the total number of critical success factors (including itself) that it is influenced by and is calculated using a vertical summation of the effect of other critical success factors over a critical success factor. The final Reachability Matrix of our analysis is indicated in Table 4.

Step 6: Level Partitioning: The final Reachability Matrix enables us to formulate the reachability and antecedent sets for each critical success factor. The Reachability matrix consists of the critical success factor itself and other critical success factors that it may influence. In contrast, the antecedent set consists of the critical success factor itself and other critical success factors that may influence it. These sets are compared to get an intersection set for all critical success factors. When elements of reachability and intersection sets are equal, then critical success factors are eliminated, and they occupy the top-level (level 1) of the

Table 4 Final Reachability Matrix

Factor	CSF1	CSF2	CSF3	CSF4	CSF5	CSF6	CSF7	CSF8	CSF9	CSF10	Driving Power
CSF1	1	1	0	1	0	0	1	1	1	1	7
CSF2	1	1	0	1	0	0	1	1	1	1	7
CSF3	1	1	1	1	0	0	1	1	1	1	8
CSF4	1	1	0	1	0	0	1	1	1	1	7
CSF5	1	1	1	1	1	1	1	1	1	1	10
CSF6	1	1	1	1	0	1	1	1	1	1	9
CSF7	0	0	0	0	0	0	1	0	0	1	2
CSF8	0	0	0	0	0	0	0	1	0	0	1
CSF9	1	1	0	1	0	0	1	1	1	1	7
CSF10	0	0	0	0	0	0	1	0	0	1	2
Dependence Power	7	7	3	7	1	2	9	8	7	9	60

ISM hierarchy. This iterative process is continued till a level is determined for all critical success factors. These critical success factors are then placed in their corresponding levels to form the ISM model.

Step 7: Formation of the digraph

Based on the levels determined using the iterative process in step 6, a digraph is prepared, which depicts the nature and direction of the relationship between the various critical success factors. Transitive relationships that are not relevant are eliminated.

Step 8: ISM Hierarchical Model:

The node elements in a digraph are replaced by statements to get the ISM Hierarchical Model. This model summarizes the level assigned to each critical success factor, which in turn throws light into the importance and dependency of each critical success factor. This model gives a holistic idea as to which of these critical success factors are essential and needs to be given priority to address the challenges faced by the manufacturing industry due to COVID-19. This ISM model was further checked for any conceptual irregularity and soundness.

Results & Discussions

The iterations which are used for level partitioning of the various critical success factors are replicated in Table 5 to Table 8. These critical success factors determined from each iteration helps in preparing the ISM model that highlights the major policy interventions

Table 5 First Iteration

Factor	Critical success factor	Reachability Set	Antecedent Set	Interaction Set	Level
CSF1	Personnel hygiene awareness	1,2,4,7,8,9,10	1,2,3,4,5,6,9	1,2,4,9	
CSF2	Innovation & promotion	1,2,4,7,8,9,10	1,2,3,4,5,6,9	1,2,4,9	
CSF3	External medical audit	1,2,3,4,7,8,9,10	3,5,6	3	
CSF4	Digitization	1,2,4,7,8,9,10	1,2,3,4,5,6,9	1,2,4,9	
CSF5	Coordination	1,2,3,4,5,6,7,8,9,10	5	5	
CSF6	Health care management system	1,2,3,4,6,7,8,9,10	5,6	6	
CSF7	Facility	7,10	1,2,3,4,5,6,7,9,10	7,10	1
CSF8	Workforce scheduling	8	1,2,3,4,5,6,9	8	1
CSF9	Labour management	1,2,4,7,8,9,10	1,2,3,4,5,6,9	1,2,4,9	
CSF10	Shop floor hygiene norms	7,10	1,2,3,4,5,6,7,9,10	7,10	1

Table 6 Second Iteration

Factor	Critical success factor	Reachability Set	Antecedent Set	Interaction Set	Level
CSF1	Personnel hygiene awareness	1,2,4,9	1,2,3,4,5,6,9	1,2,4,9	2
CSF2	Innovation & Promotion	1,2,4,9	1,2,3,4,5,6,9	1,2,4,9	2
CSF3	External medical audit	1,2,3,4,9	3,5,6	3	
CSF4	Digitization	1,2,4,9	1,2,3,4,5,6,9	1,2,4,9	2
CSF5	Coordination	1,2,3,4,5,6,9	5	5	
CSF6	Health care management system	1,2,3,4,6,9	5,6	6	
CSF9	Labour management	1,2,4,9	1,2,3,4,5,6,9	1,2,4,9	2

