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ORIGINAL ARTICLE

Integrated artificial intelligence effect on crisis management and lean production: structural equation modelling frame work

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Abstract It is a goal that manufacturing companies strive towards on a regular basis, and it involves enhancing the efficiency and productivity of maintenance operations. It is especially vital to avoid unforeseen breakdowns, which may result in costly charges and production losses if they do not occur in advance. While the execution of an acceptable management plan affects maintenance productivity, it also affects the adoption of proper procedures and tools to help in the assessment processes in this field. This difficulty, among other things, affects a company's capacity to achieve high performance with the equipment it employs, as well as the judgement process and the design of the firm's maintenance plan. In order to achieve this goal, the aim of this paper is to exemplify how intelligent systems can be used to enhance judgement techniques in the implementation of the lean maintenance perspective, allowing for an advancement in the functional capabilities of the industry's technological infrastructure. The reseachers employed artificial intelligence technologies to look for connections between specific operations carried out as part of the deployment of lean maintenance and the findings achieved. The raw set notion, which was used in this situation, was used to determine whether or not the lean maintenance method was being used in this study. The crisis management process carries with it some of the most complex data technology concerns ever encountered. It necessitates, among other items, active information gathering and information transfer efforts, that are used for a range of functions, such as decreasing uncertainty, attempting to measure and manage consequences, and attempting to manage resources in a way that goes beyond what is generally possible to deal with daily problems. It also needs the employment of artificial intelligence technology, among other things, to increase crisis awareness.

Keywords Artificial intelligence · Crisis management · Lean management · Production maintenance techniques · Monitoring robotics · Framework performance · Business · Optimizations

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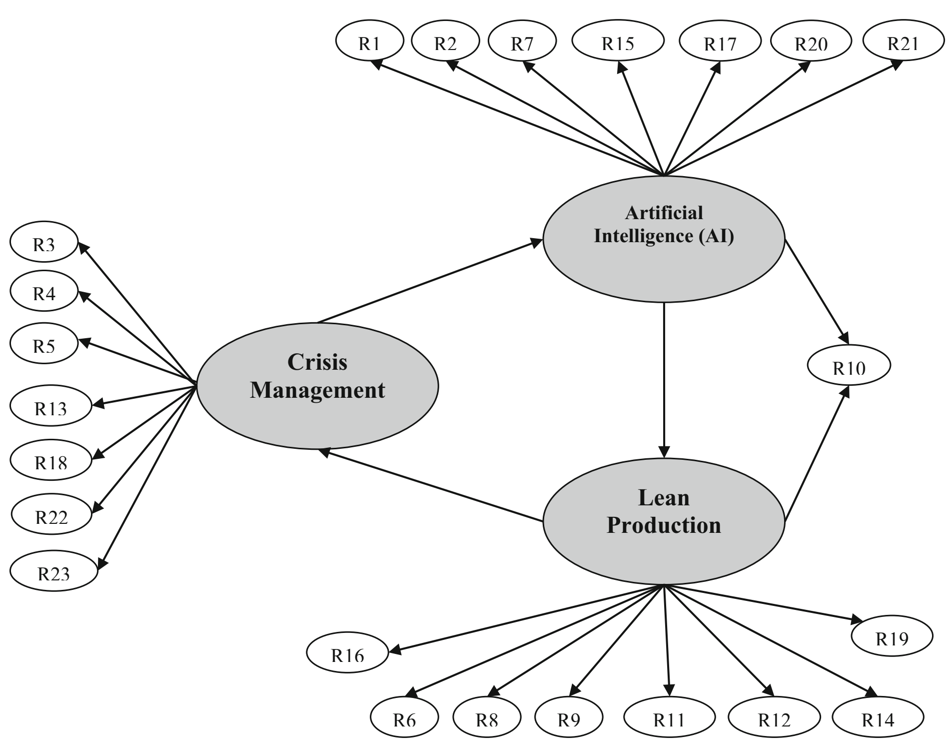
1 Introduction

