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SEM-PLS Model of Resource Based ISO 56002:2019 Integrated Lean Six Sigma for Cultivating Culture of Innovation (Cased in Precast Concrete Company in Indonesia)

Yan Ginting[1], Yusuf Latief [2], Ranti Hidayanti [3]
Universitas Indonesia[1, 2, 3]
Jl. Margonda No. 230A, Depok, Jawa Barat, Indonesia
Correspondence Email: yan.kristoper@office.ui.ac.id

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ABSTRACT

This study explores the integration of ISO 56002:2019 - based on Innovation Management Systems and Lean Six Sigma in the resource context of the precast concrete industry. Lean Six Sigma (LSS) and Innovation are powerful methodologies that exhibit several differences, there are numerous areas where LSS and Innovation share compatible foundations and common goals in the pursuit of improving implementation of Innovation Management System on these companies. In this study, the researchers conducted a literature review to identify the research variables, which were then validated by 5 experts. The researchers collected data through questionnaires from 54 respondents who work in a precast concrete company in Indonesia. SEM-PLS methods were used for analysis. Results indicate Lean Six Sigma's substantial positive influence on resource of precast concrete company in the Innovation Management System, offering valuable insights for Indonesia's precast concrete industry. This study contributes to continuous improvement in innovation culture, fostering competitiveness in the global market.

Keywords: Culture of Innovation, Innovation Management System, Lean Six Sigma, Precast Concrete, Resource

INTRODUCTION

The application of precast concrete has been widely implemented in various countries, but the technology implementation still varies from each country. Indonesia, through the collaboration of members of the Indonesian Precast and Prestressed Association (IAPPI) with various institutions, has been using precast concrete since 1979 along with the transfer of technology and its innovations. The development of using precast concrete has been increasing from year to year, but it suddenly declined when the COVID-19 pandemic entered Indonesia. It is reported that the condition of precast concrete companies in Indonesia has declined due to the pandemic. According to one of the precast concrete companies in Indonesia, the budget for research and development in 2021 has decreased compared to 2019 and 2020. Several precast concrete companies in Indonesia have started to close some of their factories to maintain the company's economy. One strategy to improve performance and compete in the market is to create innovation and improve the quality of resources. However, according to the Global Innovation Index (GII) 2021 report, Indonesia ranks 87th with a score of 27.1 (European Comission, 2021). Indonesia has dropped 2 ranks from the previous year and is ranked the second lowest in the ASEAN region. Taylor (2016) concluded that a nation's innovation level is determined by factors such as market failure, government policy and institutional intervention, global social networks, and creative insecurity.

The International Standardization Organization (ISO) recognizes the significance of innovation management systems and considers innovation a top priority for standardization. This emphasis on innovation extends beyond being merely a complementary aspect of integrated management systems; it is regarded as a distinct domain encompassing a broad range of activities. The ISO standard for innovation management is ISO 56002:2019. As per ISO 56002:2019, an innovation management system comprises interconnected elements that work together to achieve value realization. It provides a shared framework for developing and implementing innovation capabilities, assessing performance, and attaining desired outcomes. Successful organizations strive to maintain a competitive edge by implementing efficient Continuous Improvement (CI) methodologies, such as Lean Six Sigma (LSS) (Salah, 2017). Innovative companies are able to surpass their competitors by introducing technology that focuses on creative work processes, resulting in new, unique, and high-quality products. The culture of innovation can also create added value and act as a reliable catalyst for companies during challenging times. The impact of innovation culture, according to Rediyono and Ujianto (2013), includes: facing competition, surviving, and leading the market, improving sales performance, enhancing efficiency and speed of service, and meeting market demands. Moreover, the presence of innovation activities within a company leads to improved managerial performance over time. The implementation of the ISO 56002 innovation management system has the potential to enhance innovation within organizations.

The innovation management system consists of interconnected and interacting elements aimed at realizing value. It serves to develop and disseminate innovation capabilities, evaluate performance, and achieve desired outcomes. However, ISO 56002 has its limitations. The innovation system is too linear, as it still focuses on proposed products and systems, which makes it unable to address the inherent risks and uncertainties found in various forms of innovation, particularly in technology and startups (Tidd, 2021). There is also a lack of innovation tools, as the innovation standards do not prescribe how objectives should be achieved.

