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ORIGINAL RESEARCH

Investigation of key performance indicators for performance management of the manufacturing industry in the era of the COVID-19 pandemic

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Abstract
The execution of constructive Key Performance Indicators (KPIs) is a critical tool for the Performance Management (PM) of the manufacturing industry to regulate operations. The companies rely on the PM strategies grounded on conventional KPIs assessment to achieve sustainability although the current dynamic manufacturing environment is undergoing complexities. The KPIs used in the past for PM are not mutually dependent, as they have not been adequately measured and updated to address emergency situations like the COVID-19 pandemic, particularly for the Leather Products Industry (LPI). Monitoring of plentiful KPIs is inconceivable and literature is also not available. Realizing these gaps, this study accumulates suggestions from a wide-ranging context of 25 experts' feedback. Initially, a set of KPI was identified through literature review and experts survey. Later, employing a Pareto analysis, 15 KPIs were identified from 48 KPIs. Then the finalized KPIs investigated utilizing linguistic Z-digits and Decision-Making Trial and Evaluation Laboratory (DEMATEL) to find the "Cause-Effect" relationship. An industrial chronology is conferred to demonstrate the

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potency and functionality of the suggested method. The upshot signifies the "Target fulfillment within the delivery time during COVID-19" as the most important KPI for the studied case. The outcomes will assist the LPI managers to dictate crucial KPIs suitably and flourish the PM in attaining the goals and objectives.

Keywords Key performance indicators · COVID-19 · Performance management · Leather products industry · Manufacturing · DEMATEL · Linguistic Z-digit

List of symbols

KPIs	Key performance indicators
LPI	Leather products industry
PM	Performance management
COVID-19	Coronavirus disease of 2019
SDGs	Sustainable development goals
DEMATEL	Decision making trial and evaluation laboratory
LZPWG	Linguistic Z-digit power weighted geometric operator
z_{cd}^{e}	The linguistic Z-digit
Z^{e}	Linguistic straight impacting matrix (LSIM)
λ	Bunching threshold value (BTV)
C_x	xth bunch
$Y^x = (y_{cd}^x)_{t\times t}$	Bunch straight impacting matrix (BSIM)
p_x	Weight of xth bunch
Z	Overall straight impacting matrix (OSIM)
Y^l	Mean matrix of the V bunches (MMB)
Z'	Crisp straight impacting matrix (CSIM)
N	Normalized straight impacting matrix (NSIM)
J	Total impacting matrix (TIM)
I	Identity matrix (IM)
j_{cd}	Full direct and indirect influence
a_c	The sum of cth row elements in matrix J
b_d	The sum of dth column elements in matrix J

1 Introduction

According to the "The Business Standard" report on July 2021, the total exports of leather and leather products expanded from $321.77 million to $495.56 million by 54% in 2020. Due to COVID-19, the Leather Products Industry (LPI) business worldwide evolved in an unprecedented position and is facing affairs in tasks of the departments such as Production, Research, and Development (R&D), Human Resource and Compliance, Accounts or store, Business Development, etc. The LPI is recognized as one of the government's prime concerned sectors in Bangladesh and emerging as a substantial prospective because of easily available lower-cost labor, raw material, huge growth, and funding. Under those circumstances, managers require close and thoughtful concentration on Performance Management (PM) to estimate the appraisal of manufacturing operation exercises and to assess the efficacy of manufacturing operations (Froehlich FF, 1970). A systematic, well-structured, and planned

PM system can enhance leather products' quality, lessen operational costs, increase productivity, and improve employee morale and satisfaction. LPI has to accomplish and conserve high productivity and quality, with reactivity, adequate variability, and compact lead times to satisfy the fast-changing and dynamic requisitions of customers. PM helps the LPI managers by providing the necessary information for decision-making and taking action (Gunasekaran & Kobu, 2007). Operational regulation and excellence can be secured through PM which is a crucial function in the manufacturing industry (Kassaneh & Workalemahu, 2018), particularly in the LPI of Bangladesh. After determining the strategic goals for achieving the success of the LPI, each goal will be substantiated by a set of specific indicators aiding to attain the goals. These indicators are quoted as Key Performance Indicators (KPIs). Alongside reflecting the crucial factors of an organization, KPIs define a set of quantitative and strategic measurements in a PM of the manufacturing industry. For accomplishing the required business objectives, the suitable choice and progressing realization of the KPIs is compulsory (Kang et al., 2016). To boost organizational performance, good PM and matrices like KPIs will assist in the progress of more accessible and clear communication between managers and workers directing to collaborative supportive work (Gunasekaran & Kobu, 2007).

According to Eberl & Schwaiger (2005), a conventional PM system is carried out by giving importance to the financial KPIs without paying heed to non-financial KPIs. But concurrent performance measurement embraced both the use of financial as well as non-financial KPIs (Cao et al., 2015). The KPIs have mutual interdependency since various characteristics of PM are not independent and cannot be segregated from each other. Clear insight into the positive or negative relationships between KPIs is of utmost importance for improving organizational performance continuously. The inquiry of KPI relations depends on observational quantitative perspectives until now. However, detecting genuine relations and managerial insights might fail. Alongside this, the information obtained from various manufacturing firms may generate extensively diverse outcomes. Consequently, a new proposition to detect the relationships between KPIs via genuine involvement needs to be established.

During the COVID-19 pandemic, pointing out condemnatory elements in the sector of LPI can be obtained via the Decision-Making Trial and Evaluation Laboratory (DEMATEL) method. The DEMATEL method was developed by the 'Science and Human Affairs Program' of the battle memorial institute of Geneva in 1971 (Hsu & Lee, 2014). Envisioning the composition of the tough process through establishing correlation and interrelation potency between KPIs can be acquired through DEMATEL (Si et al., 2018; Asan et al., 2018). With the aid of this method, PM can be assessed in the LPI by setting up a matrix linking influencing factors because of its straightforwardness, efficacy, and potency (Abdullah et al., 2019; Chauhan et al., 2020; Dinçer et al., 2019). When experts ascertain the interrelationship between KPIs, they frequently face trouble in giving quantitative value to the level of influence (Ding & Liu, 2018; Jiang et al., 2020). In the case of emergency PM, experts are habituated to utilizing linguistic expression (Si et al., 2017) because of growing complications in the leather products design and manufacturing systems. Due to the lack of grasp and proficiency in the organization, experts are not acquainted with the given performance indicators (Jiang et al., 2020). For this reason, linguistic expression, as well as reliability of experts' appraisal, are necessary (J. qiang Wang et al., 2017). Putting Z-digits in general perspectives like the leather products sector's PM is foremost to mark out uncertain linguistic expression. Z-linguistic numbers constitute two modules: the first one is restriction and the second one is reliability (Peng & Wang, 2017).

The emergence of the COVID-19 outbreaks and its severe impacts on LPI have created difficulties in making strategic decisions. But Z-digit numbers are widely used and considered not only because of their advantageous application over other methods but also for their global

or absolute deliberation, undoubtedly expressible mood, and the capability of keeping the actual information without any kind of deformation (Peng & Wang, 2017; J. Qiang Wang et al., 2017). For identifying the KPIs and inspecting the connection between KPIs under wide-ranging scenarios, an integrated appraisal approach was proposed in hospital management combining Z-number and DEMATEL methods (Jiang et al., 2020). This proposed study merges Pareto, linguistic Z-digit, and the DEMATEL technique which is completely new in the literature. In PM of the LPI, applying this integrated model, crucial KPIs can be identified and assessed with linguistic Z-digit.

By focusing on the context of COVID-19, it is possible to gain a more in-depth comprehension of the influence that the pandemic has had on a conflict that was already complex and was still going on. The epidemic caused by the COVID-19 virus has had an effect on every facet of society, including healthcare, economics, and politics (Choudhary et al., 2022).

To understand the impact and know the current operational performance of LPI, this study considered LPI as a case example. For a variety of reasons, the LPI in Bangladesh has been investigated as a research object. The LPI is a significant component of the Bangladeshi economy. Bangladesh is one of the top exporters of leather goods in the world, making it one of the most important sectors. This Industry is responsible for the employment of a sizeable number of people and contributes to the GDP of the country. However, the LPI in Bangladesh has also been subjected to criticism and scrutiny due to environmental and social issues. The LPI has been accused of having deplorable working conditions and of violating workers' rights.

As a result, the LPI in Bangladesh provides scholars with an interesting case example to identify and assess the KPI towards improving the operational performance of the manufacturing operations. Additionally, researchers have the opportunity to investigate ways to enhance working conditions, promote sustainable development, and lessen the industry's negative influence on the environment when they examine the industry. In addition, this study can help inform policymakers and industry stakeholders on ways to improve the KPIs and create a future that is more sustainable operations and equitable for workers, communities, and the environment. This can be accomplished by providing information gained from the study.

Consequently, this study was directed by the succeeding research questions:

RQ1 Which KPIs should be selected for PM during the era of the COVID-19 pandemic?

RQ2 How managers and decision-makers will appraise KPIs for identifying the most crucial KPIs during COVID-19?

RQ3 What are the conclusions of executing KPIs?

Alongside answering the aforementioned questions, this study synchronizes the subsequent research objectives:

1. To identify and select crucial KPIs for PM using Pareto analysis and under wide-ranging scenarios, apply the integrated approach of linguistic Z-digit and the DEMATEL technique.
2. To deal with the fuzziness and unpredictability of experts' unreliable evaluation of the straight interdependence between indicators.
3. To enhance group uniformity, by bunching the appraisal of large-scale experts through the use of maximizing consensus approach and scrutinizing the interconnection between KPIs with the use of an extended DEMATEL method to boost PM in the LPI.

2 Literature review

2.1 Performance management and COVID-19

PM acts towards sustainable organizational performance data through quantification and declaration. A company's overall performance, operational excellence, growth, and expansion depend on the right PM system. Both PM and sustainability affect the long-term and short-term efficacy of the company. KPIs targeting is one of the complex tasks but detecting KPIs in PM offers sustainability to the company. To support long-term indicators are mainly targeted and assessed through monitoring and controlling in some areas of the company. For addressing Sustainable Development Goals (SDGs), managers pick out the right PM strategies. KPIs are considered benchmarks that operate PM and furnish the point of convergence for global company calibration, cooperation, and harmonization (Bauer et al., 2016). Upgradation in the supply chain, the accomplishment of sustainable competitiveness, and balancing production efficacy and delivery time can be achieved through the correct execution of KPIs.

In the growing convolution of business, managers of the companies are facing trouble in keeping steadiness between manufacturing planning and delivery time; increasing profits by promoting output on bottleneck resources; decreasing inventories through harmonizing supply with demand; permitting data-operated decision making, etc.

Assurance of employee health and safety during the crisis of COVID-19 depends on managers in decision-making to merge their ability and sense of information (Schippers & Rus, 2021). Managers are also facing complex and uncertain situations in the COVID-19 pandemic. To secure a positive result, good quality decision-making acts as a precondition. For this, Kahn and Wolak (2013) suggest optimizing the decision-making system in the era of COVID-19 applying reflexivity to counteract information processing failures. Decision-making for identifying crucial KPIs has a considerable effect on the PM system as well as on the company's overall performance. Further, Alam et al. (2021) integrate the DEMATEL method with intuitionistic fuzzy sets in the supply chain of the vaccine manufacturing companies to implicate SDGs. Identifying 15 challenges, the study discloses the 5 most critical challenges. To alleviate the outbreaks in the supply chain of manufacturing companies, caused by the COVID-19 endemic, managers need to systemize the PM system. Govindan et al. (2020) proposed an actual decision-bearing system combining experts' knowledge and a Fuzzy Inference System (FIS) in the healthcare supply chain. The study deployed risk levels and two indicators dividing community residents. Ivanov and Dolgui (2021) adopted OR (Operational Research) methods with novel categorizations and classifications to cope with the ripple effect of COVID-19, through pandemic stages from managerial insights. LPIs supply chains are operating under high risk in the act of the COVID-19 pandemic. Because they spare in opposition to leather wastage, health threats, product life cycle cost, etc. Assessment of credit risk for SMEs during industry 4.0 adopting wrapper and binary opposite whale optimization algorithm for KPIs selection contributed in identifying the crucial default features (Lu et al., 2022). Kumar et al. (2021) embraced the Fuzzy Best–Worst approach from the context of perishable food supply chains to enhance socio-economic performance and meet SDGs.

A study analyzed supply chain diversification by sampling 1434 Chinese manufacturing firms. According to ILO, 25 million people become jobless due to the crisis of COVID-19. During the era of COVID-19, like many other countries, Bangladesh has implemented practices of home quarantine, social distance, and lockdown to mitigate the risk of spreading the

deadly coronavirus. Due to the loss of jobs in various sectors, the employee faces social sustainability challenges. Majumdar et al. (2020) proposed appropriate redressal for the socially sustainable supply chain in the context of the South Asian clothing industry. In the COVID-19 pandemic, to improve organizational performance, the manufacturing industry faces continual provocation from stakeholders for stabilizing economic welfare with sustainable growth in their supply chain (Goodarzian et al., 2021; Jain & Singh, 2020; Severo et al., 2021). To obtain expected performance from the manufacturing company sustainable supplier selection (SSS) is considered by powerful mood to ensure supply chain sustainability (Hendiani et al., 2020; Orji & Wei, 2015). In the Nigerian manufacturing context, Orji and Ojadi (2021) investigated the impression of COVID-19 on SSS. The financial impacts of COVID-19 interrupted the stock markets, making it difficult to the investors and policymakers to implement sustaining prosperity. A study found that the volatility of stock market can be assessed in a better way than the returns with interventions made by the government during COVID-19 (Yang et al., 2023).

In summary, PM and KPIs are important tools for evaluating organizational success, but COVID-19 had significant impacts on society. Studying these topics can provide insights into best practices for managing performance, selecting appropriate KPIs, and responding to global events. Additionally, research can inform policy decisions and improve outcomes for individuals and organizations. It is clear that effective PM practices are critical in responding to the uncertainties of the pandemic and improving the resilience of the manufacturing industry.

2.2 Key performance indicators and their necessity in the leather products industry

Identifying, analyzing, scanning, and upgrading performance arise as a necessity for business enterprises. A significant amount of research must be supervised for detecting better performance measurement and improvement, managing remarkable combative matters of dynamic management implementation, enlarging development, and product distinction (Kassaneh & Workalemahu, 2018). According to New (1994), when there is a deprivation of PM, it becomes difficult for decision-makers for deciding on complex situations. Concerning different parameters like size, schedule, and standard the performance of products can be quantified (Hedrick, 2004). As Bangladesh's LPI has an immense possibility for uplifting the country's economy, government grants it as one of the supreme preferences. The different processes of performance measurement and improvement bring inadequate adjustment in the PM system due to the low consideration of the personal intention of employees (Kassaneh & Workalemahu, 2018). For this, organizational as well as personal KPIs must be selected for the right PM. The COVID-19 pandemic can influence buyers' behavioral commitment. Besides this, the pandemic hits businesses like the LPI with opportunities to explore real-world marketing strategies (Alshaketheep et al., 2020). Hoque et al. (2022) investigated the readymade garments sector's buyer–supplier relationship from the Bangladeshi context. Group decision-making for managing performance, and appraisal of KPI for the PM system of the company is compulsory in an emergency for sustainability (Amiri et al., 2011). LPI is not attaining comparable development in business because of negligence to direct the whole spectrum of their PM system. The linguistic Z-DEMATEL approach is a company-in-line tool that can resolve external factors through KPI appraisal. Assessment of KPI is the prerequisite during the time of COVID-19 to act on the quality of LPI.

2.3 Key performance indicators for performance management in the era of the COVID-19 pandemic

COVID-19 has stroke Bangladesh's LPI badly. It is compulsory to identify KPIs to lessen the epidemic's impression, construct a flexible as well as ruthless sector, and achieve sustainable industrial development. The impact of COVID-19 brought the biggest challenge to manufacturing operations and PM of LPI, growth, and expansion of business firms, and profitability of firms due to a decline in sales and reduced demand. To overcome those challenges, pinpointing the KPIs and implementing them properly in various departments of LPI are the demands of time. Aside from that, KPIs provide a transparent measurement to detect, inspect and optimize production process parameters concerning their size, and standard in different cost aspects. To increase profit, all companies endeavor in enlarging the top line of their business seeking to penetrate the market. KPIs play a vital role in increasing the bottom line of the company without having an expansion threat. To determine the overall performance of an organization, the categorization of similar KPIs under the same objectives is mandatory. Every single KPI exposes the specific requirement and purpose to line up business objectives and boost organizational performance. KPIs for LPI can be analyzed under the following 6 segments.