Discussions are taking place around the idea of measuring how successful it is to execute the lean maintenance framework by using artificial intelligence (AI) methodologies. Advanced product dependability and quality are accomplished via the use of appropriate business management and operational methodologies, as well as the availability of the resources necessary for their execution (Gola 2019). These strategies and approaches make it feasible to coordinate and integrate all of the firm's operations, which otherwise would not be possible. In additional to the state of technical equipment that is kept in use in businesses (Reiner 2005), one of the criteria that contributes to the excellent quality of the items is the age of the goods themselves. An item's suitability and technical quality are critical elements in deciding whether or not it will be successful.Even though maintenance management is a vital component of industrial companies' administration, many people do not realise how important it is. Therefore, much effort has been expended in recent years to develop and enhance maintenance methods with the goal of extending the useful life of all present technology, making it more accessible, and increasing its reliability (Luska 2015). Over the previous many decades, maintenance has been seen as a necessary evil in the administration of a firm since it was restricted to the right activities that were often done in emergency circumstances, such as a machine breakdown. While this approach was suitable in the past, the significance of maintenance as a strategic component of the group's revenue-generating businesses has been acknowledged in recent years. Years ago, businesses did not always manage their maintenance operations in a way that allowed them to save money while also maximizing the advantages of service and repair procedures, which was a costly oversight. In order to get the most out of the functioning of technical machine systems in real life, a few acts must be carried out to the highest possible level of excellence (Sward et al. 2019). This necessitates the development of appropriate system modelling and simulation studies as well as the optimization of comprehensive or sophisticated practical grounds by using optimization criteria produced as a consequence of the rise in machines. Frequently, these activities are carried out in relation with a particular use technique that has been created in conjunction with the introduction of new manufacturing systems. The vast bulk of businesses that received foreign investment were successful in developing appropriate maintenance strategies for their operations. For their part, small and medium enterprises are still searching for the most effective approach for reorganizing their operations, and for the most successful mechanism for assessing and reporting technological machinery, equipment, and techniques that would allow them to in or measures that are undertaken as part of a longer-term project while the crisis is still ongoing. The R is referred to the reference and undependable variables and AI-LP-CM are dependable variables.

2 SEM methodology of RP



A huge and diversified response may be necessary in the case of a crisis, including many levels of government, business entities, community activities, media organisations, and participants of the general public, among other stakeholders. Essentially, these groups act as a virtual organization, with the mission of safeguarding persons, protecting infrastructure and local assets, and restoring normality to the community (Raghu and Chen 2007).

The main goals of lean maintenance are to ensure reliability while operating as efficiently and inexpensively as possible. As a result, the fundamental aim of lean maintenance is to reduce costs while maintaining high levels of performance and productivity. During a crisis, the phrase crisis response refers to the immediate protection of human life and property in order to reduce the number of deaths and property damage. The ability to respond quickly and organized the deployment of funds, equipment, and workers in the event of a catastrophe or crisis is critical. If an emergency is ongoing, it includes activities that were started well before the crisis (for example, when a storm warning is received), measures taken in response to the crisis's immediate consequences, and The application of artificial intelligence new technologies during a crisis response aims to boost organizational efficiency by using robots to help urban relief and recovery operational operations (Shah and Chose 2004), ontologies to simplify information interchange, and tailored inquiries to crisis key players. As an example, when it refers to management practices, lean is defined as a set of solutions that are intended to improve performance and production by eliminating waste. As previously stated, the primary principle of lean is to reduce and eliminate as many non-value-adding procedures and wastes (Hitomi 1997) as feasible.

3 Methodology and scope

It is a common objective of manufacturing companies to improve maintenance operations performance and productivity. Unanticipated faults might result in high expenses and lost productivity. Execution of an appropriate management plan affects the adoption of right procedures and tools to help in assessment processes. That a company's judgement process and maintenance plans design are flawed. This research will show how intelligent systems may be used to enhance judgement processes in lean maintenance, therefore improving the industry's technical infrastructure. The researchers employed AI to look for connections between procedures and outcomes. The raw set concept was used to examine if the inquiry used lean maintenance. Among the most complex information technology concerns have yet to be investigated. Other roles include reducing uncertainty, evaluating and controlling consequences, and managing resources beyond ordinary difficulties. The possibility of the research is use into Research and crisis management lean management people to develop AI system to make and maintain smart city.