The diversity of management challenges and organizational contexts presents a difficulty in developing standardized tools that can be universally applied. Consequently, the focus shifts towards aligning useful tools with specific management challenges and organizational contexts, as opposed to providing universal solutions (Nurfidah et al., 2022). Due to the incompleteness of ISO 56002:2019, additional methodologies, such as LSS, are incorporated to complement it.

LSS is an effective methodology that has the potential to enhance process performance, increase customer satisfaction, and boost company revenue (Antony et al., 2016). It is also worth noting that LSS is not only a source of innovation but also a catalyst for innovation, making it complementary to the innovation process (Alblooshi et al., 2021). Although Lean Six Sigma (LSS) and innovation are distinct methodologies with some differences, they also have compatible foundations and shared goals in their efforts to create value for customers. Consequently, it is highly feasible and advantageous to integrate both approaches (Salah, 2017). The adoption of LSS is positively associated with improved process innovation performance within companies, as well as the overall market perception of innovation and corporate value. The nature of the relationship between LSS and innovation can vary significantly (Strong, 2018).

LITERATURE REVIEW

Implementation Context Based ISO 56002 and Lean Six Sigma

ISO 56002 provides a framework for assessing an organization's progress, while innovation entails implementing fresh concepts, technologies, services/products, processes, strategies, or business models to create additional value for both the organization and its customers (Nurfidah et al., 2022). The implementation phase is the central stage of the innovation process, where inputs, strategies, ideas, and resources all have important roles to play. The ultimate result is the development of a product and the preparation of a market for its release (Tidd, 2021). It is crucial to swiftly fulfill the strategic assumptions related to the product and its market. This stage demands a significant investment of time and cost, and entails problem-solving activities within the realms of technology and the market. Various organizational functions such as R&D, Marketing, Production, Customer Support, Procurement, Sales, and Quality demand intense efforts and cross-functional coordination. The challenge lies in transforming ideas into successful products, which involves gradually reducing uncertainty through activities like searching, selecting, experimenting, and problem-solving. The concept of the "development funnel" effectively represents the vision of this process (Wheelwright & Clark, 1992). According to Tidd and Bessant (2018), innovation is driven by the ability to identify connections, seize opportunities, and capitalize on existing possibilities. It goes beyond simply entering new markets and can also provide fresh approaches to established processes. Innovation extends beyond product manufacturing; there are numerous examples of growth through innovation in service-oriented businesses. Being innovative is consistently associated with success, as companies that innovate tend to experience better growth and achievements. Companies that gain market share and enhance profitability are typically the ones that embrace innovation. ISO 56002 has been shown to have a significant impact on fostering, managing, and sustaining innovation (Supriadi, 2017). The successful implementation of an innovation management system depends on top management's commitment and their ability to cultivate a culture that supports innovative capabilities. The Plan-Do-Check-Act (PDCA) cycle can be utilized in innovation management to facilitate continuous improvement of the innovation management system. The organization ensures that it supports innovation initiatives and processes, effectively utilizes resources, and identifies and addresses potential opportunities and risks. In its implementation, ISO 56002 highlights three crucial components, namely Resources (subclause 7.1).

Resources Based ISO 56002

Having sufficient resources is a vital factor in supporting innovation, as a lack of resources can present significant challenges for teams and hinder their ability to complete innovation projects. The allocation of resources, including human resources, facilities, and funds, is crucial for effective communication of information, the establishment of regulations for consultation, and active worker participation. The importance of company-level resources, such as financial resources, in driving innovation has been widely recognized in organizational literature (Bierly et al., 2009). This study incorporates various indicators to measure resources, including human resources, financial resources, time resources, knowledge resources, and infrastructure resources.