2.3.1 Production and quality control related KPIs

Production and quality control KPIs relate to the product life cycle to aid in the fruitful assessment of the product in some aspects like product management, ergonomics, quality control, equipment management to product packaging and dispatch. To meet customer requirements or expectations continual improvement of the manufacturing process with proper supervision is compulsory. Measuring the actual performance, comparing the performance with standard requirements, and acting according to the requirement are the tasks of quality control managers. Reducing cost, improving productivity, keeping the brand value standard are the targets of quality control. Making the structure of production timeline; tracking and measuring manufacturing alongside production efficiencies; improving organizational processes; reducing waste; ensuring the synchronization of quality; safety and cost of the resources; allocating and governing work to employees; appraising performance; gratifying and disciplining employees; controlling absence rate of employees; addressing complaints and solving out the problems; avoiding the loss during manufacturing number of deviation are some of the objectives of managers from this department. Decision-makers set production and quality control KPIs keeping consideration of those objectives.

2.3.2 Research and development related KPIs

'Research and development' also known as 'Sampling' in the leather products sector, develop designs and construct prototypes whichever is vitally a prime step in the product development process. This department allows companies to design profoundly operative marketing strategies. To retain full control over the manufacturing process, encounter buyer's specific requirements, meet quality standards, understand the end-users, products competition, improve the efficiency of the existing designing process, ensure the proper use of company resources "Research and Development" department plays an important role. "Sampling" is an important aspect of the manufacturing process of leather products and will act as a safeguard of the company from any unpleasant surprises when the products will arrive. The company

wants its final product to meet exact specifications, which is why sampling is a critical component of the proper manufacturing process. Sampling prevents full production from starting until the sample approval process has taken place.

2.3.3 Human resources and compliance related KPIs

Human resources and compliance play a key role in helping the LPI deal with a hypercompetitive business environment. To experience organization-wide improvement, human resources, and compliance track critical KPIs. Arranging better training programs, bringing improvement in the hiring process, providing compensation benefits, PM of employees, ensuring social compliance, occupational safety, and health, assessing risk, employing safety practices, adopting employee welfare, applying corrective action plan, testing and calibrating the company resources are some of the key targets of human resources and compliance to achieve organizational goals. Human resources and compliance professionals recognize and negotiate different laws and regulations controlling the employee relationship to improve the organization's reputation.

2.3.4 Financial and economic related KPIs

Financial and economic KPIs act for driving business strategy, designating financial results, tracking the progress of the company to achieve specific business objectives. COVID-19 instigates fear in investors in the global market (Dharani et al., 2023). In that case, financial and economic KPIs take a critical role in allocating resources and planning for investment. Setting growth targets over time for the company; improving the decision-making process; providing statistics about company sales, cash flow, expenses, profits are some of the objectives met through financial and economic KPIs. Apart from that, the selection of KPIs is critical for picking more profitable opportunities as well as handling negotiations.

2.3.5 Account/store related KPIs

Inventory management is considered the main task for the accounts/store department of the LPI. Keeping a sufficient stock of leather and related accessories, thread, zipper at the right levels in the proper place are the chores of the Accounts department. To prevent the business from falling through unseen cracks, inventory management lets the LPI attain orders up-to-date and in the perfect way; increases buyer's satisfaction, ensures a well-structured and planned warehouse, reduces the possibility of obstruction of company resources.

2.3.6 Business development related KPIs

Coordinating with suppliers, manufacturers, and stores to ensure correct implementation of plans, receiving "Tech-pad" or sample from the buyer, directing layout plans of the store and maintaining the inventory of products, developing the sample of the product in the sample section with time study, consumption and costing, confirmation with order quantity, assembling information on market trends and reactions of buyers to products, inspecting sales figures—delineating growth and change in markets are some of the tasks performed by business development section of LPI. This department undertakes plans or projects which point out activities to construct a business successfully on top of time. Alongside this, the department aids in the utilization of customers and markets, the accomplishment of strategical collaboration with Buyers, the establishment of the leather products company's recognition.

2.4 Existing works on KPI, PM, and DEMATEL

KPIs allow critical modification in performing business operations and aligning the business goals and objectives. Tasks like keeping an eye on company performance, quantifying the progression of the company, and handling problems can be accomplished through KPIs identification. According to Moktadir et al. (2020), KPIs signify the prosperity of a company by setting up the objectives and issues the path for further improvement. Besides, KPI reduces the study gap and helps the company to take immediate action about the arising, focusing on morale and company performance. KPIs are regarded as a constructive tool to point out the area of the company for improvement. They smooth out the company's performance through product recognition and remodeling. During the investigation of KPIs, company managers face trouble as KPIs comprise substantial components and set out conclusive figures. The productivity and profitability of the company can be acquired through the acquisition of KPIs, which can generate improvements. The supply chain of LPI is heavily disrupted during COVID-19. For mitigating a disrupted supply chain and avoiding negative results from PM Manupati et al. (2022) constructively integrate pre as well as post-disruption scenarios to provide decision-support. According to Cao et al. (2015) indicators are considered the transporter of strategy. For implementing strategy and enhancing organizational performance, the use of PM is recommended frequently.

Though many studies have been conducted on KPI and PM systems, unexpectedly LPI allied study was absent yet. Studies have been initiated in the zone of information management, improving the supply chain, higher education, management data systems, shop floor, finance service, hospital management, functional automation, transportation, bank, construction industry, etc. Moktadir et al. (2020) performed an analysis of the KPIs for operational excellence regarding sustainability in the LPI. The study identified KPIs by employing the best–worst method, developing a performance index, and lastly instigating managerial and policy implications. The results reported that KPIs under the "Management" category are acknowledged as the highest preference. Besides this, in Small Medium Enterprises (SMEs), 13 KPIs were identified based on Specific, Measurable, Economic, Attainable, Relevant, Time-specific, Explainable or Evaluated, and Relative or reviewed shortly SMARTER criteria applying analytical hierarchy process (AHP) (Kaganski et al., 2018). Further, Zairy (2013) explored practices with logistics PM in the supply chain of textiles identifying the best practices and barriers. They found barriers to establishing a collaborative culture. In research work, a conceptual framework was proposed by Kagioglou et al. (2001) by adopting the Balanced Scorecard (BS) method. They validate the process Performance Conceptual Framework (PCF) in several areas. Previously in the medical area, PM set off a functional theme and was accepted by scholars. By adopting the BS method, Behrouzi & Ma'aram (2019) furnished a technique for identifying and ranking feasible and relevant performance indicators. With the help of the path analytical model perspective, Cinaroglu and Baser (2018) inspected the relationship between the effectiveness of indicators for the improvement in health care performance. In Palestinian food manufacturing companies, to improve company performance. Hassan and Jaaron (2021) investigated the connection uniting total quality management and intensity of green manufacturing. In the supply chain, Cai et al. (2009) initiated a framework for decision-makers or managers of the organization by identifying and analyzing the interdependency of KPIs in a large retail company scenario. Many studies have been conducted using the DEMATEL method. In India, to assess the external barriers in e-waste manufacturing, Bhatia and Srivastava (2018) embraced a grey-DEMATEL method. In the case of logistics provider enterprises, key success factors (CSFs) were investigated by Ahmad et al. (2018) approaching the DEMATEL technique from the Iranian perspective. A two-dimension

uncertainty in the linguistic DEMATEL model was suggested by Ding and Liu (2018), for the assessment of CSFs in the context of emergency management. Yadegaridehkordi et al. (2018) explored the hybrid technique of DEMATEL and neuro-fuzzy inference system on manufacturing company's performance, through a large amount of data adoption. For diminishing the gaps like a wide-ranging of decision-makers, lack of interactions among performance indicators, absence of interdependency of factors, incapability of demonstrating the reliability of the information, and inefficient in handling the data from a wide-ranging perspective, Jiang et al. (2020) recommended linguistic Z-DEMATEL approach.

2.5 Research gap and contribution

Studies about PM systems have been carried out in areas of hospital management, construction industry, bank, higher education, management data system, shop floor, finance service, etc. As mentioned in the previous sections of the literature review, it was substantiated that study about KPIs for PM in the COVID-19 pandemic on the domain of LPI approaching the integrated method of Pareto, and combined large-ranging linguistic Z-DEMATEL has not been conducted. Though some studies are found in PM using KPIs in manufacturing industries, the focal point was not on the integration of the company's overall PM. Besides this, no study assessed the KPIs for PM grounded on six themes (production and quality control, research and development, human resource and compliance, financial and economic, accounts/store, and business development) of companies for the LPI using an integrated dynamic decision support model. To drive the company profitably, the identification of crucial KPIs in strenuous situations is of major importance. Scrutinizing the consequences of various KPIs is compulsory. To cope with the challenges in a complex situation like COVID-19, a well-established methodology for the identification of KPIs and implementation of them for the PM to attain the goals and objectives of the company is required. The authors of this present study mark out the aforesaid research gaps and integrated the Pareto-based linguistic Z-DEMATEL model by applying it to the field of the LPI from a Bangladeshi perspective in the context of a wide-ranging. The contribution of this research is listed below:

(a) KPIs for PM in COVID-19 are pinpointed, from literature review and taking qualitative suggestions and recommendations from experts.
(b) Pareto analysis was performed to select the most crucial KPIs for further assessment.
(c) Using the linguistic Z-DEMATEL approach, influencing and reliability factors between KPIs are determined and the interdependencies among KPIs are established to navigate PM in the era of COVID-19.
(d) To determine the PM system in COVID-19, feedback and quantitative measures from experts were captured from LPI.

3 Research design and methodology

3.1 Research design

Constructing a PM system using KPIs and approaching the linguistic Z-DEMATEL technique for the LPI in Bangladesh is the goal of this study. Firstly, KPIs were identified from the literature review and experts' feedback respectively for various departments of the LPI. Secondly, by developing a survey questionnaire, identified the most critical KPIs employing Pareto analysis. Thirdly, another questionnaire was developed for KPIs appraisal. Expert

appraisal matrices were collected from 25 industrial experts. The data analysis and calculation were performed approaching the extended lingual Z-DEMATEL method. Identification of the most relevant interdependent KPIs for PM of the LPI was accomplished using the proposed research Framework illustrated in Fig. 1. Steps 1–6 are followed before applying Z-DEMATEL.

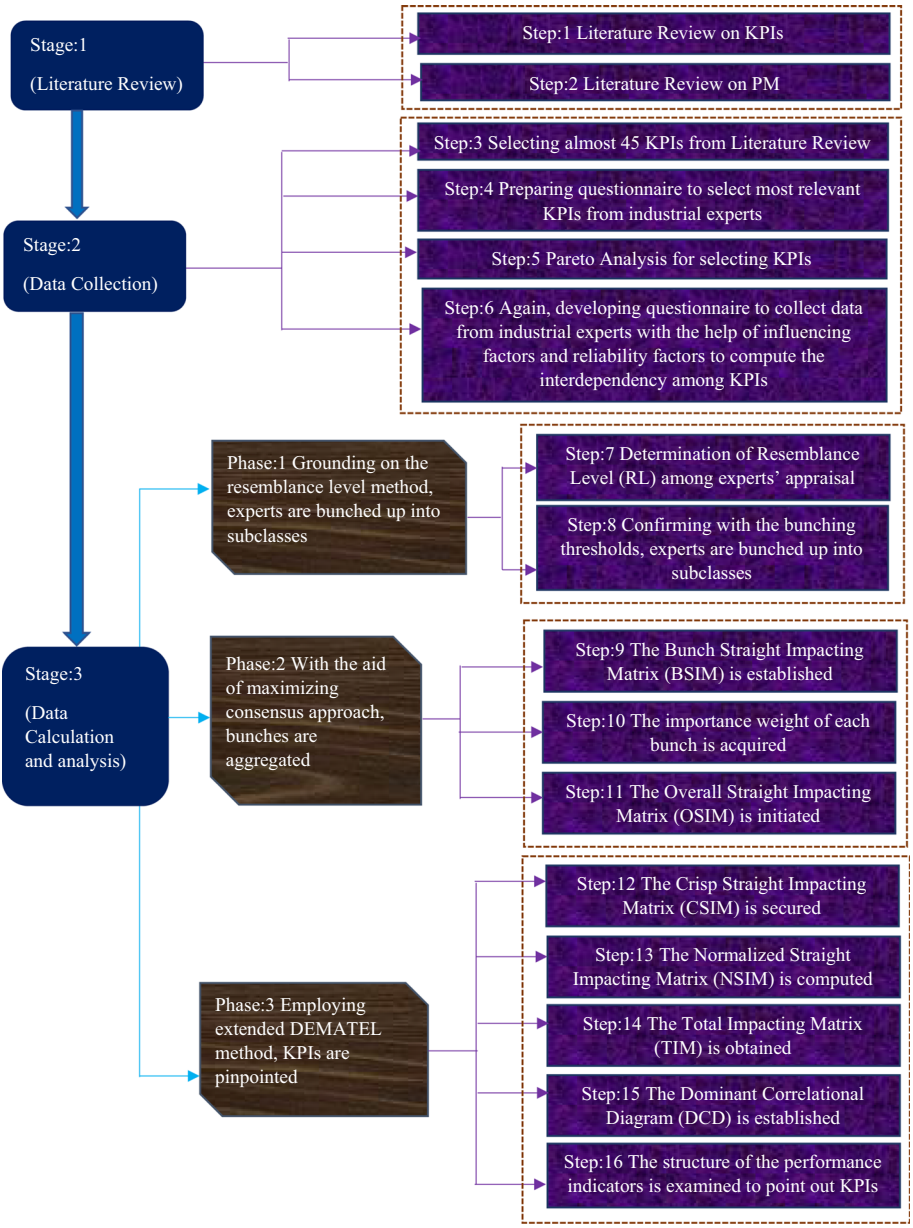

Fig. 1 Applied extended linguistic Z-DEMATEL

3.2 Solution methodology

KPIs are utilized in the LPI to assess the efficacy and potency of each department. The current study represents 15 KPIs from the suggestion of experts and a literature review in the LPI scenario. Based on the department of the LPI, 15 KPIs are codified under 6 segments, which are presented in Table 1 along with references. To identify the KPIs for PM, a systematic literature review was performed. Several keywords such as "KPIs for performance management", "KPIs for performance management during COVID-19", "Operational performance management during COVID-19 pandemic", "KPI" AND "COVID-19", were utilized to search the relevant work in the scholarly databases such as the Scopus, ScienceDirect, and Google Scholar. The identified KPIs from the literature review are presented in Table 1.

For examining the interrelationship between KPIs of the LPI, the lingual Z-DEMATEL approach in the context of a wide-ranging is proposed which was initiated by Jiang et al., (2020); Labella et al., (2018). The proposed framework comprises three phases. They are:

Phase-1: Grounding on the Resemblance Level (RL) method, experts are bunched up into compact sub-classes.

Phase-2: With the aid of maximizing consensus approach, bunches are aggregated.

Phase-3: Employing the extended DEMATEL method, KPIs are pinpointed.

Let, the set of PM indicators be, $F = \{F_1, F_2, ..., F_t\}$.

In the case of wide-ranging decision-making, the experts' extent must overpass 20 (H. C. Liu et al., 2018). So, the experts' numbers can be illustrated as, $E = \{E_1, E_2, ..., E_v\}$ where $v > 20$

Let, linguistic term sets are denoted by, $S = \{s_0, s_1, ..., s_{2g}\}$ and $S\prime = \{s_0\prime, s_1\prime, ..., s_{2g}\prime\}$

So, we can write z^e_{cd}, the lingual Z-digit is given by the expert E_e as, $z^e_{cd} = (A^e_{\phi_{cd}e}, B^e_{\varphi_{cd}e})$

If Z^e denotes the linguistic straight impacting matrix of the eth expert then, $Z^e = (z^e_{cd})_{t\times t}$

3.2.1 Phase-1

In this phase, by dint of resemblance level method, the wide-ranging extent of experts are bunched up into compact subclasses.

Step-7 Determination of RL between experts' appraisal matrices

Calculation of the RL among the appraisal matrices of experts is done in this step. If Z^e and Z^f are the LSIMs then RL will be:

$$RL\left(Z^e, Z^f\right) = 1 - d\left(Z^e, Z^f\right) = 1 - \frac{1}{t \times t}\sum_{c=1}^{t}\sum_{d=1}^{t} d\left(z^e_{cd}, z^f_{cd}\right) \tag{1}$$

Step-8 Confirming with the Bunching Threshold Values (BTV), experts are bunched up into subclasses.