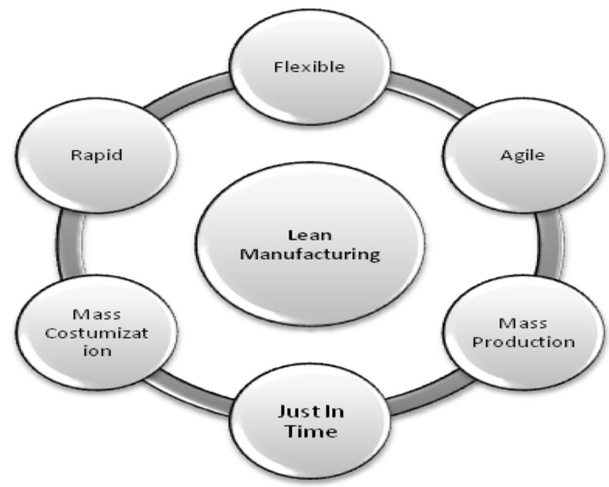


Fig. 1 Lean manufacturing or production

3.1 Discussing exactly lean manufacturing (production)

Lean manufacturing, often known as lean production, is a collection of methods and activities that are used to operate a production and services business efficiently. The methods and actions used vary depending on the applications, but they all follow the same fundamental principle: the removal of all non-value-adding operations and wastes from the company (Wickremasinghe and Wickremasinghe 2017), regardless of the framework (Fig. 1).

3.2 In production, artificial intelligence and lean management

Artificial intelligence (AI) enables increased connection between people, data, and technologies, allowing businesses to improve goods and operations more effectively. Much like Lean Management concepts have helped manufacturing, AI offers to become the next developmental process in efficiency improvement. Already, 92% of top manufacturing managers think that 'Smart Factory' modern technologies like artificial Intelligence would help them improve efficiency and encourage their employees to work intelligently (Antosz et al. 2020). These smart technologies in smart Factories leads to become a crucial part in various smart city plans like developing smart Industries, smart drainage systems, smart traffic control systems etc.

AI will enhance how employees interact with technology, and advancements in AI will render human

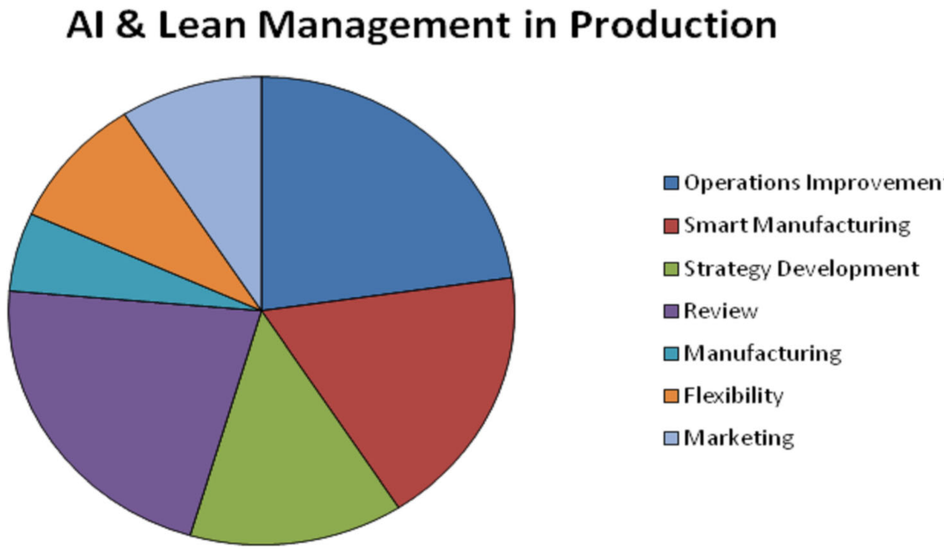


Fig. 2 AI and lean management in production

participation in many industrial procedures obsolete. Indeed, AI, or the actual implementation of artificial intelligence to particular activities and commercial procedures, removes this need human participation in advanced instances where computers' quickness **and** efficiency outperform people. AI will enhance the quality, lead-times, and costs involved with product creation via self-learning, completely altering the character of workforce administration.

AI's primary function as a technology is as an operator of optimization algorithms, much as continued growth and a dedication to transformation are principles of the Lean methodology. As a result, it is critical that investors integrate Lean concepts as they balance certain conventional human jobs while incorporating AI. Currently, the application of AI may decrease manufacturers' transformation cost and increase to 20%, with increased worker efficiency accounting for up to 70% of the reducing costs (Panwar et al. 2021). Integrating AI with Lean will enable companies to establish a new corporate culture, guaranteeing not just improved operations but also more flexible workflows for workers as they relinquish some tasks and take on new roles (Fig. 2).

The much-heralded advent of "Smart Cities" was expected to usher in data-driven answers to urban problems. While Asia continues to lead the way, legacy cities (especially in the West) are now under pressure to modernize aging infrastructure. The COVID-19 epidemic, growing commitments to sustainability, resource limits, and continuing urbanization all contribute to a fresh justification for investment. It has never been more critical to transform cities into smarter, more efficient, and more sustainable places to live. By 2026, smart cities could create $20 trillion in economic benefits. Businesses are being enticed to sponsor Smart City initiatives through green stimulus packages and tactics that help them mitigate financial risk while also providing the possibility of supplementary revenue. Our analysts suggest that prioritizing changes to urban infrastructure is critical to the growth of Smart Cities, as it lays the groundwork for additional solutions and services.