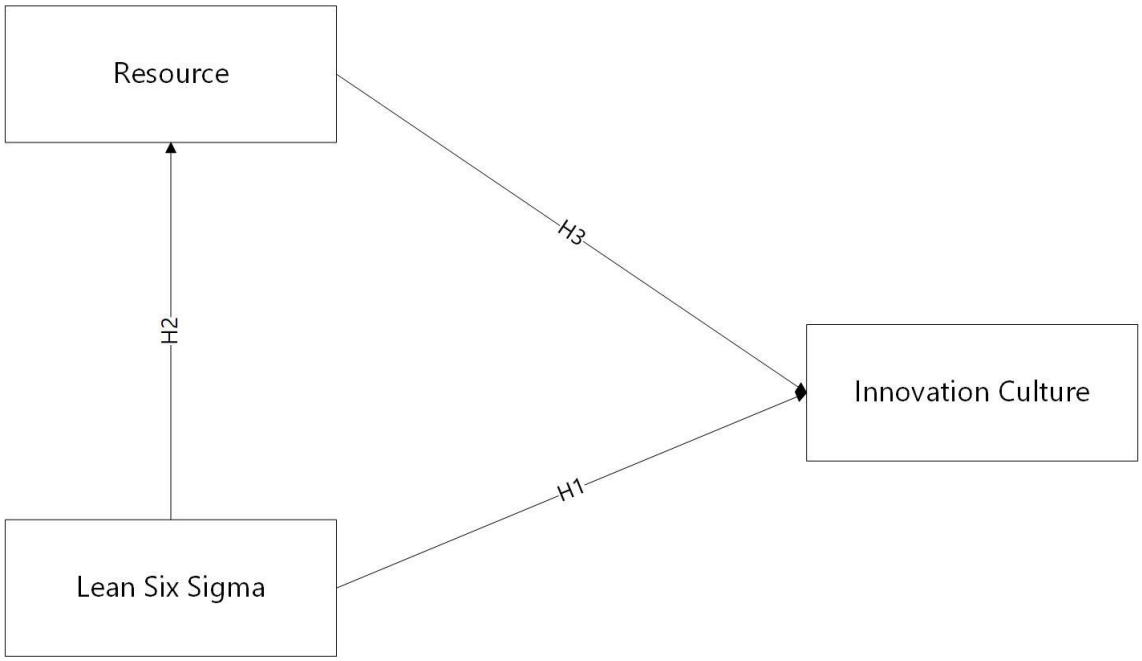
Lean Six Sigma

According to Sunder (2016), supplier selection is one of the main activities in procurement. Without adequate methods for selecting the most suitable supplier, the performance of the entire project may be affected, including the organization's innovation supplier selection is one of the primary activities in the procurement field. Without adequate criteria and the right method to select the most suitable supplier, the performance of the entire project may be affected, including the organization's innovation (Chen & Huang, 2009). According to Snee (2010), Lean Six Sigma (LSS) serves as both a sustainable development methodology and a business strategy that enhances process performance by improving key performance metrics, thereby impacting overall results. The principles of Lean Management can be utilized in advanced manufacturing processes, such as Industry 4.0, resulting in numerous benefits including improved quality and waste reduction (Villalba-Díez et al., 2020) The interconnectedness of technology in Industry 4.0 enables greater production autonomy, with machines having the ability to influence one another. Lack of understanding and knowledge about the products being produced often leads to errors in the production process, resulting in product failure. This procedure delegates the certification process and provides similar incentives for organizations to build, highlight, and market their own successful innovation portfolios. The innovation process is inseparable from the commitment of all components within the company, which is called organizational commitment. The implementation of this commitment describes how an employee feels ownership of the company (Tarigan, 2018). Ballard (2020) suggests that Target Value Delivery (TVD) overcomes obstacles to innovation by promoting shared risk and reward and setting challenging yet achievable delivery targets. TVD is proposed as a replacement for target costing (TC) because it represents an evolution of TC that emphasizes value rather than solely focusing on costs. Relevant aspects of target costing are adapted to align with the construction context. Software developers, academics, and project owners spearhead the integration of Building Information Modeling (BIM) into the innovation process in developing countries. The primary driving forces behind BIM innovation are clients and contractors. The advancements made in implementing BIM have the potential to shape stakeholder actions, address existing concerns, and equip them for future challenges (Jin et al., 2019). A framework that includes several propositions was proposed to guide future studies. The strategy of using lean management tools for organizations can foster creativity and enhance innovation capability. The indicators used in this study include (1) Utilization of Lean Management Tools; (2) IPD Supplier Selection Process; (3) Appropriate Technology; (4) Daily Commitment Management; (5) Target Value Delivery/TVD Implementation; and (6) Building Information Modelling/BIM Implementation.