For detecting BTV, the Expert's appraisal matrices are bunched up.

$$\lambda = \min_{e,\, f=1,2,...,y,\, e\neq d} RL\left(Z^e, Z^f\right) + \frac{2}{3}\left(\max_{e,\, f=1,2,...,y,\, e\neq d} RL\left(Z^e, Z^f\right) - \min_{e,\, f=1,2,...,y,\, e\neq d} RL\left(Z^e, Z^f\right)\right) \tag{2}$$

here, $0 \leq \lambda \leq 1$

Z^e and Z^f can be put down into the same bunch only if $RL(Z^e, Z^f) \geq \lambda$.

Table 1 List of KPIs selected from Literature Review

Segment of KPIs	Indicator	References
Production	Productivity	Jovan and Zorzut (2006)
	Handling of tasks	Nara et al. (2019)
	Quality of work	Fung (2020), Joppen et al. (2019), Jovan and Zorzut (2006), Scafà et al. (2019)
	Arrangement of Tasks	Nara et al. (2019)
	Taking security measures	Scafà et al. (2019)
	Relationship with colleagues	Scafà et al. (2019)
	Layout planning	Scafà et al. (2019)
	Delegation in management	Scafà et al. (2019)
	Employee turnover rate	Pinna et al. (2018)
	Target Fulfilment within the delivery time	Siedler et al. (2020)
	Maintenance Delivery	Lima et al. (2021)
	Individual Layout of the worker in the workplace	Scafà et al. (2019)
	Worker's perception of work	Scafà et al. (2019)
Research and Development	Time management	Ahmad et al. (2012)
Human resource and compliance	Monitoring the mean time between failure	Siedler et al. (2020)
	Asset Management Policy	Lima et al. (2021)
	Corrective Action Plan Application	Scafà et al. (2019)
	Risk mitigation strategies application	Lima et al. (2021)
	Technical standards and legislation	Lima et al. (2021)
	Management, Review, Audit, and Assurance	Lima et al. (2021)
	Assurance of Occupational Health and Safety (OSH)	Amrina and Vilsi (2015), Liu et al. (2021)
	Gender Equity	Amrina and Vilsi (2015)
	Compliance with institution privacy and security policies	Fung (2020)
Financial and Economic	Gross and net profit margin (Profitability)	Bilal and Oyedele (2020)
	Capital Investment Decision Making	Lima et al. (2021)
	Application of Technology	Nudurupati et al. (2021), Siedler et al. (2020)
	Net Sales Value	Bilal and Oyedele (2020)
	Retention of Sales	Bilal and Oyedele (2020)
	Total Cost (Inventory, Labor, Material)	Amrina and Vilsi (2015), Bilal and Oyedele (2020); Jovan and Zorzut (2006)

Table 1 (continued)

Segment of KPIs	Indicator	References
	Resource Costing and Valuation	Lima et al. (2021)
Accounts/Store	Identification of company's resources	Scholarios and Taylor (2014)
	Governing and Utilizing Inventory/Resource	Fung 2020), Lima et al. (2021), Lindberg et al. (2015), Scafà et al. (2019)
Business Development	Monitoring and controlling core Competencies	Lima et al. (2021)
	Buyer Satisfaction	Lima et al. (2021), Pinna et al. (2018)

If v denotes the number of appraisal matrices stated by experts and V dictates the number of bunches then we can split the v matrices into V bunches where $C_x(x = 1, 2, ..., V)$.

Provided in the x^{th} bunch, the number of experts is $l_x(l_x \geq 2)$, validating the condition $\sum_{x=1}^{V} l_x = y$

3.2.2 Phase-2

The formation of an OSIM can be achieved by combining all the LSIMs.

$$Z^e(e = 1, 2, ..., v)$$

Step-9 The BSIM is established.

If Y^x denotes the BSIM then, $Y^x = (y_{cd}^x)_{t\times t}$ here,

$$y_{cd}^x = \frac{1}{l_x}\sum_{e=1}^{l_x} z_{cd}^e \tag{3}$$

Here, the RLs between experts' appraisal matrices are noticeably high.

Step-10 The importance weight of each bunch is acquired.

Resting on the consensus strategy, expert weights are retained from the popular maximizing consensus approach (Zhang & Xu, 2015; Zhang et al., 2014).

Based on the maximizing consensus approach, additional weight needs to allocate to the bunch C_x when the consensus measure of, $Y^x > Y^s$ where $Y^s = (y_{cd}^s)_{t\times t}$

Consequently, the subsequent constrained optimization model for gaining the weights of bunches can be established.

$$max F(p_x) = \sum_{x=1}^{V}\left(\frac{1}{t \times t \times (V-1)}\sum_{s=1, s\neq x}^{V}\sum_{c=1}^{t}\sum_{d=1}^{t}(1 - d(y_{cd}^x, y_{cd}^s))\right)p_x \tag{4}$$

$$s.t.\begin{cases}\sum_{x=1}^{V} p_x = 1\\ p_x \in P\\ p_x \geq 0\end{cases}$$

Here, P = the partial familiar weighting information.

The bunch weight $p_x(x = 1, 2, ..., V)$ can be prevailed through resolving the above-constrained optimization model.

Step-11 The OSIM is initiated.

If matrix Z signifies the OSIM then,

$$Z = (z_{cd})_{t\times t}$$

where z_{cd} can be calculated by applying the LZPWG operator,

$$\begin{aligned} z_{cd} &= LZPWG(y_{cd}^1,\ y_{cd}^2,\ ...,\ y_{cd}^V) \\ &= \left(f^{*^{-1}} \left(\prod_{x=1}^{V} f^*(\Delta_{cd}^x)^{\frac{p_x(1+J(y_{cd}^x))}{\sum_{x=1}^{V} p_x(1+J(y_{cd}^x))}} \right),\ g^{*^{-1}} \left(g^*(\nabla_{cd}^x)^{\frac{p_x(1+J(y_{cd}^x))}{\sum_{x=1}^{V} p_x(1+J(y_{cd}^x))}} \right) \right) \end{aligned} \tag{5}$$

In which, $J(y_{cd}^x) = \sum_{\substack{x=1 \\ x\neq s}}^{V} Sup(y_{cd}^x,\ y_{cd}^l) = \sum_{\substack{x=1 \\ x\neq s}}^{V} 1 - d(y_{cd}^x,\ y_{cd}^l)$

Here, $Y^l = (y_{cd}^l)_{t\times t}$ indicates the Mean Matrix of V bunches (MMB).

3.2.3 Phase-3

For clarifying the interdependencies and pointing out KPIs of LPI, the traditional DEMATEL approach is expanded concerning linguistic Z-digits.

Step-12 The CSIM is secured.

If f^* and g^* refers to the feasible linguistic scale function, by evaluating the scoring rate of an individual element in Z, the CSIM $Z\prime$ can be computed as $Z\prime = (z_{cd\prime})_{t\times t}$. Here,

$$z_{cd\prime} = S(z_{cd}) = f^*(A_{\alpha_{cd}}) \times g^*(B_{\beta_{cd}}) \tag{6}$$

Step-13 The normalized straight impacting matrix is computed.

$$\text{If} h = max\left\{ \underset{1\le c\le t}{max} \sum_{d=1}^{t} z_{cd\prime},\ \underset{1\le d\le t}{max} \sum_{c=1}^{t} z_{cd\prime} \right\} \tag{7}$$

then the NSIM $N = (n_{cd})_{t\times t}$ will be,

$$N = \frac{Z\prime}{h} \tag{8}$$

Step-14 The TIM is obtained.

If $J = (j_{cd})_{t\times t}$ signifies the TIM then regarding the NSIM N, the value of J will be,

$$J = \lim_{w\to\infty} (N + N^2 +, ..., +N^w) = N(I - N)^{-1} \tag{9}$$

In which, I = Identity matrix.

j_{cd}= full primary and secondary impact endeavored from F_c to F_d.

Step-15 The DCD is established.

Let, a_c= the entire influence endeavored by F_c from all the other indicators.

b_d= the entire influence endeavored by F_d from all the other indicators

A = total sum of rows from the J

B= total sum of columns from the J

Then,

$$A = (a_c)_{t\times 1} = \left(\sum_{d=1}^{t} j_{cd}\right)_{t\times 1} \tag{10}$$

$$B = (b_c)_{t\times 1} = \left(\sum_{c=1}^{t} j_{cd}\right)_{1\times t} \tag{11}$$

If $c = d$ and $c, d = 1, 2, ..., t$; then for developing a DCD calculation of $(a_c + b_c)$ denoting the significance level and $(a_c - b_c)$ denoting exclusive impact level can be done.

Step:16 The structure of the performance indicators is examined to point out KPIs

"Prominence" $(a_c + b_c)$; $c = (1, 2, ..., t)$ is the term that signifies the potency of the influences and is placed on the horizontal axis. On the vertical axis of the graph, $(a_c - b_c)$; $c = (1, 2, ..., t)$ is placed which signifies the "relation" displaying the net effect exerted by the indicators.

The gross prominence of the indicator F_c will be increased when the value of $(a_c + b_c)$ will be increased.

The cause-and-effect group can be analyzed as follows:

When, $a_c + b_c > 0$, the F_c has an exclusive impact on the other KPIs.

When, $a_c - b_c < 0$, the F_c is an exclusive consequence of the other KPIs.

3.2.4 Conceptualization of Z-numbers

Functions related to linguistic scales Let g represents a non-negative whole number and s_i is a thinkable value of the linguistic variable. Then, a defined, limited, and perfectly arranged linguistic expression coupled with odd cardinality will be:

$$S = \{s_0, s_1, s_2, ..., s_{2g}\}$$

According to Herrera et al. (2000) and Ding and Liu (2018), S must assure the subsequent possessions:

(a) $s_i \leq s_j$ if and only if $i \leq j$
(b) $neg(s_i) = s_j$, assuring $j = 2g - i$

Here, 'neg' denotes the negation operator.

An uninterrupted set is embraced to conserve entire data. In consequence, a discrete linguistic expression set must be extended Xu, Z. (2006) to a continual form.

If $s_i > s_j, i > j$ and $\tau(\tau > 2g)$ then,

$$\widetilde{S} = \{s_i | i \in [0, \tau]\}$$

$S = \{s_0, s_1, s_2, ..., s_{2g}\}$ will be considered as a virtual linguistic term until $\theta_i \in [0, 1]$. When, $\theta_i \in [0, 1], 0 \leq \theta_0 \leq \theta_1 \leq ..... \leq \theta_{2g}$ will be a real linguistic expression.

Virtual linguistic expressions become visible in the performance activity to escape information deprivation and deformation. Designating non-identical semantic values into linguistic expression in various circumstances is very difficult. For this, linguistic scale functions were suggested by Wang et.al. (2014) to show up semantic values rapidly and introduce information under various situations constructively.

Concept 1 Functions (Wang et.al. 2014).

Considering, $0 \le \theta_0 \le \theta_1 \le \ldots\ldots\ldots \le \theta_{2g}$; the linguistic scale function can be recognized as a mapping from s_i to θ_i,

$$f : s_i \to \theta_i (i = 0,\ 1,\ \ldots\ldots,\ 2g) \tag{12}$$

where $\theta_i \in [0,\ 1]$ and $f_1(\theta_i) = \theta_i = \frac{i}{2g} (0 \le i \le 2g)$ represents repetitiously growing function concerning i.

Function:1 Grounded on i, the first function can be defined as,

$$f_1(\theta_i) = \theta_i = \frac{i}{2g}; (0 \le i \le 2g) \tag{13}$$

Function:2 Concerning, the exponential scale the second function can be explained as,

$$f_2(\theta_i) = \theta_i = \begin{cases} \frac{a^g - a^{g-i}}{2a^g - 2} (0 \le i \le g), \\ \frac{a^g + a^{i-g} - 2}{2a^g - 2} (g+1 \le i \le 2g). \end{cases} \tag{14}$$

According to Liu et al. (2019), the parameter $f_3(\theta_i) = \theta_i = \{ \begin{matrix} \frac{g^\alpha - (g-i)^\alpha}{2g^\alpha} (0 \le i \le g), \\ \frac{g^\beta - (i-g)^\beta}{2g^\beta} (g+1 \le i \le 2g), \end{matrix}$ will be acquired in the range [1.36,1.4].

Function:3 Regarding prospect theory, the third function can be obtained,

$$f_3(\theta_i) = \theta_i = \begin{cases} \frac{g^\alpha - (g-i)^\alpha}{2g^\alpha}; & (0 \le i \le g), \\ \frac{g^\beta - (i-g)^\beta}{2g^\beta}; & (g+1 \le i \le 2g). \end{cases} \tag{15}$$

Here, $\alpha,\ \beta \in [0,\ 1]$. Based on Jiang et al. (2020),$\alpha = \beta = 0.88$.

3.2.5 Principles of linguistic Z-numbers

Considering human cognitive information, Wang et al. (2014) suggested Z-numbers to express the information precisely and smoothly.

Concept 2 Set of linguistic Z-numbers (Wang et al. 2017).

Allowing, $S' = \{s'_0,\ s'_1,\ s'_2,\ \ldots\ldots,\ s'_{2g'}\}$

$$S' = \{s'_0,\ s'_1,\ s'_2,\ \ldots\ldots,\ s'_{2g'}\}$$

And X represents a domain of expression, we can define a linguistic Z-number set Z in X by:

$$Z = \{(x,\ A_{\phi(X)},\ B_{\varphi(X)}) \big| x \in X\}, \tag{16}$$

Here, $A_{\phi(x)}$ = Fuzzy restriction taken by the uncertain variable X.

$B_{\varphi(x)}$ = Reliability measure of $A_{\phi(x)}$.

Concept 3 Operational rules of linguistic Z-numbers (Wang et al. 2017).

Let, f^* and g^* be the distinct linguistic scale function and linguistic Z-numbers be,

$$z_i = (A_{\phi(i)},\ B_{\varphi(i)})$$

$$z_j = (A_{\phi(j)},\ B_{\varphi(j)})$$

(a) Direct Summation rule: $z_i \oplus z_j = (f^{*^{-1}}(f^*(A_{\phi(i)}) + f^*(A_{\phi(j)})),\ g^{*^{-1}}(\frac{f^*(A_{\phi(i)}) \times g^*(B_{\varphi(i)}) + f^*(A_{\phi(j)}) \times g^*(B_{\varphi(j)})}{f^*(A_{\phi(i)}) + f^*(A_{\phi(j)})}))$;

(b) Constant multiplication rule:

$\lambda z_i = (f^{*^{-1}}(\lambda f^*(A_{\phi(i)})),\ B_{\varphi(i)})$, where $\lambda \geq 0$;

(c) Exponential rule:

$z_i^{\lambda} = (f^{*^{-1}}(f^*(A_{\phi(i)})^{\lambda}),\ g^{*^{-1}}(g^*(B_{\varphi(i)})^{\lambda}))$, here $\lambda \geq 0$.

Concept 4 Score function and Accuracy function of Linguistic Z-numbers (Wang et al. 2017).

Score function of linguistic Z-number $z_i = (A_{\phi(i)},\ B_{\varphi(i)})$ can be represented as $S(z_i)$ and is calculated by:

$$S(z_i) = f^*(A_{\phi(i)}) \times g^*(B_{\varphi(i)}) \tag{17}$$

In the same way, the Accuracy function of z_i can be represented as,

$$A(z_i) = f^*(A_{\phi(i)}) \times (1 - g^*(B_{\varphi(i)})) \tag{18}$$

Concept 5 Comparison method (Wang et al. 2017).

Let, two distinct values of linguistic Z-numbers be,

$z_i = (A_{\phi(i)},\ B_{\varphi(i)})$ and $z_j = (A_{\phi(j)},\ B_{\varphi(j)})$.

(1) When z_i is greater than z_j, $z_i > z_j$, if $A_{\phi(i)} > A_{\phi(j)}$ and $B_{\varphi(i)} > B_{\varphi(j)}$;
(2) If $S_{(z_i)} > S_{(z_j)}$ or $S_{(z_i)} = S_{(z_j)}$ and $A(z_i) > A(z_j)$; then z_i will be larger than z_j.
(3) If $S_{(z_i)} = S_{(z_j)}$ and $A(z_i) = A(z_j)$; then $z_i = z_j$, $z_i \sim z_j$.
(4) If $S_{(z_i)} < S_{(z_j)}$ or $S_{(z_i)} = S_{(z_j)}$ and $A(z_i) < A(z_j)$; then z_i will be smaller than z_j.

Concept 6 Distance between linguistic Z-numbers (Wang et al. 2017).

Let, two distinct values of linguistic Z-numbers be, $z_i = (A_{\phi(i)},\ B_{\varphi(i)})$ and $z_j = (A_{\phi(j)},\ B_{\varphi(j)})$.