3.2.1 The basis of lean maintenance in lean manufacturing

Organizations in the twenty-first century are motivated to develop and execute a much more efficient manufacturing system. Many of them use or intend to use lean manufacturing. In industries, the lean manufacturing concept is primarily utilized to improve performance and production. It was created in the 1990s and is founded mostly on the Toyota Production System (TPS) (Haven 1994). The reduction of needless expenditures that have a major effect on production **and** profitability is the foundation of this idea. These reductions are classified into three types: Muda, Mura, and Muri.

- As per Muda, there are seven kinds of waste: transportation, suppliers, repetitive motion, holding, increased production, over processing, or faults.
- Mura, which meaning uneven distribution, non-uniformity, or irregularities, is the cause of any of the seven wastes. Lastly,
- Muri denotes overburden, within one's power, excessiveness, impossibility, or unfairness, and may be produced by Mura or, in certain instances, by insufficient elimination of Muda from the system (Sakai and Li 2021).

Lean manufacturing must comprise of decreasing the number of losses linked to people, inventories, time-to-market, or production area in order to achieve a strong

Table 1 Reduction of maintenance costs

Postpones in the completion of projects	Preparing for the existence of technological facilities to take out preventative measures
Inadequate stock management	Inadequate availability of required replacement components at a given moment
Inadequate utilization of commodities	Poor utilization of existing resources and service crews' abilities
Inadequate information handling	Gathering worthless information while ignoring critical information
Misuse of machines	Malfunction or deliberate operating methods resulting in unnecessary service tasks
Reworking	Activities must be repeated owing to low performance level
Work that is ineffective	Work that does not improve the dependability of the technological infrastructures

oxidizing desire for consumer requirements while creating high-quality goods in the most productive and cost-effective way (Jain and Pandey 2017). Lean manufacturing may be utilized as a cost-cutting technique, and if correctly applied, it can transform a company into a world-class organization. Most significantly, lean manufacturing can be employed in any industry (Mishra and Chakraborty 2019). Many businesses have adopted the concept of using lean tools, mainly to reduce wasteful manufacturing. Companies that have implemented lean manufacturing techniques have substantial performance and cost benefits over those that remain to utilize conventional manufacturing techniques.

3.3 Failure reduction in lean maintenance

Lean maintenance is a paradigm that includes actions that seek to improve the efficiency of technological infrastructure and artificial intelligence. In Table 1. These actions are linked to the reduction of maintenance costs, such as (Gazebo and Shahadah 2010):

3.4 Where will the combination of lean and AI affect production?

As the implementation of Lean Management resulted in significant cultural shifts in workplace culture, the use of AI in industrial operations necessitates its own culturally adjustment, wherein lean administration must serve a vital part.

In many instances, AI is restricted to assisting human specialists who utilize its analysis to enhance judgments procedures. But it will soon go beyond its 'aided awareness' function by becoming independent, and AI will progressively make choices on which corporate executives may depend (Dou et al. 2021).

Because there are now hundreds of AI applications in many industrial sectors, the move to independence will have a profound impact on all aspects of the business. However, Lean principles embrace the benefit of AI as businesses enhance hundreds of repetitive business tasks, such as evaluating IoT sensor information, anticipating machine breakdown, or reducing supply chain inefficiencies.

Table 2 metal processing sector led the assessed businesses

Serial No	Type of industry	Stage 1	Stage 2
1	Automotive	18.81%	20.69%
2	Aviation	23.76%	24.14%
3	Food	5.94%	–
4	Chemical	5.94%	3.45%
5	Wood and paper	7.92%	1.72%
6	Metal processing	22.77%	22.41%
7	Others	12.87%	24.14%

3.5 The application of the OEE indicators in enterprises: study findings

The first step of the study sought data on the usage of lean maintenance techniques and technologies in businesses, including such total productive maintenance (TPM), single moment exchanging of die (SMED), 5S, and the OEE indicator.