Culture of Innovation Concept

Innovation is linked to concepts, procedures, or products that individuals identify as having novelty or originality (Ferdinan & Lindawati, 2021). The implementation of innovative work practices significantly and positively impacts organizational progress (Mendo, 2019). Companies recognize the importance of innovation as it can generate additional revenue through new products or services, as well as reduce costs or enhance the quality of existing processes (Khazanchi et al., 2007). Garcia and Calantone (2002) suggest that innovation is driven by the organization's willingness and ability to innovate, with motives stemming from both internal and external factors. Internal factors include factors such as shareholder orientation, financial considerations, quality, speed and efficiency, and industry leadership. External factors include customer orientation and competition (Soosay & Hyland, 2004). To foster innovation, organizations must effectively manage their resources and skills, with the quality of human resources having a positive impact on technology adoption (Lin & Chen, 2006).

Figure 1. **Hypothesis Lean Six Sigma on Resources to innovation Culture**



The Influence of Lean Six Sigma on Innovation Culture

According to Möldner et al. (2020), Taherdoost & Brard (2019), and Malvik et al. (2021), LSS has a positive influence on innovation culture within a company. By implementing LSS, companies can create value and improve business performance, as well as bottom-line performance. The LSS methodology combines the Lean approach, which focuses on waste reduction and standardization improvement, with the Six Sigma approach, which focuses on process variation reduction and process control improvement. By combining these two approaches, companies can achieve positive outcomes in process improvement and foster an innovation culture.

H1: Lean Six Sigma influence on innovation culture.

The Influence of Lean Six Sigma on Resource for Innovation
According to Wahyudi (2020), LSS has a positive influence on resources for innovation within a company. By implementing LSS, companies can identify and eliminate unnecessary waste in business processes, allowing resources to be efficiently allocated for innovation activities. The LSS approach also helps companies improve product or service quality, providing added value to customers and enhancing the company's competitiveness in the market.

H2: LSS influence on resource.

The Influence of Resource on Innovation Culture
According to Möldner et al. (2020) and Taherdoost & Brard (2019), adequate resource availability has a significant influence on innovation culture within an organization. With sufficient resources, companies can allocate the necessary time, energy, and budget to develop new ideas, conduct research and development, and implement innovations. Employees feel supported and motivated to think creatively, take risks, and try new things, creating an environment that nurtures innovation growth within the company.

H3: Resource influence on innovation culture.

RESEARCH METHOD

The quantitative analysis technique was used. A questionnaire was conducted on 54 respondents who work in precast concrete companies in Indonesia. Job analysis and experience were also taken into account, as well as their highest education level, resulting in the following respondent data.

Table 1. Respondent Criteria

Category	Description	Frequency	Percentage
Position	Director	6	11.1 %
	Manager	18	33.3 %
	Engineer	11	20.3 %
	Staff	19	35.3 %
Experience	< 5 Years	11	20.4 %
	5 – 10 Years	20	37 %
	10 – 15 Years	9	16.6 %
	> 15 Years	14	26 %

The study involved utilizing a sample of employees from a precast concrete company in Indonesia as research subjects. The data collected through a questionnaire was then analyzed using Structural Equation Modeling with Partial Least Squares (SEM-PLS). A total of 54 samples were included in the study. Chin (2000) suggests that the minimum sample size for PLS-SEM ranges from 30 to 100. In this particular case, it can be noted that the minimum sample size required for PLS-SEM is smaller compared to SEM.