The distance between the numbers will be:

$$\begin{aligned} d(z_i,\ z_j) = \frac{1}{2}\big(&\left|f^*(\phi(i)) \times g^*(\varphi(i)) - f^*(\phi(j)) \times g^*(\varphi(j))\right| \\ &+ \max\{\left|f^*(\phi(i)) - f^*(\phi(j))\right|,\ \left|g^*(\varphi(i)) - g^*(\varphi(j))\right|\}\big) \end{aligned} \tag{19}$$

Concept 7 LZPWG operator in Z-linguistic numbers (Jiang et al., 2020).

Let,$w = (w_1,\ w_2,\ w_3,\ .....,\ w_n)$ be the weight vector of $z_i = (A_{\phi(i)},\ B_{\varphi(i)})$ $(i = 1,\ 2,\ .....,\ n)$ concerning $w_i \in [0,\ 1]$ and $\sum_{i=1}^{n} w_i = 1$.

LZPWG operator is the abbreviation form of Linguistic Z-number Power Weighted Geometric operator.

$$\begin{aligned} LZPWG(z_1,\ z_2,\ z_3,\ .....,\ z_n) = {} & z_1^{\frac{w_1(1+T(z_1))}{\sum_{i=1}^{n} w_i(1+T(z_i))}} \otimes z_2^{\frac{w_2(1+T(z_2))}{\sum_{i=1}^{n} w_i(1+T(z_i))}} \\ & \otimes z_3^{\frac{w_3(1+T(z_3))}{\sum_{i=1}^{n} w_i(1+T(z_i))}} \otimes ..... \otimes z_n^{\frac{w_n(1+T(z_n))}{\sum_{i=1}^{n} w_i(1+T(z_i))}} \end{aligned} \tag{20}$$

Here, $T(z_i) = \sum_{\substack{i=1 \\ i \neq j}}^{n} Sup(z_i,\ z_j)$ and $Sup(z_i,\ z_j) = 1 - d(z_i,\ z_j)$.

LZPWG operator aggregates the values and exhibits a linguistic Z-number,

$$\begin{aligned} LZPWG(z_1,\ z_2,\ z_3,\ .....,\ z_n) = {} & \left(f^{*^{-1}}\left(\prod_{i=1}^{n} f^*(A_{\phi(i)}\right)^{\frac{w_i(1+T(z_i))}{\sum_{i=1}^{n} w_i(1+T(z_i))}}\right), \\ & g^{*^{-1}}\left(\prod_{i=1}^{n} f^*(B_{\varphi(i)})^{\frac{w_i(1+T(z_i))}{\sum_{i=1}^{n} w_i(1+T(z_i))}}\right) \end{aligned} \tag{21}$$

Table 2 Selection of KPIs from suggestions of Experts

Segment/section	Indicator	References
Production	Initiating the right call	Expert
	Knowledge of every operation and Momentum of work	Expert
	Recognition of work	Expert
	Identification of sequence of operation	Expert
	Wrong signals and inappropriate action	Expert
Research and Development	Lack of coordination between R&D and Production Department	Expert
	Accuracy in making the pattern of the sample (Expert)	Expert
Human Resource and Compliance	Controlling absence rate of employee	Expert
	The implication of maternal leave and payment (Expert)	Expert
	Ensuring proper training	Expert
	Certifications and System Appraisal	Expert
Financial and Economic	Seasonality	Expert
Accounts/store	Formulation of detailed plans and budgets	Expert
Business Development	Digital Marketing	Expert

4 An industrial case study

As the COVID-19 delineate wide-ranging interruption in PM of LPI, decision-makers are rethinking about KPI investigation process. In this section, the outcomes regarding the pinpointed KPIs are examined as a path for moving forward in these situations.

4.1 Data collection

Data is collected via inspection, survey questionnaire, and conversation with company experts. The details of data collection protocol are given in online Appendix-A and Appendix-B.

4.1.1 Selection of KPIs from industrial experts

Almost 14 KPIs were chosen from discussion with the experts from various departments of the LPI by collecting data according to Table A3 shown in online Appendix-A and are represented in Table 2.

4.1.2 Preparing a questionnaire to select most relevant KPIs from industrial experts feedback

A survey questionnaire was developed given in online Appendix-A in Table A2 for selecting KPIs from industrial experts. The main objective of this selection was to acquire the most important KPIs that affect the company's PM system.

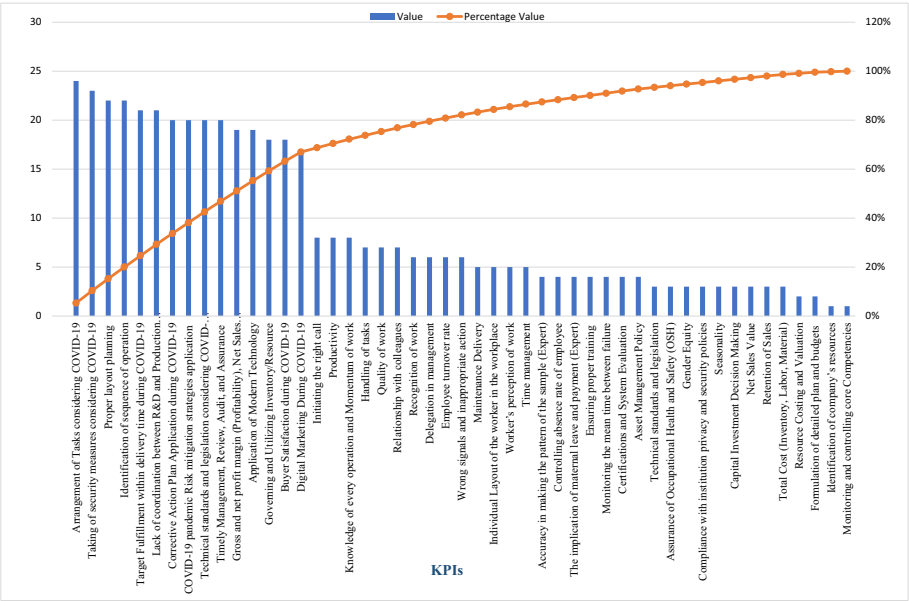

Fig. 2 Pareto Chart for identifying KPIs

4.1.3 Pareto analysis for selecting relevant KPIs

In a wide-ranging data analysis with a causes and effect group containing KPIs, a Pareto Analysis (PA) has been picked out. A PA chart is a bar chart that administrates the industrial case and the quality of data. PA is used tremendously for the PM system. This PA unified the "80–20 Rule" or "70–30 Rule" for constructing the level of effort that occurs in a specific proposal. Here, the rule states that 80% or 70% of the "Effect" indicators emerge from 20% or 30% of the "Cause" indicators. A chart is made for PA in Fig. 2 to select the most relevant KPIs from total 48 KPIs. Here, the chart dictates the areas that are accepted by most experts as the KPIs selected from the literature survey and suggested by the experts. Based on the PA of the survey questionnaire of experts, the highest priority list of 15 KPIs was selected from 48 KPIs (Hepatis, 1844). This study pursues divergent relationship of 67/33 for KPIs of PM in LPI. Most important 15 KPIs $\{F_1, F_2, ..., F_{15}\}$ for PM in LPI considering the COVID-19 based on Pareto analysis are selected and represented in Table 3.

4.1.4 Developing another questionnaire to collect data from industry experts with the help of influencing factors and reliability factors

With the help of two rating scales of influencing and reliability factors, another survey questionnaire was developed to compute the interdependency among KPIs. Matrices were collected from 25 experienced experts $\{E_1, E_2, ..., E_{25}\}$ in the LPI. The designation, years of experience, and the number of experts is displayed in Table 4. Detailed information of experts was collected by Table A1 given in online Appendix-A and details of expert's profiles are given in Table 4.

Table 3 Selected 15 KPIs based on Pareto Analysis with description

Segment	Code of KPI	Key performance indicators	Description
Production and quality control	F_1	Arrangement of tasks considering COVID-19	Proper task arrangement is helpful to improve efficiency and reduce hazards in the COVID-19 pandemic (Nara et al., 2019)
	F_2	Taking of security measures considering COVID-19	How Safety and Security Regulators like hand sanitizing, wearing masks, keeping distance in the workplace address challenges during the COVID-19 epidemic (Scafà et al., 2019)
	F_3	Proper layout planning	Within a provision, proper layout planning is marking on the best physical conformation of all resources that utilize space. The production rate of a company depends on layout planning to a great extent (Scafà et al., 2019)
	F_4	Identification of sequence of operation	The sequence of operation relates to design, specification, and construction. So, identification of the sequence of operation is compulsory to improve the productivity and quality of the LPI (Expert)
	F_5	Target Fulfillment within the delivery time during COVID-19	The challenge for success in target fulfillment within the delivery time during the COVID-19 pandemic relies on the company's ability to compete with the other company. Different strategies are involved in assuring successful delivery and target fulfillment Siedler et al., (2020)
Research and development	F_6	Lack of coordination between R&D and production department during COVID-19	R&D and production interact with each other in attaining the business goal of the LPI. But COVID-19 pandemic situation is harming coordination between the departments (Expert)

Table 3 (continued)

Segment	Code of KPI	Key performance indicators	Description
Human resource and compliance	F_7	Corrective action plan application during COVID-19	To boost the operations of the business and task associated affairs, well-structured exchanges are carried out by assigned manpower like administrator, manager to develop a corrective action plan. In the COVID-19 pandemic condition, proper application of CAP is useful to eliminate the problem that occurred during the manufacturing process to avoid the risk of loss Scafà et al., (2019)
	F_8	COVID-19 pandemic risk mitigation strategies application	Risk mitigation strategies are designed to eradicate, decrease or monitor the consequences of known threats inherent with a designated commitment, before any kind of offence. With these implementations, threats occurring in the COVID-19 pandemic can be foreseen and dealt with Lima et al., (2021)
	F_9	Technical standards and legislation considering COVID-19 pandemic	A technical standard is constructed based on measures or demand for a reproducible high-tech responsibility. Health and Safety Legislation in the LPI considering the COVID-19 pandemic involves many rules and regulations Lima et al., (2021)
	F_{10}	Timely management, review, audit, and assurance	Audit and assurance are a planned inquiry, appraisal of details. and are an executive maintenance to affect the aspect and clarity of information. Management, Review, Audit, and Assurance evaluates the PM system of an industry Lima et al., (2021)

Table 3 (continued)

Segment	Code of KPI	Key performance indicators	Description
Financial and economic	F_{11}	Gross and net profit margin (profitability), net sales value and retention of sales	Gross and net profit margin examines profit and manufacturing costs, predicting future revenues or costs, and identifying gross profit will assist to dictate on the whole profitability. They are important as the starting point toward achieving a healthy profit Bilal and Oyedele, (2020)
	F_{12}	Application of modern technology	Technology has increased the productivity of the LPI all over the world. It can impart higher-standard leather products, increase consumer service and the buyer experience, and decrease wastage (Nudurupati et al., 2021; Siedler et al., 2020)
Accounts or store	F_{13}	Governing and utilizing inventory/resource	Utilizing inventory incurs reserving, warehousing, and utilizing the inventory of organization. Alongside this, incorporates the management of raw materials, components, and final assembled products, and also the warehousing and processing of these components. Continuous governing of inventory/resources has significant effects on company performance (Fung, 2020; Lima et al., 2021; Lindberg et al., 2015; Scafà et al., 2019)

Table 3 (continued)

Segment	Code of KPI	Key performance indicators	Description
Business development	F_{14}	Buyer satisfaction during COVID-19	Buyer satisfaction indicates the fulfillment that they derive from doing business with a leather products company. Buyer satisfaction is crucial as it helps companies understand what they need to do to retain buyers for long-term business growth. With more people spending more time on social media due to COVID-19, brands need to use social media to connect with buyers. The user experience has to be smooth, and the navigation easy in websites so that buyers can find whatever they need within a few clicks (Lima et al., 2021; Pinna et al., 2018)
	F_{15}	Digital marketing during COVID-19	For intercepting emergency environmental and social challenges, COVID-19 pandemic suggests businesses a wonderful possibility to move to actual and honest marketing (Expert)

Table 4 Designation and years of experience of experts

Code of experts	Designation	Years of experience	Types of organization
E_1	Production Leader	8 + years	Manufacturing
E_2	Assistant Manager	7 + years	Manufacturing
E_3	Managing Director	7 + years	Manufacturing
E_4	Quality Assurance Executive	6 + years	Manufacturing
E_5	Owner	7 + years	Manufacturing
E_6	Assistant Manager	8 + years	Manufacturing
E_7	Professor	15 + years	Manufacturing
E_8	Senior Lecturer	13 + years	Manufacturing
E_9	Deputy Manager, Product Development	8 + years	Manufacturing
E_{10}	Lecturer	2 + years	University
E_{11}	Officer- Merchandising	7 + years	Manufacturing
E_{12}	P.D. Manager	10 + years	Manufacturing
E_{13}	Senior Merchandiser	6 + years	Manufacturing
E_{14}	Production Planning & Quality Assurance Manager	5 + years	Manufacturing
E_{15}	Owner	7 + years	Manufacturing
E_{16}	Assistant Lecturer	7 + years	University
E_{17}	Head of Leather Goods, Accessories Buyer	7 + years	Manufacturing
E_{18}	Executive, Pattern Engineering	6 + years	Manufacturing
E_{19}	Officer (Research & Development)	8 + years	Manufacturing
E_{20}	Senior Officer (Research & Development)	8 + years	Manufacturing
E_{21}	Chief Executive Officer	10 + years	Manufacturing
E_{22}	Senior Officer Human Resource	7 + years	Manufacturing
E_{23}	Deputy Manager Compliance	11 + years	Manufacturing
E_{24}	Assistant Manager	10 + years	Manufacturing
E_{25}	Production Manager	22 + years	Manufacturing

4.2 Data calculation and analysis

After completing data collection, calculation and analysis of the expert appraisal matrices were performed employing the wide-ranging lingual Z-DEMATEL method. Two different functions are applied for influencing and reliability factors. Appraisal of the chosen performance indicators by experts was performed adopting two linguistic term sets which are mentioned below:

$$S = \begin{cases} s_8 = ExtremelyGood,\ s_7 = VeryGood,\ s_6 = Good,\ s_5 = SlightlyGood,\ s_4 = Fair, \\ s_3 = SlightlyPoor,\ s_2 = Poor,\ s_1 = VeryPoor,\ s_0 = ExtremelyPoor, \end{cases}$$

$$S\prime = \begin{cases} s\prime_8 = StronglySure,\ s\prime_7 = VerySure,\ s\prime_6 = Sure,\ s\prime_5 = SomewhatSure,\ s\prime_4 = Neutral, \\ s\prime_3 = SlightlyPoor,\ s\prime_2 = Uncertain,\ s\prime_1 = VeryUncertain,\ s\prime_0 = StronglyUncertain, \end{cases}$$

Here, S is the set of interrelation between indicators and $S\prime$ is the set of reliability of the assessed value given by the experts. The two factors with numerical value are given in

Table B2 and Table B3 in online Appendix-B. Two different functions, $f^* = f_3(\phi_i)$ and $g^* = f_1(\varphi_i)$ were used for influencing factors and reliability factors respectively. Evaluation of experts were assessed by matrix given in Table B4 in online Appendix-B. The LSIM of expert E_1 is given below in Table 5. Other experts' LSIM is provided in online Appendix-B from Table B5 to Table B29.

4.2.1 Determination of RL among experts' appraisals

RL stands for resemblance level between experts' assessment matrices. According to the mathematical statement (1), the $RL(Z^e, Z^f)(e, f = 1, 2, ..., 25)$ between experts' appraisal matrices is determined. For instance, if Z^1 and Z^2 are the 1^{st} and 2^{nd} experts then the RL between their matrices will be calculated as follows:

$$RL(Z^1, Z^2) = 1 - d(Z^1, Z^2)$$

Here, $d(Z^1, Z^2) = \frac{1}{15\times15}\sum_{i=1}^{15}\sum_{j=1}^{15} d(z_{ij}^1, z_{ij}^2) = \frac{1}{225} \times 79.92 = 0.3552$

So, $RL(Z^1, Z^2) = 1 - 0.3552 = 0.6448$. The Similarity Degree between Expert 1 and other experts is represented in Table 6.