The study, which was conducted in two phases, stage I (2010–2015) and stage II (2015–2020), included 150 manufacturing firms. When categorizing the assessed businesses, the key factors were considered: the organization size, productivity, kind, industry, type of administration, capital, the industry's health, as well as the kind of machinery possessed (Sokoto et al. 2021). Among some of the examined businesses were those that engaged in multiple kinds of production or functioned in multiple industries the Table 2 shows metal processing sector led the assessed businesses (stage I: 22.77%, stage II: 22.41%), following by the aviation sector (stage I: 23.76%, stage II: 24.14%) and the automobile industry (stage I: 23.76%, stage II: 24.14%) (stage I: 18.81%, stage II: 20.69%).

According to the raw data investigation it is critical for businesses to recognize that this is a two-way learning

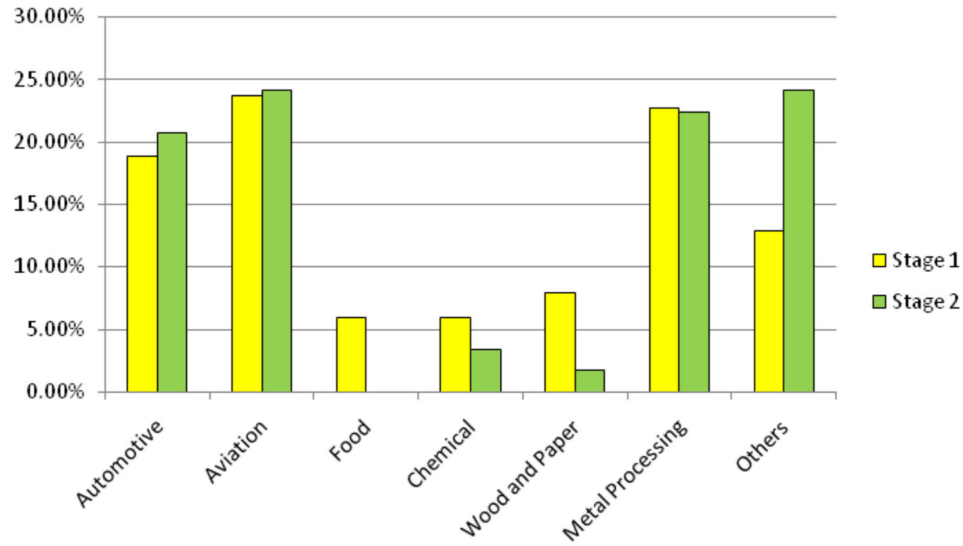


Fig. 3 Examined study enterprises by industrial sector

process—the board of directors, senior management teams, and business and control functions will need to improve their understanding of AI, while AI specialists will benefit from an understanding of risk and regulatory perspectives, to the extent they do not already have them (Fig. 3).

3.6 Robotics

In the field of crisis response, robotics is a developing study topic. Multi-robot technologies were used in a variety of crisis response activities. Robots are particularly employed in Urban Search and Rescue (USAR) missions. The process of finding, rescuing, or therapeutically stabilizing individuals imprisoned in tight places is known as urban search and rescue. USAR personnel have 48 h to locate imprisoned individuals in a collapsed building; otherwise, the chances of finding people alive are practically nil. The difficulties that the USAR squad must face have been divided into four categories.

- Timely response
- Rescuers' security
- Environmental disturbances and climatic circumstances, as well as
- Inadequate technology and skills

Building's material hinders rescue personnel from investigating because of the intolerable actual danger of future collapse; furthermore, collapse restricted areas are often too tiny for humans to enter, restricting the investigation to no more than just few feet from the outside. Rescue workers may be squashed by building collapse or experience lung problems as a result of toxic chemicals, gases, and dust (Jain et al. 2020). The location must be fortified and deemed safe for rescuers to access, which takes three to four vital early part of the crisis when locating people alive is essential. Robots can avoid risk and speed up the chase for survivors soon after a collapse. Their capacity to travel through closely restricted areas where humans are unable to enter makes them very helpful for rapidly reaching a spot inside the crisis site. To accelerate the search procedure, robots may be sent to a major crisis to search several areas at the same time. Using Radio Frequency Identification (RFID) tagging, they can scan the region and pinpoint the position of individuals. During the investigation, they may leave radio transmitters to connect with individuals, use tiny probing to monitor patients' heart rates and body temperatures, and provide a source of heat as well as little quantities of food and medicine to keep victims alive. During the World Trade Center disaster in New York, robots were used in finding and rescuing operations for the first time (Fig. 4).