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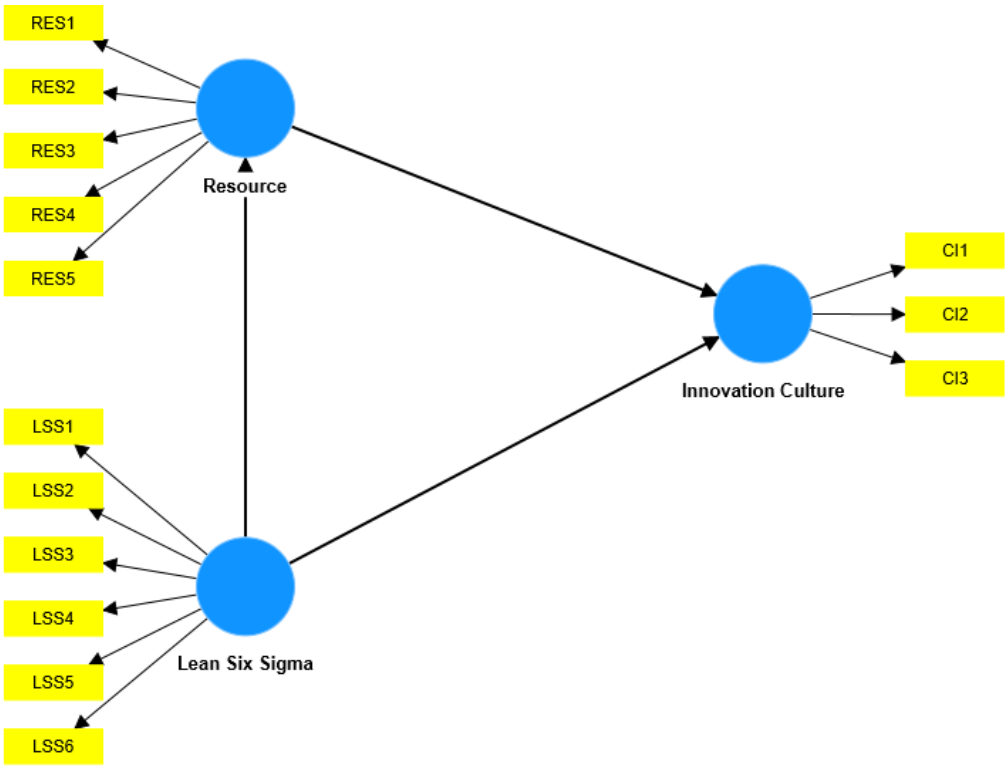
RESULTS

Figure 2. SEM-PLS Model



Evaluation of Measurement Model

In this study, the Measurement Model incorporates both reflective and formative measurement models. The variables related to resources and LSS are measured reflectively, while the variable of innovation culture is measured formatively. According to Hair et al. (2021), the assessment of the measurement model considers criteria such as loading factors greater than 0.70 (although > 0.6 is still acceptable), Cronbach Alpha greater than 0.70, and average variance extracted (AVE) greater than 0.5. Additionally, the model is evaluated for discriminant validity using criteria like Fornell and Larcker's criteria and HTMT (Heterotrait – Monotrait Ratio) below 0.90. The formative evaluation examines the significance of the outer weights and ensures that there is no multicollinearity among the measurement systems, as indicated by the outer VIF below 5.

Table 2. Outer Loading, Cronbach Alpha, AVE

Variable	Measurement Item	Indicator	Outer Loading	Cronbach Alpha	AVE
LSS	LSS1	Utilization of Lean Management	0.770	0.812	0.563
	LSS2	IPD Supplier Selection	0.771		
	LSS3	Appropriate Technology	0.741		
	LSS4	Daily Commitment Management	0.682		
	LSS5	Target Value Delivery Implementing	0.744		

	LSS6	Building Information Modelling Implementation	0.733		
Resources	RES1	Human	0.726	0.700	0.579
	RES2	Financial	0.804		
	RES3	Time	0.788		
	RES4	Knowledge	0.719		
	RES5	Infrastructure	0.711		

The LSS and resource have 6 and 5 measurement items in building an innovation culture. All measurement items have loading factors between 0.682 – 0.863, indicating that all measurement items are valid. The LSS variable has a reliability level indicated by Cronbach's alpha of 0.812 > 0.70 and AVE of 0.563 > 0.5. The resource variable has a Cronbach's alpha of 0.740 > 0.70 and AVE of 0.579 > 0.5. It can be confirmed that all variables in building an innovation culture are valid variables.