4.2.2 Confirming the bunching thresholds, experts are bunched up into subgroups

With the help of the mathematical statement (2), firstly bunching threshold $\lambda = 0.4936$ is constructed. Secondly, as per this value λ, 25 experts are bunched up into 3 subgroups as follows:

$C_1 = \{E_3, E_6, E_7, E_8, E_9, E_{10}, E_{12}, E_{13}, E_{14}, E_{15}, E_{16}, E_{17}, E_{18}, E_{20}, E_{21}, E_{22}, E_{23}, E_{24}\}$,
$C_2 = \{E_1, E_4, E_5, E_{11}, E_{19}\}$, $C_3 = \{E_2, E_{25}\}$

4.2.3 Establishment of the BSIM

Straight impacting matrices of those three bunches $Y^x(x = 1, 2, 3)$ are established with the help of the mathematical statement (3). The straight impacting matrices of the 1st bunch are shown in the following Table 7. Other BSIMs are provided in online Appendix-B in Table B30 and Table B31.

4.2.4 Acquirement of the importance weight of each bunch

A constrained optimization model is constructed by dint of the mathematical statement (4).

$$max F(p_x) = 0.981266105\mathrm{p}_1 + 0.9425989055\mathrm{p}_2 + 0.8814027855\mathrm{p}_3$$

$$s.t. \begin{cases} 0.5 \le p_1 \le 0.7; 0.05 \le p_3 \le 0.1; \\ p_3 \le p_2 \le p_1; p_1 \le 9p_3 \\ p_1 + p_2 + p_3 = 1 \\ p_1, p_2, p_3 \ge 0 \end{cases}$$

Here, the bunch's investigated weighting information was acquired grounding on the experience of experts as follows: $P = \{0.3 \le p_1 \le 0.7, 0.05 \le p_3 \le 0.1, p_3 \le p_2 \le p_1, p_1 \le 9p_3\}$

Table 5 LSIM given by the 1st Expert

KPIs	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8	F_9	F_{10}	F_{11}	F_{12}	F_{13}	F_{14}	F_{15}
F_1	**0**	(s_8, s'_2)	(s_6, s'_8)	(s_7, s'_2)	(s_8, s'_8)	(s_5, s'_2)	(s_7, s'_2)	(s_5, s'_7)	(s_8, s'_5)	(s_6, s'_2)	(s_6, s'_7)	(s_6, s'_7)	(s_8, s'_3)	(s_5, s'_8)	(s_4, s'_6)
F_2	(s_3, s'_3)	**0**	(s_2, s'_5)	(s_8, s'_4)	(s_7, s'_6)	(s_8, s'_4)	(s_6, s'_2)	(s_2, s'_4)	(s_2, s'_5)	(s_5, s'_5)	(s_3, s'_5)	(s_7, s'_7)	(s_4, s'_6)	(s_5, s'_7)	(s_4, s'_6)
F_3	(s_6, s'_5)	(s_2, s'_4)	**0**	(s_6, s'_3)	(s_6, s'_4)	(s_7, s'_6)	(s_2, s'_3)	(s_6, s'_4)	(s_4, s'_3)	(s_7, s'_5)	(s_7, s'_2)	(s_3, s'_4)	(s_3, s'_7)	(s_6, s'_5)	(s_2, s'_2)
F_4	(s_3, s'_4)	(s_7, s'_6)	(s_3, s'_6)	**0**	(s_5, s'_5)	(s_6, s'_5)	(s_3, s'_5)	(s_4, s'_2)	(s_5, s'_8)	(s_5, s'_6)	(s_4, s'_4)	(s_7, s'_8)	(s_5, s'_5)	(s_5, s'_3)	(s_5, s'_8)
F_5	(s_5, s'_5)	(s_2, s'_3)	(s_3, s'_4)	(s_5, s'_8)	**0**	(s_5, s'_5)	(s_6, s'_8)	(s_4, s'_7)	(s_3, s'_8)	(s_8, s'_8)	(s_3, s'_2)	(s_7, s'_8)	(s_3, s'_8)	(s_8, s'_4)	(s_8, s'_3)
F_6	(s_7, s'_4)	(s_3, s'_5)	(s_4, s'_5)	(s_6, s'_7)	(s_6, s'_3)	**0**	(s_5, s'_2)	(s_5, s'_8)	(s_7, s'_3)	(s_8, s'_3)	(s_7, s'_6)	(s_4, s'_6)	(s_8, s'_6)	(s_6, s'_3)	(s_6, s'_8)
F_7	(s_5, s'_2)	(s_3, s'_3)	(s_8, s'_6)	(s_5, s'_5)	(s_8, s'_2)	(s_2, s'_4)	**0**	(s_5, s'_5)	(s_5, s'_4)	(s_4, s'_6)	(s_6, s'_6)	(s_5, s'_4)	(s_6, s'_2)	(s_2, s'_2)	(s_7, s'_5)
F_8	(s_4, s'_4)	(s_4, s'_8)	(s_2, s'_8)	(s_6, s'_7)	(s_2, s'_7)	(s_5, s'_6)	(s_7, s'_7)	**0**	(s_8, s'_6)	(s_8, s'_7)	(s_4, s'_4)	(s_7, s'_3)	(s_5, s'_3)	(s_6, s'_2)	(s_5, s'_5)
F_9	(s_2, s'_4)	(s_3, s'_5)	(s_8, s'_2)	(s_3, s'_4)	(s_7, s'_7)	(s_4, s'_3)	(s_4, s'_7)	(s_7, s'_8)	**0**	(s_3, s'_3)	(s_7, s'_8)	(s_5, s'_3)	(s_5, s'_3)	(s_3, s'_8)	(s_8, s'_4)
F_{10}	(s_6, s'_3)	(s_3, s'_2)	(s_8, s'_5)	(s_7, s'_7)	(s_3, s'_8)	(s_7, s'_3)	(s_7, s'_4)	(s_5, s'_3)	(s_7, s'_4)	**0**	(s_3, s'_6)	(s_4, s'_6)	(s_5, s'_7)	(s_2, s'_6)	(s_7, s'_6)
F_{11}	(s_8, s'_7)	(s_7, s'_5)	(s_8, s'_3)	(s_8, s'_7)	(s_2, s'_5)	(s_2, s'_3)	(s_4, s'_7)	(s_4, s'_4)	(s_5, s'_2)	(s_7, s'_2)	**0**	(s_3, s'_7)	(s_5, s'_7)	(s_8, s'_5)	(s_6, s'_7)
F_{12}	(s_3, s'_5)	(s_4, s'_4)	(s_5, s'_4)	(s_6, s'_3)	(s_6, s'_6)	(s_4, s'_5)	(s_6, s'_7)	(s_8, s'_7)	(s_5, s'_5)	(s_2, s'_2)	(s_5, s'_3)	**0**	(s_3, s'_2)	(s_8, s'_3)	(s_6, s'_3)
F_{13}	(s_6, s'_2)	(s_3, s'_8)	(s_6, s'_4)	(s_7, s'_6)	(s_4, s'_6)	(s_8, s'_8)	(s_3, s'_7)	(s_8, s'_4)	(s_3, s'_3)	(s_4, s'_5)	(s_8, s'_8)	(s_3, s'_6)	**0**	(s_4, s'_8)	(s_7, s'_8)
F_{14}	(s_6, s'_8)	(s_2, s'_2)	(s_5, s'_2)	(s_8, s'_5)	(s_6, s'_3)	(s_3, s'_3)	(s_2, s'_7)	(s_2, s'_6)	(s_2, s'_7)	(s_7, s'_3)	(s_7, s'_5)	(s_5, s'_2)	(s_4, s'_4)	**0**	(s_2, s'_5)
F_{15}	(s_3, s'_7)	(s_5, s'_6)	(s_3, s'_4)	(s_3, s'_6)	(s_2, s'_5)	(s_7, s'_7)	(s_5, s'_7)	(s_4, s'_5)	(s_2, s'_2)	(s_8, s'_2)	(s_6, s'_2)	(s_4, s'_5)	(s_5, s'_7)	(s_7, s'_8)	**0**

Table 6 RL between Expert 1 and other experts

Coding of Experts	E_2	E_3	E_4	E_5	E_6	E_7	E_8	E_9	E_{10}	E_{11}	E_{12}	E_{13}
Similarity Degree Between Expert 1 and others	0.645	0.487	0.531	0.505	0.434	0.491	0.482	0.439	0.476	0.502	0.487	0.472
Coding of Experts	E_{14}	E_{15}	E_{16}	E_{17}	E_{18}	E_{19}	E_{20}	E_{21}	E_{22}	E_{23}	E_{24}	E_{25}
Similarity Degree Between Expert 1 and others	0.418	0.441	0.449	0.456	0.436	0.504	0.461	0.45	0.449	0.435	0.419	0.449

After working out the above-mentioned optimization model, each bunch's weight is obtained as follows: $p_1 = 0.700$, $p_2 = 0.222$ and $p_3 = 0.078$.

The optimization model is illustrated at Table B32 in online Appendix-B.

4.2.5 Initiation of the OSIM

The OSIM $Z = (z_{cd})_{15\times 15}$ of the bunches is initiated as the mathematical statement (5) and is represented in Table 8.

4.2.6 Securing the CSIM

The CSIM $Z\prime = (z_{cd}\prime)_{15\times 15}$ of the bunches is calculated with the help of the mathematical statement (6) and is displayed in Table 9.

4.2.7 Computation of the NSIM

The NSIM $N = (N_{cd})_{15\times 15}$ is computed as the mathematical statement (7) and (8) is represented in Table 10.

4.2.8 Obtaining the TIM

Putting in the mathematical statement (9), the TIM $J = [j_{cd}]_{15\times 15}$ is obtained and shown in Table 11.

4.2.9 Obtaining the DCD

If A and B signify the sum of rows and the sum of columns respectively, then with the help of the mathematical statements (10) and (11), A and B can be obtained. $(a_c + b_c)$ and $(a_c - b_c)$ are also computed where $(a_c + b_c)$ and $(a_c - b_c)$ denotes the "significance level" and "exclusive impact level" sequentially. The levels are represented in Table 12. DCD is represented in Fig. 3 containing 15 indicators constructed utilizing the data from Table 12.

Table 7 1st BSIM

KPIs	F_1	F_2	F_3	F_4	.....	F_{13}	F_{14}	F_{15}
F_1	**0**	$(s_{4.5}, s'_{5.278})$	$(s_{4.778}, s'_{5.278})$	$(s_{5.333}, s'_{3.722})$	.....	$(s_{5.056}, s'_{4.222})$	$(s_{3.889}, s'_{3.444})$	$(s_{3.722}, s'_{4.389})$
F_2	$(s_{5.167}, s'_{4.222})$	**0**	$(s_{5.000}, s'_{5.333})$	$(s_{4.000}, s'_{5.278})$	.....	$(s_{5.000}, s'_{5.167})$	$(s_{4.556}, s'_{4.000})$	$(s_{4.333}, s'_{4.333})$
F_3	$(s_{5.000}, s'_{5.333})$	$(s_{4.667}, s'_{4.278})$	**0**	$(s_{4.056}, s'_{4.722})$	.....	$(s_{4.111}, s'_{4.667})$	$(s_{5.056}, s'_{5.333})$	$(s_{5.167}, s'_{4.722})$
F_4	$(s_{4.778}, s'_{4.833})$	$(s_{5.278}, s'_{4.444})$	$(s_{5.333}, s'_{4.167})$	**0**	.....	$(s_{5.000}, s'_{4.111})$	$(s_{4.833}, s'_{5.556})$	$(s_{5.611}, s'_{5.222})$
F_5	$(s_{4.778}, s'_{4.778})$	$(s_{5.833}, s'_{4.444})$	$(s_{5.500}, s'_{5.167})$	$(s_{4.000}, s'_{4.944})$	.....	$(s_{4.833}, s'_{3.833})$	$(s_{5.611}, s'_{5.500})$	$(s_{5.167}, s'_{4.167})$
F_6	$(s_{4.333}, s'_{4.056})$	$(s_{4.278}, s'_{4.389})$	$(s_{5.167}, s'_{4.5})$	$(s_{4.444}, s'_{5.722})$	.....	$(s_{4.944}, s'_{4.333})$	$(s_{3.556}, s'_{4.389})$	$(s_{4.667}, s'_{4.278})$
F_7	$(s_{3.899}, s'_{5.222})$	$(s_{5.000}, s'_{4.944})$	$(s_{5.111}, s'_{5.278})$	$(s_{3.944}, s'_{4.889})$	.....	$(s_{3.722}, s'_{4.222})$	$(s_{5.611}, s'_{4.722})$	$(s_{3.500}, s'_{4.833})$
F_8	$(s_{4.167}, s'_{5.222})$	$(s_{4.944}, s'_{5.444})$	$(s_{4.778}, s'_{5.389})$	$(s_{4.611}, s'_{5.056})$	.....	$(s_{4.889}, s'_{4.667})$	$(s_{5.167}, s'_{5.056})$	$(s_{5.444}, s'_{5.056})$
F_9	$(s_{4.8333}, s'_{4.833})$	$(s_{5.167}, s'_{3.833})$	$(s_{4.889}, s'_{4.333})$	$(s_{5.222}, s'_{4.944})$	.....	$(s_{4.500}, s'_{4.778})$	$(s_{3.778}, s'_{3.278})$	$(s_{5.056}, s'_{4.889})$
F_{10}	$(s_{4.611}, s'_{5.667})$	$(s_{5.000}, s'_{4.889})$	$(s_{4.889}, s'_{4.833})$	$(s_{5.389}, s'_{4.278})$	.....	$(s_{5.278}, s'_{3.833})$	$(s_{4.889}, s'_{5.667})$	$(s_{4.833}, s'_{4.167})$
F_{11}	$(s_{5.778}, s'_{5.056})$	$(s_{3.944}, s'_{4.778})$	$(s_{3.111}, s'_{5.167})$	$(s_{6.722}, s'_{4.944})$	.....	$(s_{4.500}, s'_{4.222})$	$(s_{5.222}, s'_{3.778})$	$(s_{4.611}, s'_{4.333})$
F_{12}	$(s_{4.333}, s'_{4.778})$	$(s_{4.167}, s'_{5.111})$	$(s_{4.722}, s'_{4.778})$	$(s_{4.778}, s'_{4.111})$	.....	$(s_{4.167}, s'_{4.722})$	$(s_{3.944}, s'_{4.833})$	$(s_{3.889}, s'_{5.000})$
F_{13}	$(s_{4.000}, s'_{3.889})$	$(s_{4.389}, s'_{4.389})$	$(s_{4.833}, s'_{5.056})$	$(s_{5.000}, s'_{4.444})$	.....	**0**	$(s_{5.500}, s'_{5.111})$	$(s_{4.778}, s'_{4.111})$
F_{14}	$(s_{5.833}, s'_{5.222})$	$(s_{4.611}, s'_{5.000})$	$(s_{4.833}, s'_{5.333})$	$(s_{4.500}, s'_{4.944})$	.....	$(s_{4.500}, s'_{4.444})$	**0**	$(s_{4.389}, s'_{5.667})$
F_{15}	$(s_{4.611}, s'_{3.667})$	$(s_{3.667}, s'_{4.111})$	$(s_{3.333}, s'_{4.333})$	$(s_{4.389}, s'_{4.889})$	.....	$(s_{4.167}, s'_{4.278})$	$(s_{5.444}, s'_{3.944})$	**0**