Table 7 Third Iteration

Factor	Critical success factor	Reachability Set	Antecedent Set	Interaction Set	Level
CSF3	External medical audit	3	3, 5, 6	3	3
CSF5	Coordination	3, 5, 6	5	5	
CSF6	Health care management system	3, 6	5, 6	6	

Table 8 Fourth Iteration

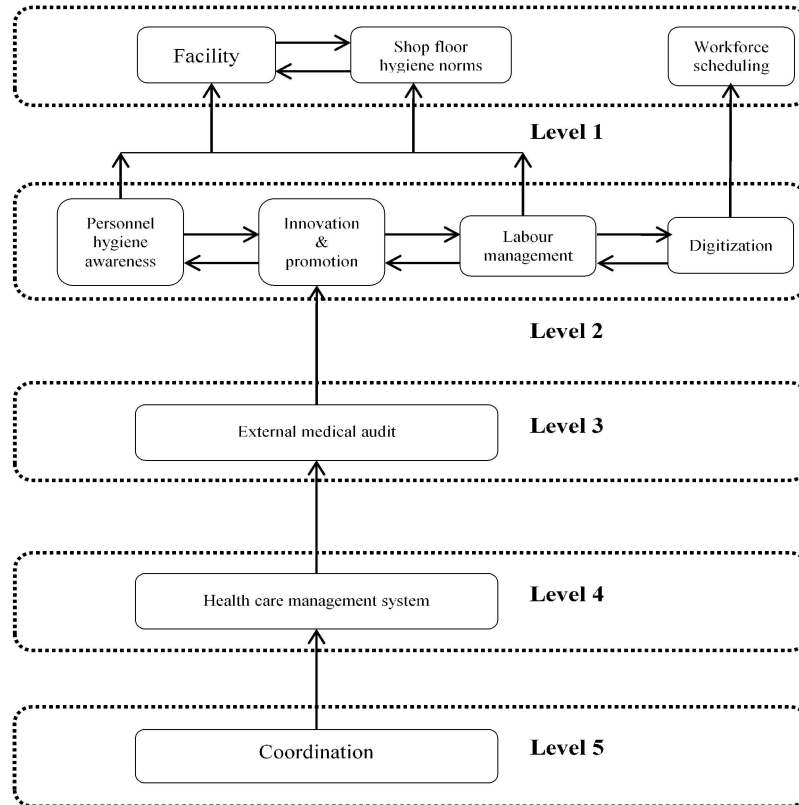
Factor	Critical success factor	Reachability Set	Antecedent Set	Interaction Set	Level
CSF5	Coordination	5, 6	5	5	5
CSF6	Health care management system	6	5, 6	6	4

that could be implemented for a revival of the manufacturing industry.

The antecedent and reachability set for each critical success factor is deter-

mined from the final Reachability Matrix. The intersection of the antecedent and reachability sets gives us critical success factors and their corresponding levels in the ISM digraph, which helps in

Fig. 3 ISM Diagram



level partitioning, ultimately leading to the formation of the ISM digraph, as shown in Fig. 3.

Each iteration assigns a level to one or more critical success factors. From the first iteration in Table 5, three critical success factors “Shop floor hygiene norms” through maintaining optimal social distancing and mandatory cleanliness, “Workforce scheduling” through monitoring shift time and appropriate rest to the workforce and “facility” by ensuring optimum airflow and ventilation at the shop floor, are assigned to level I. Since these

critical success factors do not influence any other factors, they are eliminated from the next level of iteration. Table 6 corresponds to the second iteration, which assigns level II to four critical success factors, namely – “Personnel hygiene awareness”, “Innovation & promotion”, “Digitization of the supply chain”, and “Labor management” through precaution guidelines for infectious disease. These critical success factors do not lead to any other critical success factor and are eliminated. Likewise, “External medical audit” through regular medical team survey is categorized as a critical success