Table 3. Fornell and Lecker

Variable	Lean Six Sigma	Resources
Lean Six Sigma	0.761	
Resources	0.597	0.751

The Fornell and Larcker criteria are employed to assess the discriminant validity. This criterion ensures that variables are conceptually distinct and supported by empirical or statistical evidence. According to the Fornell and Larcker criteria, the square root of the Average Variance Extracted (AVE) for a variable should exceed the correlation between that variable and others. In the present study, the AVE for the LSS variable is 0.761, surpassing its correlation with Organizational Management (0.748) and Resources (0.751). These findings demonstrate that the variables are indeed distinct and provide support for their discriminant validity. Variables meet the criteria for discriminant validity, as well as the other variables in the study.

Table 4. HTMT (Heterotrait-Monotrait) Ratio

Variable	Culture of Innovation	Lean Six Sigma	Resources
Lean Six Sigma	0.690		
Resources	0.136	0.746	

Hair et al. (2021) suggests using the Heterotrait-Monotrait Ratio (HTMT) as a discriminant validity measure, as it is considered to be more sensitive and accurate in detecting discriminant validity. The recommended threshold is below 0.90. The test results in this study indicate that the HTMT values for the variable pairs are below 0.90, confirming the achievement of discriminant validity. This means that the variables exhibit stronger variations in the measurement items that measure them compared to the measurement items of other variables.

Table 5. Inner VIF

Variable	Culture of Innovation	Resources
Lean Six Sigma	2.613	1.000
Resources	2.604	

Before proceeding with hypothesis testing, it is important to check for multicollinearity between variables in the structural model using the inner Variance Inflation Factor (VIF) statistic. The estimation results reveal that the inner VIF value is < 5, suggesting a low level of multicollinearity between the variables. This further reinforces the robustness and unbiased nature of the estimation results for the SEM-PLS parameters.

Evaluation of Structural Model

Table 6. R Square Test

Variable	R-square	R-square Adjusted	Level
Culture of Innovation	0.563	0.527	Medium to High
Resources	0.357	0.344	Low to Medium

Note: R^2 < 0.25 (low), < 0.50 (medium), < 0.75 (high) (hair et al, 2019).

Based on the processing results mentioned above, it can be concluded that LSS and Innovation Culture have a medium to high influence of 52.7%. Additionally, the influence of LSS on Organizational Management is also medium to high, at 66.9%. Similarly, LSS has a medium to high influence of 72.3% on innovative processes. However, when it comes to resource availability, the influence of LSS is relatively low to medium, at 34.4%.

Table 7. Q Square Test

Variable	Q Square	Level
Culture of Innovation	0.385	Medium
Resources	0.144	Low

Note: q^2 = 0 (low), < 0.25 (medium), < 0.50 (high) (hair et al, 2019).

Based on the processing results, the Q-square values for resource variable is 0.144 > 0.144 (low prediction accuracy), and for innovation culture variable is 0.385 > 0.25 (medium prediction accuracy).

Table 8. SRMR

	Saturated Model	Estimated Model
SRMR	0.095	0.095

SRMR stands for Standardized Root Mean Square Residual. This value is a measure of fit (model fit), which is the difference between the correlation matrix of the data and the correlation matrix of the estimated model. An SRMR value between 0.08-0.10 indicates an acceptable fit. The estimated model result is 0.095, which means that the model has an acceptable fit.

Table 9. Hypothesis Analyze

	Original Sample (O)	Sample Mean (M)	Standard Deviation	T Statistics	P Values
Lean Six Sigma -> Culture Innovation	0.539	0.554	0.144	3.74	0
Lean Six Sigma -> Resources	-0.597	-0.611	0.087	6.851	0
Resources -> Culture of Innovation	0.474	0.482	0.141	3.37	0.001

DISCUSSION

Lean Six Sigma Influence Innovation Culture

The first hypothesis (H1) is accepted, indicating a significant influence between LSS and innovation culture (p-value = 0.000) with a positive coefficient, indicating a positive relationship. This means that the higher the implementation of LSS, the better the innovation culture. This finding is consistent with the research conducted by Malvik et al. (2021), which states that LSS influences innovation culture by promoting continuous improvement, data-driven decision making, structured problem-solving, cross-functional collaboration, and standardization, all of which contribute to fostering an innovation culture within an organization. The LSS methodology encourages employees to continuously seek new ways to improve efficiency, quality, and production processes. This stimulates teams to think more creatively and innovate in finding better solutions. LSS emphasizes the importance of understanding and meeting customer needs. By implementing this methodology, precast concrete companies proactively seek feedback from customers and use this information to improve their products and services. This helps companies develop more innovative and market-relevant products.