Table 8 The OSIM of the three bunches

KPIs	F_1	F_2	F_3	F_4	.....	F_{13}	F_{14}	F_{15}
F_1	**0**	$(s_{4.829}, s'_{5.569})$	$(s_{4.989}, s'_{5.523})$	$(s_{5.304}, s'_{5.067})$	.....	$(s_{5.195}, s'_{5.258})$	$(s_{4.445}, s'_{4.949})$	$(s_{4.546}, s'_{5.371})$
F_2	$(s_{5.044}, s'_{5.327})$	**0**	$(s_{4.999}, s'_{5.744})$	$(s_{4.553}, s'_{5.620})$	.....	$(s_{5.027}, s'_{5.759})$	$(s_{4.883}, s'_{5.192})$	$(s_{4.741}, s'_{5.427})$
F_3	$(s_{5.091}, s'_{5.753})$	$(s_{4.892}, s'_{5.145})$	**0**	$(s_{4.628}, s'_{5.359})$	.....	$(s_{4.623}, s'_{5.530})$	$(s_{5.127}, s'_{5.734})$	$(s_{5.091}, s'_{5.511})$
F_4	$(s_{4.936}, s'_{5.509})$	$(s_{5.192}, s'_{5.487})$	$(s_{5.206}, s'_{5.363})$	**0**	.....	$(s_{5.049}, s'_{5.217})$	$(s_{5.026}, s'_{5.839})$	$(s_{5.374}, s'_{5.832})$
F_5	$(s_{4.940}, s'_{5.561})$	$(s_{5.298}, s'_{5.412})$	$(s_{5.238}, s'_{5.746})$	$(s_{4.643}, s'_{5.687})$	.....	$(s_{4.815}, s'_{5.195})$	$(s_{5.335}, s'_{5.875})$	$(s_{5.171}, s'_{5.302})$
F_6	$(s_{4.847}, s'_{5.218})$	$(s_{4.642}, s'_{5.347})$	$(s_{5.177}, s'_{5.491})$	$(s_{4.802}, s'_{6.077})$	.....	$(s_{5.005}, s'_{5.346})$	$(s_{4.514}, s'_{5.405})$	$(s_{4.902}, s'_{5.366})$
F_7	$(s_{4.526}, s'_{5.832})$	$(s_{5.008}, s'_{5.649})$	$(s_{5.220}, s'_{5.854})$	$(s_{4.620}, s'_{5.592})$	.....	$(s_{4.437}, s'_{5.211})$	$(s_{5.294}, s'_{5.538})$	$(s_{4.443}, s'_{5.600})$
F_8	$(s_{4.671}, s'_{6.079})$	$(s_{4.982}, s'_{5.838})$	$(s_{4.891}, s'_{5.842})$	$(s_{4.819}, s'_{5.804})$	.....	$(s_{4.947}, s'_{5.459})$	$(s_{5.133}, s'_{5.684})$	$(s_{5.238}, s'_{5.748})$
F_9	$(s_{4.984}, s'_{5.626})$	$(s_{5.108}, s'_{5.159})$	$(s_{5.040}, s'_{5.302})$	$(s_{5.138}, s'_{5.635})$	.....	$(s_{4.785}, s'_{5.625})$	$(s_{4.529}, s'_{4.890})$	$(s_{5.167}, s'_{5.687})$
F_{10}	$(s_{4.960}, s'_{5.972})$	$(s_{5.066}, s'_{5.591})$	$(s_{4.968}, s'_{5.569})$	$(s_{5.213}, s'_{5.297})$	.....	$(s_{5.241}, s'_{5.103})$	$(s_{4.985}, s'_{5.985})$	$(s_{5.004}, s'_{5.349})$
F_{11}	$(s_{5.458}, s'_{5.712})$	$(s_{4.540}, s'_{5.590})$	$(s_{4.265}, s'_{5.713})$	$(s_{5.813}, s'_{5.774})$	.....	$(s_{4.753}, s'_{5.402})$	$(s_{5.139}, s'_{5.003})$	$(s_{4.929}, s'_{5.386})$
F_{12}	$(s_{4.803}, s'_{5.561})$	$(s_{4.767}, s'_{5.701})$	$(s_{4.911}, s'_{5.490})$	$(s_{4.967}, s'_{5.206})$	.....	$(s_{4.712}, s'_{5.606})$	$(s_{4.667}, s'_{5.663})$	$(s_{4.646}, s'_{5.584})$
F_{13}	$(s_{4.568}, s'_{5.126})$	$(s_{4.767}, s'_{5.478})$	$(s_{5.012}, s'_{5.771})$	$(s_{5.112}, s'_{5.478})$	.....	**0**	$(s_{5.230}, s'_{5.803})$	$(s_{5.008}, s'_{5.345})$
F_{14}	$(s_{5.429}, s'_{5.808})$	$(s_{4.836}, s'_{5.659})$	$(s_{4.844}, s'_{5.820})$	$(s_{4.908}, s'_{5.733})$	.....	$(s_{4.846}, s'_{5.311})$	**0**	$(s_{4.743}, s'_{5.915})$
F_{15}	$(s_{4.957}, s'_{4.968})$	$(s_{4.458}, s'_{5.276})$	$(s_{4.265}, s'_{5.413})$	$(s_{4.613}, s'_{5.720})$	.....	$(s_{4.643}, s'_{5.435})$	$(s_{5.363}, s'_{5.302})$	**0**

Table 9 The CSIM

KPIs	F_1'	F_2'	F_3'	F_4'	F_5'	F_6'	F_7'	F_8'	F_9'	F_{10}'	F_{11}'	F_{12}'	F_{13}'	F_{14}'	F_{15}'
F_1'	**0**	.473	.485	.472	.491	.492	.459	.510	.516	.519	.503	.430	.48	.385	.428
F_2'	.473	**0**	.505	.449	.467	.543	.521	.423	.502	.427	.504	.476	.509	.446	.452
F_3'	.515	.443	**0**	.435	.548	.525	.440	.457	.437	.486	.470	.435	.449	.517	.494
F_4'	.478	.501	.491	**0**	.518	.424	.446	.429	.451	.516	.525	.520	.464	.516	.551
F_5'	.483	.504	.529	.464	**0**	.431	.469	.448	.449	.476	.489	.441	.440	.551	.482
F_6'	.445	.436	.500	.513	.489	**0**	.490	.498	.405	.492	.464	.472	.471	.427	.463
F_7'	.463	.498	.537	.453	.466	.529	**0**	.577	.493	.476	.478	.404	.404	.515	.435
F_8'	.499	.512	.503	.492	.509	.518	.448	**0**	.482	.449	.471	.468	.475	.513	.530
F_9'	.493	.464	.47	.509	.504	.455	.460	.438	**0**	.409	.474	.406	.473	.388	.517
F_{10}'	.521	.498	.487	.486	.539	.500	.431	.472	.580	**0**	.500	.451	.470	.525	.471
F_{11}'	.548	.445	.424	.588	.488	.390	.513	.488	.455	.519	**0**	.515	.451	.452	.467
F_{12}'	.470	.478	.474	.455	.446	.431	.450	.516	.451	.496	.454	**0**	.464	.464	.455
F_{13}'	.411	.459	.509	.493	.480	.448	.446	.393	.463	.425	.444	.452	**0**	.534	.471
F_{14}'	.554	.481	.496	.495	.560	.481	.444	.514	.460	.477	.458	.519	.453	**0**	.493
F_{15}'	.433	.412	.401	.463	.521	.416	.460	.452	.528	.449	.492	.440	.443	.500	**0**

Table 10 The NSIM

KPIs	F_1'	F_2'	F_3'	F_4'	F_5'	F_6'	F_7'	F_8'	F_9'	F_{10}'	F_{11}'	F_{12}'	F_{13}'	F_{14}'	F_{15}'
F_1'	**.000**	.067	.069	.067	.070	.070	.065	.073	.073	.074	.072	.061	.068	.055	.061
F_2'	.067	**.000**	.072	.064	.066	.077	.074	.060	.071	.061	.072	.068	.072	.063	.064
F_3'	.073	.063	**.000**	.062	.078	.075	.063	.065	.062	.069	.067	.062	.064	.074	.070
F_4'	.068	.071	.070	**.000**	.074	.060	.063	.061	.064	.073	.075	.074	.066	.073	.078
F_5'	.069	.072	.075	.066	**.000**	.061	.067	.064	.064	.068	.070	.063	.063	.078	.069
F_6'	.063	.062	.071	.073	.070	**.000**	.070	.071	.058	.070	.066	.067	.067	.061	.066
F_7'	.066	.071	.076	.065	.066	.075	**.000**	.082	.070	.068	.068	.058	.058	.073	.062
F_8'	.071	.073	.072	.070	.072	.074	.064	**.000**	.069	.064	.067	.067	.068	.073	.075
F_9'	.070	.066	.067	.072	.072	.065	.065	.062	**.000**	.058	.067	.058	.067	.055	.074
F_{10}'	.074	.071	.069	.069	.077	.071	.061	.067	.083	**.000**	.071	.064	.067	.075	.067
F_{11}'	.078	.063	.060	.084	.070	.056	.073	.069	.065	.074	**.000**	.073	.064	.064	.066
F_{12}'	.067	.068	.067	.065	.064	.061	.064	.073	.064	.071	.065	**.000**	.066	.066	.065
F_{13}'	.058	.065	.072	.070	.068	.064	.063	.056	.066	.060	.063	.064	**.000**	.076	.067
F_{14}'	.079	.068	.071	.070	.080	.068	.063	.073	.065	.068	.065	.074	.064	**.000**	.070
F_{15}'	.062	.059	.057	.066	.074	.059	.065	.064	.075	.064	.070	.063	.063	.071	**.000**

Table 11 The TIM

KPIs	F_1'	F_2'	F_3'	F_4'	F_5'	F_6'	F_7'	F_8'	F_9'	F_{10}'	F_{11}'	F_{12}'	F_{13}'	F_{14}'	F_{15}'
F_1'	**1.192**	1.224	1.260	1.251	1.297	1.223	1.202	1.231	1.241	1.232	1.248	1.19	1.199	1.235	1.236
F_2'	1.263	**1.169**	1.271	1.256	1.302	1.237	1.217	1.228	1.247	1.229	1.257	1.204	1.211	1.251	1.247
F_3'	1.262	1.222	**1.197**	1.248	1.306	1.228	1.201	1.226	1.232	1.23	1.246	1.192	1.197	1.253	1.246
F_4'	1.287	1.258	1.292	**1.219**	1.333	1.244	1.23	1.251	1.263	1.263	1.282	1.231	1.227	1.283	1.283
F_5'	1.259	1.231	1.268	1.253	**1.235**	1.218	1.206	1.226	1.235	1.23	1.25	1.194	1.197	1.258	1.246
F_6'	1.239	1.207	1.249	1.243	1.283	**1.145**	1.193	1.217	1.214	1.217	1.231	1.183	1.186	1.228	1.228
F_7'	1.269	1.242	1.282	1.264	1.31	1.243	**1.155**	1.254	1.253	1.242	1.261	1.202	1.204	1.267	1.253
F_8'	1.295	1.265	1.299	1.29	1.338	1.262	1.236	**1.199**	1.273	1.26	1.281	1.23	1.234	1.288	1.286
F_9'	1.226	1.192	1.226	1.224	1.266	1.187	1.172	1.191	**1.141**	1.188	1.214	1.157	1.168	1.204	1.216
F_{10}'	1.309	1.274	1.308	1.301	1.353	1.27	1.244	1.273	1.296	**1.211**	1.296	1.239	1.244	1.3	1.289
F_{11}'	1.282	1.238	1.270	1.283	1.315	1.227	1.225	1.245	1.25	1.25	**1.199**	1.218	1.212	1.261	1.259
F_{12}'	1.232	1.202	1.236	1.226	1.268	1.193	1.178	1.209	1.21	1.207	1.22	**1.111**	1.175	1.222	1.217
F_{13}'	1.211	1.187	1.226	1.217	1.258	1.182	1.165	1.18	1.198	1.185	1.205	1.158	**1.1**	1.218	1.206
F_{14}'	1.306	1.265	1.302	1.294	1.347	1.261	1.239	1.271	1.273	1.267	1.283	1.24	1.234	**1.223**	1.285
F_{15}'	1.211	1.178	1.210	1.211	1.260	1.175	1.164	1.185	1.203	1.186	1.208	1.154	1.157	1.21	**1.14**

Table 12 Every indicator's stated and encountered influences

Code of KPIs	*A*	*B*	*A* + *B*	Ranking order	*A*–*B*	Cause/effect
F_1	18.461	18.842	37.303	8	− 0.381	Effect
F_2	18.589	18.355	36.944	9	0.234	Cause
F_3	18.484	18.895	37.380	7	− 0.411	Effect
F_4	18.946	18.781	37.727	3	0.165	Cause
F_5	18.504	19.469	37.973	1	− 0.965	Effect
F_6	18.263	18.295	36.558	11	− 0.032	Effect
F_7	18.702	18.027	36.728	10	0.675	Cause
F_8	19.037	18.384	37.421	5	0.652	Cause
F_9	17.970	18.529	36.500	12	− 0.559	Effect
F_{10}	19.206	18.397	37.602	4	0.809	Cause
F_{11}	18.733	18.680	37.413	6	0.053	Cause
F_{12}	18.106	17.904	36.010	14	0.202	Cause
F_{13}	17.897	17.945	35.842	15	− 0.049	Effect
F_{14}	19.090	18.700	37.790	2	0.390	Cause
F_{15}	17.854	18.637	36.491	13	− 0.783	Effect

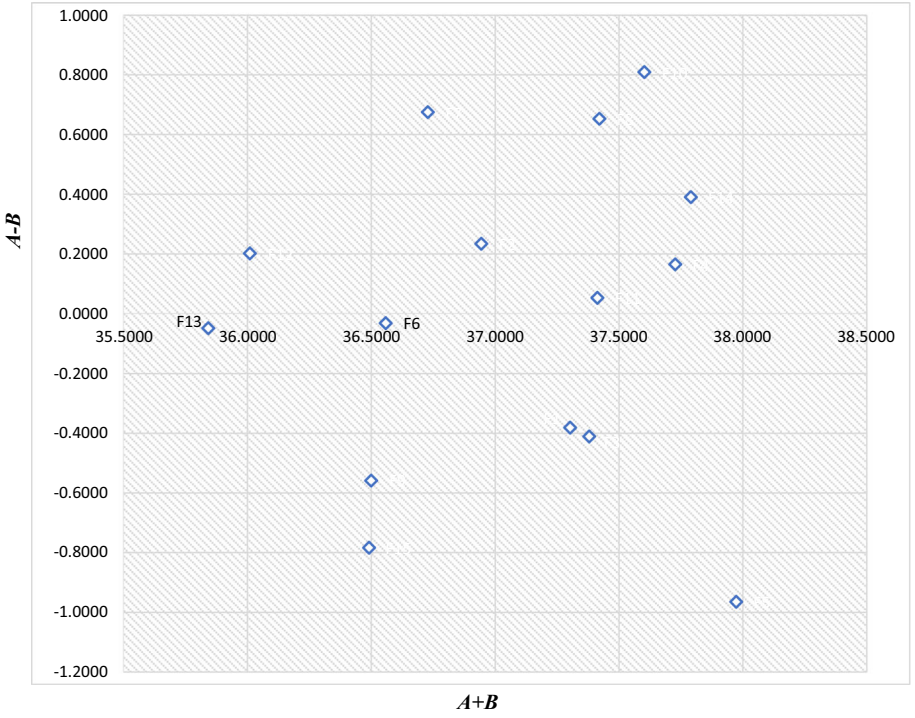

Fig. 3 DCD of KPIs

4.2.10 Examining the structure of the performance indicators

As per the values $(r_i - c_i)$ $(i = 1, 2, ..., 15)$, 15 indicators are split up into an effect cause and a cause group. From the graph, it is seen that the effect group incorporates indicators namely F_1, F_3, F_5, F_6, F_9, F_{13}, F_{15} and the cause group encompasses indicators namely F_2, F_4, F_7, F_8, F_{10}, F_{11}, F_{12}, F_{14}.

5 Results and discussions

This section lays down the outcomes obtained from the Z-DEMATEL approach alongside some observations simultaneously. The acquired overall sequence of KPIs is given as follows: $F_5 > F_{14} > F_4 > F_{10} > F_8 > F_{11} > F_3 > F_1 > F_2 > F_7 > F_6 > F_9 > F_{15} > F_{12} > F_{13}$. From the rank, F_5 (Target Fulfillment within the delivery time during COVID-19) is the most dominant KPI that affects the PM system of LPI. It signifies that F_5 concerning the overall ranking of the KPIs and importance exhibits as the highest important indicator. Considerable observation needs to pay to F_5 by managers or decision-makers of the LPI by judiciously executing proper management of time within tentative delivery time irrespective of the effect generated from COVID-19. The large-ranging linguistic Z-DEMATEL "Cause" group KPIs rank is obtained as $F_{10} > F_7 > F_8 > F_{14} > F_2 > F_{12} > F_4 > F_{11}$. The ranking of the effect group KPIs is as follows: $F_6 > F_{13} > F_1 > F_3 > F_9 > F_7 > F_5$.

From the IRD and Table 12, it is clear that F_4, F_8, F_{10}, F_{11}, F_{14} has the highest $(a_c - b_c)$ value. So, these KPIs have a greater impact on other indicators confiscated to possess considerable preference over other indicators. F_5 has the supreme influence on other indicators despite the fact it is an effect group indicator because of its value $(a_c + b_c)$ is as high as 37.97291 and $(a_c - b_c)$ as low as -0.96470. So, LPI's PM system must be directed to pay heed to these 6 KPIs for inspecting, guiding, and enhancing the overall performance of the company. Using the LZPWG operator in the suggested Z- linguistic DEMATEL method results in consideration of each expert's assessed information. As a result, the correlations of different expert appraisal statistics are anticipated in the aggregation process through the LZPWG operator.