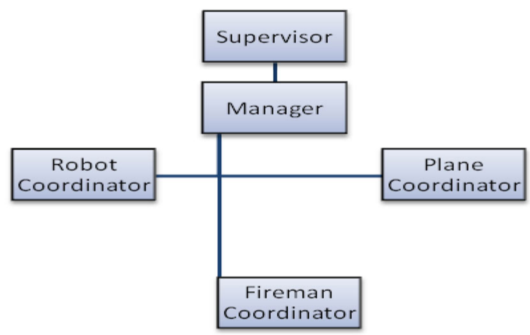


Fig. 4 Robotics in crisis management

3.7 Ontology

The goal of data administration and analytics in crisis response is to create virtual models of a common and prominent operational image that can be shared across all responders.

This common Image will not be successful unless and until the following issues (Jorge-Martinez et al. 2021) are addressed:

1. *Diversification of sources of data*: Data important to judgement may be distributed among a variety of sources, ranging from devices where data is produced to heterogeneous data sources owned by independent organisations (Ross 2014). Furthermore, crucial data may be communicated via a variety of media, including voice chats between crisis managers, cameras information, sensors and data flows, geographic information systems (GIS)-oriented information, and structural data stored in databases, among others.
2. *Various data consumers*: Different people/organizations have varying degrees need and immediacy when it comes to the very same data, which is a good thing. Based on the job, various types of information may be utilised, but a core collection of information may be maintained throughout all of the tasks. A formalised ontology may be used to describe this shared core collection of knowledge.

Ontologies have been created in a variety of forms, including the following:

a. *Ontologies for the entire crisis management process*: The E-Response program has created a variety of responder ontologies, including an ontology for the whole crisis management procedure, a pathology ontology, and a healthcare ontology, among others (Ye et al. 2009).

b. *Robotic searching and recovery ontology for urban environments:* In order to aid in the experimentation and advancement of advanced methods for sensing, route planning, planning, assimilation, and direct human communication within lookup and recovery robot processes, a robot ontology is being developed. This ontology will capture key data about robots and their skills. There are three categories of captured information: structural characteristics (such as size and weight), functionality (such as weather resistance, level of independence, abilities of locomotion, detectors as well as operational processes, and communication systems), and operational aspects (such as human operator training and education) (Drury et al. 2005). Structural features include size, mass, power supply, motion control mechanism, detectors, and processing units, among other things.

4 Results and discussion

Individuals and data may be integrated with equipment and systems to enhance the quality of manufacturing procedures and goods. Integration, along with Lean Management, is predicted to be the next step in the advancement of productivity. As previously said, 92% of top manufacturing executives feel that digital technologies like artificial intelligence would assist in raising productivity and enabling their employees to perform more efficiently. People will no longer be required to participate in many production processes as a result of technological advancements. As a result of Pragmatic AI, which is the practical application of artificial intelligence to particular jobs and business processes, the necessity for human participation in advanced situations where machines' speed and performance surpass humans is reduced. Incorporating integrating techniques may be used to create "smart machines," which are capable of imitating intelligent behavior without the need for any human intervention. Self-learning artificial intelligence will revolutionize labor management by improving products and services, reducing lead times, and lowering prices. As a result of this new approach, an integrated artificial intelligence framework is created that enables both the larger Organization as well as the smaller, most risk-resolved Structure. Essentially, it's a complete framework. Continuous improvement and a willingness to adapt are important aspects of lean manufacturing, and risk management optimization is one of them. As a consequence, stakeholders must adopt Lean concepts as artificial intelligence (AI) takes over certain human tasks. Integrating their processes may result in cost reductions of up to 20% on conversion expenses, with up to 70% of the cost savings coming from increased labor productivity. It is possible to build a new business culture via the integration of artificial intelligence with lean manufacturing, enabling firms to create a more inclusive workflows for workers as they take on new duties and surrender old ones. When employees move from one position to another, their workday becomes much more flexible for everyone involved. When employees move from one position to another, their workday becomes more flexible for everyone involved.

5 Conclusion

The study Research examined the concept of lean manufacturing, which found production, and afterwards at artificial intelligence or lean administration in an industrial setting do established. According to the notion of lean maintenance in lean manufacturing, the study being addressed is described in the following. Afterwards, explore at ways to decrease failures in lean maintenance operations. In this essay, we look at the effects of combining lean manufacturing with artificial intelligence on the manufacturing process. Researcher Explores how companies are using the ore indicators (based on research results), and towards the end, discussed the role that robots and ontologies play in crisis management strategies.

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Declarations

Conflict of interest The authors declare that they have no conflict of interest and all ethical issues including human or animal participation has been done. No such consent is applicable.

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