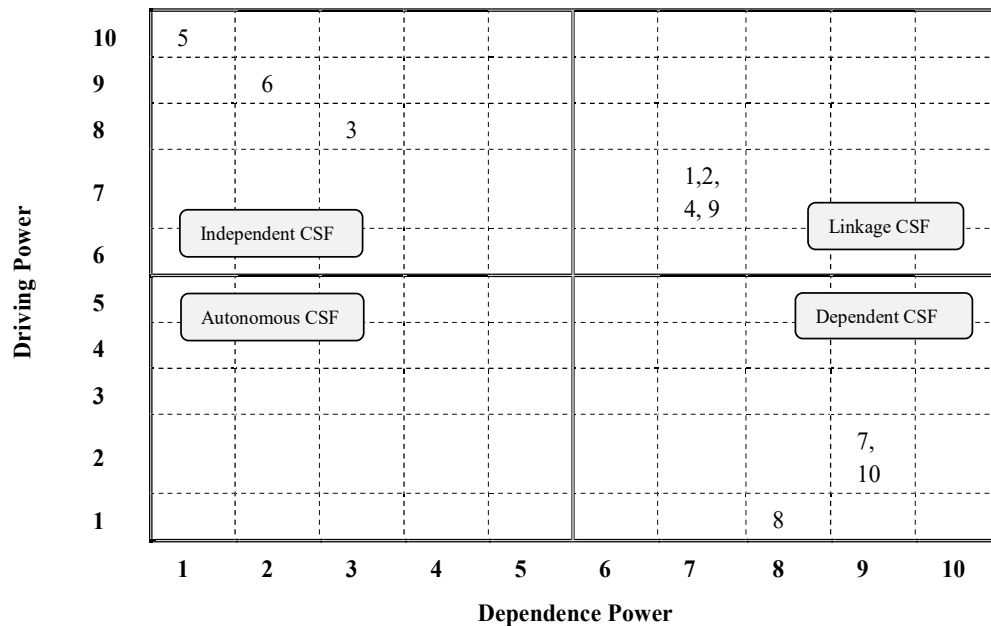
factor in level III, as shown in Table 7. Table 8 gives us the two most crucial critical success factors with the establishment of a “Health care management system” to support workers placed in

level IV, and “Coordination” placed in level V. Level V is the last level in our ISM model and is the most crucial critical success factor.

Table 8 gives us the two most crucial critical success factors with the establishment of a “Health care management system” to support workers placed in level IV, and “Coordination” placed in level V.

ISM model is substantiated by MICMAC analysis, which segregates the critical success factors based on their driving powers and dependence. The driving powers and dependence calculated from the final Reachability Matrix in Table 4 classify the factors into autonomous critical success factors, dependent critical success factors, link-

Fig. 4 MICMAC Analysis



age critical success factors, and independent critical success factors. MICMAC analysis of our study is shown in Fig. 4.

From Fig. 4, it can be seen that there are no autonomous critical success factors in quadrant 1. On the other hand, quadrant 2, which is a zone of high de-

pendence and low driving power has three critical success factors - “Facility”, “Workforce scheduling” and “Shop floor hygiene norms”. Linkage critical success factors were found in quadrant 3, which refers to high driving power and high dependence. The factors in this quadrant are in a zone that is highly unstable as

any change is likely to affect other factors, including itself as feedback. In our study, we found “Personnel hygiene awareness”, “Innovation and promotion”, “Digitization”, and “Labor management” as the linkage factors in quadrant 3. We found “External medical audit”, “Establishment of health care management system to support workers”, and “Coordination” in quadrant 4, which refers to critical success factors with high driving power and low dependence. These critical success factors are referred to as independent or driving critical success factors. These critical success factors are quite significant for the manufacturing industry that we considered in our study.

Conclusion

In the present work, critical success factors to mitigate the effect of COVID-19 and for sustainable business in the manufacturing industry have been recognized and analyzed. Ten critical success factors from COVID-19 have been identified through extensive literature review, qualitative surveys, and focus group discussions with the industry experts. ISM methodology has been used for finding contextual relationships among critical success factors and developing a hierarchy of factors. Personnel hygiene awareness, Workforce scheduling, Shop floor

Coordination has been found an independent bottom level critical success factors in combating COVID-19 impact, with the highest driving power and the least dependence power.

hygiene norms have been found dependent on top-level critical success factors. However, Coordination has been found an independent bottom level critical success factors in combating COVID-19 impact, with the highest driving power and the least dependence power.

The developed hierarchical structural model will be useful for policymakers to identify and prioritize critical success factors for the efficient functioning of the manufacturing industry and combating the global health emergency. This model will help government bodies and other nodal agencies to achieve “COVID-19 free and sustainable manufacturing industry” and help all stakeholders to achieve economic growth. Our model has significant managerial implications in identifying the manufacturing industry’s critical success factors from COVID-19, which can apply to other industries. However, our results comprise the data only from a limited number of Indian experts, which might also include human biases. Further study might consider the validation of our results using other MCDM tools. Study of critical success factors for different industries apart from the manufacturing industry like tourism & hotel, education, retail sector and aviation, would be exciting to study in the future.

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