The conventional DEMATEL method flourishes on the foundation of "Cause Vs Effect". The KPIs grounded in the "Cause" group are accounted crucial as those indicators have a dominant impulse of permitting an upsurge to the "Effect" group KPIs (Addae et al., 2021). Engaging the general sustainable perspective for the PM system during the era of COVID-19 permits experts to cordially cooperate in the decision-making process which will influence their working environment and the success of the company greatly. The principal target of this study is to statistically codify KPIs which are responsible for the PM system of the LPI in the decision-making process. Implementing the large-ranging linguistic Z-DEMATEL approach, results are obtained which reveal the opinion of the experts in the leather products sector of Bangladesh.

More $(a_c + b_c)$ value KPIs can be concluded as extremely critical KPIs as these transmit both importance and cause a degree of impact on the entire PM system. Wide-ranging linguistic Z-DEMATEL "Cause" group KPIs signify that these 8 KPIs have the overall influence of giving rise to 7 KPIs on the entire system. This lets the experts make an important decision in emergency PM. From the "Effect" group it is seen that the KPIs of F_1, F_3, F_6,F_7, F_9, F_{13} can be ignored though there are such KPIs like F_1 and F_3 which have moderate $(a_c + b_c)$ values in the entire KPIs. Expert suggests "Identification of sequence of operation" as the

task of production manager to monitor PM system in LPI. Varisco et al. (2018) proposed a framework with 778 KPIs for operation management which in our case "Identification of sequence of operation". This study concluded that operation management in Production contains a large amount of KPIs initiated by ISO 22400 to maintain operational sequence.

After regression analysis, Ishaq Bhatti and Awan (2014) explored the standardized coefficient for delivering reliability which is in our case "Target fulfillment within the delivery time during COVID-19" which is highest as 0.591 and has a supplementary effect on the overall performance measures. Alongside this, that study got "Customer satisfaction" which in our case "Buyer satisfaction during COVID-19" with the second-highest standardized coefficient of 0.443. But the standardized co-efficient value of financial term was 0.119 which in our case is "Gross and net profit margin (Profitability), net sales value and retention of sales" from the financial dimension. According to Whicker et al. (2009), the industry's supply chain performance can be increased by reducing time and optimizing the value of the product. So, F_{10} "Timely Management, Review, Audit, and Assurance" with the highest $(a_c + b_c)$ and $(a_c - b_c)$ value exhibits great influence on the other indicators.

In the context of the semiconductor industry, Hsu and Lee (2014) assessed sustainability with the help of 25 criteria and inaugurated that "Customer satisfaction" is the fourth important factor. Also, for manufacturing SMEs, a study constructed a model to evaluate the sustainability and spotted "Customer satisfaction" as the most dominant measure. In our case, for LPI "Customer" can be regarded as "Buyer" and "Consumer". De Andrade and Sadaoui (2017) discussed the risk mitigation strategy application in the case of the supply chain and proposed a decision-oriented framework. Ivanov (2019) in another study suggested "Audit" all the updates in the database as 66% responsible for the overall Business Indicator Management (BIM). From this study, it is clear that "Timely management, review, audit, and assurance" can be considered an effective KPI. Besides this, Due to COVID-19, all over the world manufacturing industry has slowed down, and the presented economic crisis affects the LPI most. According to Velimirovi et al. (2011), "Gross and net profit margin (Profitability), Net Sales Value and Retention of Sales" can be influenced by market slowdown and even gross profit can be affected negatively. In accordance with Nalewaik and Mills (2016), to review the efficiency, effectiveness, and economy of an organization utilizing available resources a performance audit can be used. Kagioglou et al. (2001) discussed the customer perspective that affects the performance of the internal and external business and operational process which is in our case "Buyer Satisfaction during COVID-19". Alongside this, after reviewing relevant market literature Mone et al. (2013) got "Customer Satisfaction" has a strong influence on purchase intentions because of its constructional and worldwide applicability.

6 Implications of the study

As LPI is appraised for being one of the extensive export-credited sectors of the country, the introduced large-ranging linguistic Z-DEMATEL method is absolutely practical and convenient for decision-makers or managers to govern KPIs, observe and boost performance. This advantageous method of KPIs assessment is distinctive because of its strength in combining linguistic Z-digits and the DEMATEL technique based on a wide-ranging scheme. This newly proposed method has subsequent supremacy in the field of the LPI's PM system during the era of COVID-19. The presented method can perform constructively with the actual PM system that entails interdependent indicators in today's complex business model

context. Coupling fundamental and dominance indicators for enhancing performance moderately alongside finite resources, this method furnishes feasible and conceptual instruction for LPI. This proposed study inspected the case companies' PM through KPIs for achieving sustainability in LPI.

(a) *Target fulfilment within the delivery time during the emergency* As COVID-19 have disrupted the communication between countries closing the air, shipping and land routes, the supply chain of LPI is interrupted badly. In this case, attention must be paid to timely delivery by LPI managers through the application of proper PM and evaluation of focused KPIs.
(b) *Buyer Satisfaction* For achieving success and increasing profit, buyer satisfaction plays an important role in an organization. Conformation of the quality products to the end consumers can be obtained through better buyer satisfaction. So, buyer satisfaction should be the focal point in the case of policy implication of LPI.
(c) *Maintenance of operational sequence* For getting the supply material lately during COVID-19 the LPI needs to maintain the operational sequence by adapting to the fluctuated lead time. Without proper sequence, the product will lack dimensional quality which will subsequently decrease customer satisfaction. Because of having an extensive impact on the supply chain across the world, severe problems like the flow of goods, shortage of products, and increase in fuelling costs have occurred. Decision makers of LPI must make allowances for such problems in PM evaluation.
(d) *Risk Mitigation strategies application* COVID-19 has brought risk and economic destruction across the world. Manufacturing industries like LPI are facing risks to their workers, supply chain, PM, operations, and assets globally. Risk mitigation strategies should be implemented in a planned way for operational excellence to recover the consequences of COVID-19.
(e) *Timely Management* COVID-19 revealed the delicacy of supply chains as well as PM and the weakness of manufacturing policies, lean inventories, and timely replenishing. This study will contribute to enhancing adaptability to modify supply chains and inaugurate duplicate resourcing.
(f) *Profit, Sales Value, and Retention of Sales* Because of having an impact on interest rates, COVID-19 has brought a larger proportion of liability to Gross Domestic Product (GDP) which is ultimately increasing extended interest rates. Afterward, the prices of fuels, foods and various commodities enhanced globally, deteriorating inflation and imposing budgetary deprivation on people. Greater attention of policymakers on the calculation of company assets, supply sources, and inventory management can maximize profit and retention of sales.

7 Conclusions, limitations, and future research avenues

This section is outlined grounded on the finding that can be executed to ensure the viability of PM because of the COVID-19 outbreak.

7.1 Conclusions

Due to the absence of proper aspects, PM Systems are not satisfactory in Bangladesh. An appropriate PM system can minimize internal and external level problems. For observing company performance in genuine time, the execution of PM using KPIs can be coupled

with the knowledge of the PM system (Selviyanti et al., 2021). For the PM system of the LPI, this study pointed out KPIs conferring a large-ranging linguistic Z-DEMATEL method. Grounding on linguistic Z-digits assessment of 25 experts were collected with two scales of influencing and reliability factors. Afterward, 25 experts of large V bunched in three subgroups employing similarity degree assumed bunching threshold value. Subsequently, a maximizing consensus approach was implemented to obtain a comprehensive straight impacting matrix. Lastly, with the help of an elongated DEMATEL approach, KPIs for PM of the LPI during the era of the COVID-19 pandemic are settled terminating the interrelationship between indicators. A descriptive model was presented to substantiate the relevancy of the suggested KPI assessment method. From the outcome, it is clear that the represented model will consistently assist decision-makers to identify bounded KPIs which are crucial for enhancing the PM system of the LPI, to scan and administer the company performance. The 6 KPIs are regarded as critical for PM during the era of covid-19. The outcomes are sophisticated with significance because the method measures the KPI quantitatively which is directed towards the views of the PM system for the decision-maker for ranking and selecting effective KPIs.

7.2 Limitations and future research avenues

The assessment of KPI for improving the PM system has acquired prominence in worldwide research. Even so, this study is comprehensive but fortuities for future research direction are present over there.

(a) Professional expertise and bordered intellect affect the experience of the experts. In this study, LPI experts gave introductory data intuitively. So, in the succeeding research work, it is recommended to flourish an upgraded DEMATEL approach positioning instinctive as well as unbiased and objective data.
(b) Buyers, government, and training institutions act as stakeholders for the LPI and are engaged in the LPI's PM system. In this study, data is collected only from company employees and academicians. Future inquiry is suggested for accumulating data from various stakeholders and ascertaining more operative KPIs for PM in the LPI.
(c) Furthermore, the suggested method was applied only to LPI (mainly small and big leather goods) PM systems during COVID-19 for determining KPIs in Bangladesh. The relevance of the introduced method is to provide superior unbiased data. Subsequent investigations may utilize studies of various leather footwear companies. Hence, the method will be able to demonstrate its potency and functionality for leather products as well as footwear companies' PM systems.
(d) The personal desire of employees and related KPIs aren't taken into consideration in the literature review of this work. According to Kassaneh and Workalemahu (2018) absence of personal KPIs acts as an obstacle to improving the PM system for any organization. Besides this, the KPIs aren't selected with a great focus on "Supply Chain Management". So, future research work may be directed toward contemplating personal KPIs and "Supply Chain Management".
(e) To administer technologies and other resources, LPI can promote cooperation with research organizations and prospective opponents.
(f) Discovering experimental and complex issues in the COVID-19 pandemic, which is effective and attaining the LPI's sustainability is in the hand of the government and inspection agencies. Government can construct various institutes that will assist the industry in bringing development for the PM system. Future research could explore the

role of government policies in supporting the PM of the LPI including the effectiveness of policies such as subsidies, tax incentives and investment in research and development.

(g) Managers must give focus on potential planning to control the repetitive disruptions caused by the sequential impacts of COVID-19. As COVID-19 has a negative influence on the supply chain as well as PM, managers should implement potential planning of monitoring KPIs one after another.

(h) The unpredictability and uncertainty of the COVID-19 pandemic have highlighted the importance of agile PM practices. Future research could investigate the effectiveness of agile practices, such as real-time monitoring and decision-making, in improving the resilience and performance of the LPI.

(i) The unpredictability and uncertainty of the COVID-19 pandemic have highlighted the importance of agile PM practices. Future research could investigate the effectiveness of agile practices, such as real-time monitoring and decision-making, in improving the resilience and performance of the LPI.

(j) The COVID-19 pandemic has led to changes in consumer preferences and behaviour, which may have a lasting impact on the LPI. Future research could explore the impact of these changes on the PM of the industry, including the effectiveness of strategies to adapt to changing consumer needs and preferences.

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Declarations

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References

Abdullah, L., Zulkifli, N., Liao, H., Herrera-Viedma, E., & Al-Barakati, A. (2019). An interval-valued intuitionistic fuzzy DEMATEL method combined with Choquet integral for sustainable solid waste management. *Engineering Applications of Artificial Intelligence, 82*(April 2018), 207–215. https://doi.org/10.1016/j.engappai.2019.04.005

Addae, B. A., Wang, W., Xu, H., & Feylizadeh, M. R. (2021). Sustainable evaluation of factors affecting energy-resource conflict in the western region of Ghana using large group-DEMATEL. In *Group Decision and Negotiation* (Vol. 30, Issue 4). Springer Netherlands. https://doi.org/10.1007/s10726-021-09737-y

Ahmad Alinejad, E., Pishvaee, M. S., & Bonyadi Naeini, A. (2018). Key success factors for logistics provider enterprises: An empirical investigation in Iran. *Kybernetes, 47*(3), 426–440. https://doi.org/10.1108/K-10-2015-0269

Ahmad, N. L., Mohd. Yusuf, A. N., Mohamed Shobri, N. D., & Wahab, S. (2012). The relationship between time management and job performance in event management. *Procedia—Social and Behavioral Sciences*. https://doi.org/10.1016/j.sbspro.2012.11.223

Alam, S. T., Ahmed, S., Ali, S. M., Sarker, S., Kabir, G., & ul-Islam, A. (2021). Challenges to COVID-19 vaccine supply chain: Implications for sustainable development goals. *International Journal of Production Economics, 239*(April), 108193. https://doi.org/10.1016/j.ijpe.2021.108193

Alshaketheep, K. M. K. I., Salah, A. A., Alomari, K. M., Khaled, A. S. D., & Jray, A. A. A. (2020). Digital marketing during COVID 19: Consumer's perspective. *WSEAS Transactions on Business and Economics, 17*(November), 831–841. https://doi.org/10.37394/23207.2020.17.81

Amiri, M., Salehi Sadaghiyani, J., Payani, N., & Shafieezadeh, M. (2011). Developing a DEMATEL method to prioritize distribution centers in supply chain. *Management Science Letters, 1*(3), 279–288. https://doi.org/10.5267/j.msl.2010.04.001

Amrina, E., & Vilsi, A. L. (2015). Key performance indicators for sustainable manufacturing evaluation in cement industry. *Procedia CIRP*. https://doi.org/10.1016/j.procir.2014.07.173

Asan, U., Kadaifci, C., Bozdag, E., Soyer, A., & Serdarasan, S. (2018). A new approach to DEMATEL based on interval-valued hesitant fuzzy sets. *Applied Soft Computing Journal, 66*, 34–49. https://doi.org/10.1016/j.asoc.2018.01.018

Bauer, M., Lucke, M., Johnsson, C., Harjunkoski, I., & Schlake, J. C. (2016). KPIs as the interface between scheduling and control. *IFAC-PapersOnLine, 49*(7), 687–692. https://doi.org/10.1016/j.ifacol.2016.07.258

Behrouzi, F., & Ma'aram, A. (2019). Identification and ranking of specific balanced scorecard performance measures for hospitals: A case study of private hospitals in the Klang Valley area, Malaysia. *International Journal of Health Planning and Management, 34*(4), 1364–1376. https://doi.org/10.1002/hpm.2799

Bhatia, M. S., & Srivastava, R. K. (2018). Analysis of external barriers to remanufacturing using grey-DEMATEL approach: An Indian perspective. *Resources, Conservation and Recycling, 136*(December 2017), 79–87. https://doi.org/10.1016/j.resconrec.2018.03.021

Bilal, M., & Oyedele, L. O. (2020). Big Data with deep learning for benchmarking profitability performance in project tendering. *Expert Systems with Applications*. https://doi.org/10.1016/j.eswa.2020.113194

Cai, J., Liu, X., Xiao, Z., & Liu, J. (2009). Improving supply chain performance management: A systematic approach to analyzing iterative KPI accomplishment. *Decision Support Systems, 46*(2), 512–521. https://doi.org/10.1016/j.dss.2008.09.004

Cao, Y., Zhao, K., Yang, J., & Xiong, W. (2015). Constructing the integrated strategic performance indicator system for manufacturing companies. *International Journal of Production Research, 53*(13), 4102–4116. https://doi.org/10.1080/00207543.2014.994715

Chauhan, A., Kaur, H., Yadav, S., & Jakhar, S. K. (2020). A hybrid model for investigating and selecting a sustainable supply chain for agri-produce in India. *Annals of Operations Research, 290*(1–2), 621–642. https://doi.org/10.1007/s10479-019-03190-6

Choudhary, O. P., Saied, A. R. A., Priyanka, Ali, R. K., & Maulud, S. Q. (2022). Russo-Ukrainian war: An unexpected event during the COVID-19 pandemic. *Travel Medicine and Infectious Disease, 48*(3), 102346. https://doi.org/10.1016/j.tmaid.2022.102346

Cinaroglu, S., & Baser, O. (2018). Understanding the relationship between effectiveness and outcome indicators to improve quality in healthcare. *Total Quality Management and Business Excellence, 29*(11–12), 1294–1311. https://doi.org/10.1080/14783363.2016.1253467

De Andrade, P. R. M., & Sadaoui, S. (2017). Improving business decision making based on KPI management system. In *2017 IEEE international conference on systems, man, and cybernetics, SMC 2017*, *2017-Janua*(October) (pp. 1280–1285). https://doi.org/10.1109/SMC.2017.8122789

Dharani, M., Hassan, M. K., Huda, M., & Abedin, M. Z. (2023). Covid-19 pandemic and stock returns in India. *Journal of Economics and Finance, 47*(1), 251–266. https://doi.org/10.1007/s12197-022-09586-8

Ding, X. F., & Liu, H. C. (2018). A 2-dimension uncertain linguistic DEMATEL method for identifying critical success factors in emergency management. *Applied Soft Computing Journal, 71*, 386–395. https://doi.org/10.1016/j.asoc.2018.07.018

Dinçer, H., Yüksel, S., & Martínez, L. (2019). Interval type 2-based hybrid fuzzy evaluation of financial services in E7 economies with DEMATEL-ANP and MOORA methods. *Applied Soft Computing Journal, 79*, 186–202. https://doi.org/10.1016/j.asoc.2019.03.018

Eberl, M., & Schwaiger, M. (2005). Corporate reputation: Disentangling the effects on financial performance. *European Journal of Marketing, 39*(7–8), 838–854. https://doi.org/10.1108/03090560510601798

FROEHLICH FF. (1970). Percussion welding and its applications, (Ueber das Perkussionsschweissen und seine Anwendungen). In *Schweisstechnik (Berlin)* (Vol. 20, Issue 9).