Lean Six Sigma Influence Resources

The second hypothesis (H2) is accepted, which means there is a significant influence of LSS on resources based on the p-value (0.000 < 0.05) with a negative coefficient, indicating an inverse relationship. This implies that the higher the implementation of LSS, the less resources are available for innovation, as LSS aims to optimize resource utilization for innovation. This result supports the findings of Wirasasmita and Hendriawan (2020) that LSS can minimize resources in fostering an innovation culture. By minimizing resources in innovation, overall efficiency of activities can be achieved. By optimizing the use of raw materials, labor, and equipment, it is possible to improve the efficiency of precast concrete production. For example, by redesigning the factory layout or utilizing more efficient technologies. By implementing LSS, precast concrete companies can develop a culture that encourages innovative thinking. The LSS approach involves close teamwork between various departments and organizational levels. This fosters better collaboration among employees with diverse backgrounds, knowledge, and skills. This collaboration allows for the exchange of ideas, collective problem-solving, and increased innovation.

Resources Influence Innovation Culture

The third hypothesis (H3) has been accepted, indicating a significant impact of resource availability on the innovation culture. This is supported by a p-value of 0.001, indicating that it is less than 0.05, and a positive p-coefficient, which suggests a positive relationship. Essentially, the study found that organizations with better resource availability exhibit a stronger innovation culture. This finding is consistent with previous research conducted by Kim et al. (2005), which emphasized the substantial influence of resource allocation on fostering an innovation culture. Factors such as adequate financial resources, a skilled workforce, time and flexibility, infrastructure and technology, and organizational support and leadership all play pivotal roles in nurturing an innovation culture. Sufficient resources allow companies to conduct experiments, test innovations, and create an environment that encourages employees to explore new ideas, implement innovation projects, and learn from their experiences. In this culture, mistakes are viewed as opportunities for learning and improvement. By providing ample resources such as time, funds, and facilities, companies can inspire their employees to think creatively and develop fresh concepts. In an innovative culture, employees feel supported to take risks and embrace new endeavors without the fear of failure.

CONCLUSION

Based on the conducted research, it is evident that LSS has an impact on all aspects of the resource context for innovation, as per ISO 56002 innovation management, in building an innovation culture. The establishment of an innovation culture is expected to have a positive influence on the overall innovation management within the company, enabling it to effectively compete with its competitors. The presence of LSS is anticipated to enhance the efficiency of all innovation processes while aligning with the company's vision. The aspects identified in this research can serve as a foundation for future studies in this area. The implementation of LSS in the precast concrete industry has several significant impacts. By using the Lean approach, it can identify and reduce resource wastage in the precast concrete production process, such as excess inventory, inefficient material movement, or wasted time. This can reduce the risk of structural failure and improve customer satisfaction. With the combination of LSS, the precast concrete industry can enhance their efficiency, quality, and product reliability.

LIMITATION

This research still uses LSS in general as a supporting indicator for its innovation management system. Future research could connect each indicator of LSS to the existing innovation management system. Focusing on company resources may overlook a deep understanding of customer needs and preferences. While adequate resources are important, it is also crucial to align efforts with customer needs in order to provide significant added value. At this way, the research results could be more specific about the impact of LSS on innovation management. LSS research that solely focuses on company resources may place too much emphasis on efficiency without considering the potentially more important aspects of effectiveness in achieving business goals. Adequate resources are one aspect, but it is also important to consider how those resources are used in the most effective manner. The broad scope of LSS still leaves many gaps in this research, such as its impact on the final product, market, leadership, and more. Future research is expected to take a broader look at LSS on the precast concrete company.

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DECLARATION OF CONFLICTING INTERESTS

The authors declared no potential conflicts of interest.

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