Fung, A. W. S. (2020). Utilizing connectivity and data management system for effective quality management and regulatory compliance in point of care testing. *Practical Laboratory Medicine*. https://doi.org/10.1016/j.plabm.2020.e00187

Goodarzian, F., Taleizadeh, A. A., Ghasemi, P., & Abraham, A. (2021). An integrated sustainable medical supply chain network during COVID-19. *Engineering Applications of Artificial Intelligence, 100*(November 2020), 104188. https://doi.org/10.1016/j.engappai.2021.104188

Govindan, K., Mina, H., & Alavi, B. (2020). A decision support system for demand management in healthcare supply chains considering the epidemic outbreaks: A case study of coronavirus disease 2019 (COVID-19). *Transportation Research Part E: Logistics and Transportation Review, 138*(May), 101967. https://doi.org/10.1016/j.tre.2020.101967

Gunasekaran, A., & Kobu, B. (2007). Performance measures and metrics in logistics and supply chain management: A review of recent literature (1995–2004) for research and applications. *International Journal of Production Research, 45*(12), 2819–2840. https://doi.org/10.1080/00207540600806513

Hassan, A. S., & Jaaron, A. A. M. (2021). Total quality management for enhancing organizational performance: The mediating role of green manufacturing practices. *Journal of Cleaner Production, 308*(April), 127366. https://doi.org/10.1016/j.jclepro.2021.127366

Hedrick, C. (2004). Performance improvement. *Journal of Infusion Nursing, 27*(6), 379–380. https://doi.org/10.1097/00129804-200411000-00002

Herrera, F., Herrera-Viedma, E., & Martínez, L. (2000). A fusion approach for managing multi-granularity linguistic term sets in decision making. *Fuzzy Sets and Systems, 114*(1), 43–58. https://doi.org/10.1016/S0165-0114(98)00093-1

Hendiani, S., Mahmoudi, A., & Liao, H. (2020). A multi-stage multi-criteria hierarchical decision-making approach for sustainable supplier selection. *Applied Soft Computing Journal, 94*, 106456. https://doi.org/10.1016/j.asoc.2020.106456

Hepatis, A. (1844). *Page numbers followed by "f " indicate figures, "t" indicate tables, and "b" indicate boxes.* 1, 836–844. https://doi.org/10.1016/B978-0-12-373717-5.00029-4

Hoque, I., Hasle, P., & Maalouf, M. M. (2022). Buyer–supplier role in improving ergonomics in garment supplier factories: empirical evidence from the garment industry of bangladesh. *Sustainability (Switzerland), 14*(1). https://doi.org/10.3390/su14010

Hsu, C. C., & Lee, Y. S. (2014). Exploring the critical factors influencing the quality of blog interfaces using the Decision-Making Trial and Evaluation Laboratory (DEMATEL) method. *Behaviour and Information Technology, 33*(2), 184–194. https://doi.org/10.1080/0144929X.2012.695395

Ishaq Bhatti, M., & Awan, H. M. (2014). The key performance indicators (KPIs) and their impact on overall organizational performance. *Quality and Quantity, 48*(6), 3127–3143. https://doi.org/10.1007/s11135-013-9945-y

Ivanov, D. (2019). *Supply chain risk management and resilience : A decision-oriented introduction to the creation of value this is an author version of the chapter " Supply chain risk chapter 15 supply chain risk management and resilience*. *January*. https://doi.org/10.1007/978-3-319-94313-8

Ivanov, D., & Dolgui, A. (2021). OR-methods for coping with the ripple effect in supply chains during COVID-19 pandemic: Managerial insights and research implications. *International Journal of Production Economics, 232*, 107921. https://doi.org/10.1016/j.ijpe.2020.107921

Jain, N., & Singh, A. R. (2020). Sustainable supplier selection under must-be criteria through Fuzzy inference system. *Journal of Cleaner Production*. https://doi.org/10.1016/j.jclepro.2019.119275

Jiang, S., Shi, H., Lin, W., & Liu, H. C. (2020). A large group linguistic Z-DEMATEL approach for identifying key performance indicators in hospital performance management. *Applied Soft Computing Journal, 86*(xxxx), 105900. https://doi.org/10.1016/j.asoc.2019.105900

Joppen, R., von Enzberg, S., Gundlach, J., Kühn, A., & Dumitrescu, R. (2019). Key performance indicators in the production of the future. *Procedia CIRP*. https://doi.org/10.1016/j.procir.2019.03.190

Jovan, V., & Zorzut, S. (2006). Use of key performance indicators in production management. In *2006 IEEE conference on cybernetics and intelligent systems*. https://doi.org/10.1109/ICCIS.2006.252343

Kaganski, S., Majak, J., & Karjust, K. (2018). Fuzzy AHP as a tool for prioritization of key performance indicators. *Procedia CIRP, 72*, 1227–1232. https://doi.org/10.1016/j.procir.2018.03.097

Kagioglou, M., Cooper, R., & Aouad, G. (2001). Performance management in construction: A conceptual framework. *Construction Management and Economics, 19*(1), 85–95. https://doi.org/10.1080/01446190010003425

Kahn, M. E., & Wolak, F. A. (2013). Using information to improve the effectiveness of nonlinear pricing: Evidence from a field experiment. *Working Paper*, 1–43.

Kang, N., Zhao, C., Li, J., & Horst, J. A. (2016). A Hierarchical structure of key performance indicators for operation management and continuous improvement in production systems. *International Journal of Production Research, 54*(21), 6333–6350. https://doi.org/10.1080/00207543.2015.1136082

Kassaneh, T. C., & Workalemahu, R. N. (2018). Performance measurement and improvement method for leather footwear industries. *Journal of Engineering, Project, and Production Management, 8*(2), 97–104. https://doi.org/10.32738/jeppm.201807.0005

Kumar, A., Mangla, S. K., Kumar, P., & Song, M. (2021). Mitigate risks in perishable food supply chains: Learning from COVID-19. *Technological Forecasting and Social Change, 166*(January), 120643. https://doi.org/10.1016/j.techfore.2021.120643

Labella, Liu, Y., Rodríguez, R. M., & Martínez, L. (2018). Analyzing the performance of classical consensus models in large scale group decision making: A comparative study. *Applied Soft Computing Journal, 67*, 677–690. https://doi.org/10.1016/j.asoc.2017.05.045

Lima, E. S., McMahon, P., & Costa, A. P. C. S. (2021). Establishing the relationship between asset management and business performance. *International Journal of Production Economics*. https://doi.org/10.1016/j.ijpe.2020.107937

Lindberg, C. F., Tan, S., Yan, J., & Starfelt, F. (2015). Key performance indicators improve industrial performance. *Energy Procedia*. https://doi.org/10.1016/j.egypro.2015.07.474

Liu, H. C., You, X. Y., Tsung, F., & Ji, P. (2018). An improved approach for failure mode and effect analysis involving large group of experts: An application to the healthcare field. *Quality Engineering, 30*(4), 762–775. https://doi.org/10.1080/08982112.2018.1448089

Liu, P., & Zhang, X. (2019). A Multicriteria Decision-Making Approach with Linguistic D Numbers Based on the Choquet Integral. *Cognitive Computation, 11*(4), 560–575. https://doi.org/10.1007/s12559-019-09641-3

Liu, X., Li, L., Wang, L., Herr, K., & Chen, Q. (2021). Implementation and evaluation of a pain management core competency education program for surgical nurses. *International Journal of Nursing Sciences*. https://doi.org/10.1016/j.ijnss.2020.09.008

Lu, Y., Yang, L., Shi, B., Li, J., & Abedin, M. Z. (2022). A novel framework of credit risk feature selection for SMEs during industry 4.0. *Annals of Operations Research*. https://doi.org/10.1007/s10479-022-04849-3

Majumdar, A., Shaw, M., & Sinha, S. K. (2020). COVID-19 debunks the myth of socially sustainable supply chain: A case of the clothing industry in South Asian countries. *Sustainable Production and Consumption, 24*, 150–155. https://doi.org/10.1016/j.spc.2020.07.001

Manupati, V. K., Schoenherr, T., Ramkumar, M., Panigrahi, S., Sharma, Y., & Mishra, P. (2022). Recovery strategies for a disrupted supply chain network: Leveraging blockchain technology in pre- and post-disruption scenarios. *International Journal of Production Economics, 245*, 108389. https://doi.org/10.1016/J.IJPE.2021.108389

Moktadir, M. A., Dwivedi, A., Rahman, A., Chiappetta Jabbour, C. J., Paul, S. K., Sultana, R., & Madaan, J. (2020). An investigation of key performance indicators for operational excellence towards sustainability in the leather products industry. *Business Strategy and the Environment, 29*(8), 3331–3351. https://doi.org/10.1002/bse.2575

Mone, S., Pop, M. D., & Paina, N. (2013). The " What " AND " HOW " OF MARKETING PERFORMANCE Sorina-Diana MONE Faculty of Economics and Business Faculty of Economics and Business Nicoleta-Dorina RACOL Ţ A-PAINA Faculty of European Studies. *Management and Marketing, 8*(1), 129–146.

Nalewaik, A., & Mills, A. (2016). Project performance review: Capturing the value of audit, oversight, and compliance for project success. In *Project performance review: Capturing the value of audit, oversight, and compliance for project success*, *July 2016*, (pp. 1–90). https://doi.org/10.4324/9781315602424

Nara, E. O. B., Sordi, D. C., Schaefer, J. L., Schreiber, J. N. C., Baierle, I. C., Sellitto, M. A., & Furtado, J. C. (2019). Prioritization of OHS key performance indicators that affecting business competitiveness—A demonstration based on MAUT and Neural Networks. *Safety Science*. https://doi.org/10.1016/j.ssci.2019.06.017

New, S. (1994). Modeling and analysis of manufacturing systems. *Journal of the Operational Research Society, 45*(6), 725–726. https://doi.org/10.1057/jors.1994.112

Nudurupati, S. S., Garengo, P., & Bititci, U. S. (2021). Impact of the changing business environment on performance measurement and management practices. *International Journal of Production Economics*. https://doi.org/10.1016/j.ijpe.2020.107942

Orji, I. J., & Ojadi, F. (2021). Investigating the COVID-19 pandemic's impact on sustainable supplier selection in the Nigerian manufacturing sector. *Computers and Industrial Engineering, 160*, 107588. https://doi.org/10.1016/j.cie.2021.107588

Orji, I. J., & Wei, S. (2015). An innovative integration of fuzzy-logic and systems dynamics in sustainable supplier selection: A case on manufacturing industry. *Computers and Industrial Engineering, 88*, 1–12. https://doi.org/10.1016/j.cie.2015.06.019

Peng, H. gang, & Wang, J. qiang. (2017). Hesitant Uncertain Linguistic Z-Numbers and Their Application in Multi-criteria Group Decision-Making Problems. *International Journal of Fuzzy Systems, 19*(5), 1300–1316. https://doi.org/10.1007/s40815-016-0257-y

Pinna, C., Demartini, M., Tonelli, F., & Terzi, S. (2018). How soft drink supply chains drive sustainability: Key performance indicators (KPIs) identification. *Procedia CIRP*. https://doi.org/10.1016/j.procir.2018.04.008

Scafà, M., Papetti, A., Brunzini, A., & Germani, M. (2019). How to improve worker's well-being and company performance: A method to identify effective corrective actions. *Procedia CIRP*. https://doi.org/10.1016/j.procir.2019.03.029

Schippers, M. C., & Rus, D. C. (2021). Optimizing decision-making processes in times of COVID-19: Using reflexivity to counteract information-processing failures. *Frontiers in Psychology, 12*(June), 1–14. https://doi.org/10.3389/fpsyg.2021.650525

Scholarios, D., & Taylor, P. (2014). "Decommissioned vessels"—Performance management and older workers in technologically-intensive service work. *Technological Forecasting and Social Change*. https://doi.org/10.1016/j.techfore.2014.08.004

Selviyanti, E., Sardjono, W., Mukhlis, M., Tohir, M., Maswar, M., & Fariz, A. (2021). Model of developing key performance indicator to increase the quality of education during the Covid-19 pandemic. *Journal of Physics: Conference Series*. https://doi.org/10.1088/1742-6596/1832/1/012030

Severo, E. A., De Guimarães, J. C. F., & Dellarmelin, M. L. (2021). Impact of the COVID-19 pandemic on environmental awareness, sustainable consumption and social responsibility: Evidence from generations in Brazil and Portugal. *Journal of Cleaner Production*. https://doi.org/10.1016/j.jclepro.2020.124947

Si, S. L., You, X. Y., Liu, H. C., & Huang, J. (2017). Identifying key performance indicators for holistic hospital management with a modified DEMATEL approach. *International Journal of Environmental Research and Public Health, 14*(8). https://doi.org/10.3390/ijerph14080934

Si, S. L., You, X. Y., Liu, H. C., & Zhang, P. (2018). DEMATEL Technique: A Systematic Review of the State-of-the-Art Literature on Methodologies and Applications. *Mathematical Problems in Engineering, 2018*(1). https://doi.org/10.1155/2018/3696457

Siedler, C., Langlotz, P., & Aurich, J. C. (2020). Modeling and assessing the effects of digital technologies on KPIs in manufacturing systems. *Procedia CIRP*. https://doi.org/10.1016/j.procir.2020.04.008

Varisco, M., Johnsson, C., Mejvik, J., Schiraldi, M. M., & Zhu, L. (2018). KPIs for manufacturing operations management: Driving the ISO22400 standard towards practical applicability. *IFAC-PapersOnLine, 51*(11), 7–12. https://doi.org/10.1016/j.ifacol.2018.08.226

Velimirovi, D., Velimirovi, M., & Stankovi, R. (2011). *1452–48641101063V*. *6*(1), 63–72.

Wang, J. Q., Wu, J. T., Wang, J., Zhang, H. Y., & Chen, X. H. (2014). Interval-valued hesitant fuzzy linguistic sets and their applications in multi-criteria decision-making problems. *Information Sciences, 288*(1), 55–72. https://doi.org/10.1016/J.INS.2014.07.034

Wang, J. qiang, Cao, Y. xi, & Zhang, H. yu. (2017). Multi-Criteria Decision-Making Method Based on Distance Measure and Choquet Integral for Linguistic Z-Numbers. *Cognitive Computation, 9*(6), 827–842. https://doi.org/10.1007/s12559-017-9493-1

Whicker, L., Bernon, M., Templar, S., & Mena, C. (2009). Understanding the relationships between time and cost to improve supply chain performance. *International Journal of Production Economics, 121*(2), 641–650. https://doi.org/10.1016/j.ijpe.2006.06.022

Xu, Z. (2006). An approach based on the uncertain LOWG and induced uncertain LOWG operators to group decision making with uncertain multiplicative linguistic preference relations. *Decision Support Systems, 41*(2), 488–499. https://doi.org/10.1016/j.dss.2004.08.011

Yadegaridehkordi, E., Hourmand, M., Nilashi, M., Shuib, L., Ahani, A., & Ibrahim, O. (2018). Influence of big data adoption on manufacturing companies' performance: An integrated DEMATEL-ANFIS approach. *Technological Forecasting and Social Change, 137*(March), 199–210. https://doi.org/10.1016/j.techfore.2018.07.043

Yang, C., Abedin, M. Z., Zhang, H., Weng, F., & Hajek, P. (2023). An interpretable system for predicting the impact of COVID-19 government interventions on stock market sectors. *Annals of Operations Research*. https://doi.org/10.1007/s10479-023-05311-8

Zairy, M. (2013). The TQM Legacy-Gurus' contribution and theoretical impact. *TQM Journal, 25*(6), 659–676.

Zhang, G., Dong, Y., & Xu, Y. (2014). Consistency and consensus measures for linguistic preference relations based on distribution assessments. *Information Fusion, 17*(1), 46–55. https://doi.org/10.1016/j.inffus.2012.01.006

Zhang, X., & Xu, Z. (2015). Soft computing based on maximizing consensus and fuzzy TOPSIS approach to interval-valued intuitionistic fuzzy group decision making. *Applied Soft Computing Journal, 26*, 42–56. https://doi.org/10.1016/j.asoc.2014.08.073