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The Development of the Lean Six Sigma Readiness Assessment Model for the Hotel Sector

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ABSTRACT

Lean Six Sigma (LSS) implementation still shows a high failure rate. Lack of readiness is one of the causes. Readiness assessment requires special exploration of each sector, including the hotel sector, where there is still no development of an LSS readiness assessment model. This study aims to develop a readiness assessment model for LSS implementation in the hotel sector. Data processing in the readiness assessment model uses the fuzzy logic method, is translated again into linguistic terms using Euclidean distance, and is ranked using the TOPSIS approach. The literature review produced 34 Readiness Factors (RF) that were validated by eight credible hotel practitioners and used as guidelines in conducting LSS readiness assessments in the hotel sector. Case studies were conducted on Hotel A and Hotel B, which showed that Hotel A was “Very Ready” and Hotel B was “Ready” to implement LSS. This research is perhaps the first of its kind in the hotel sector. This research also uses the Delphi method to collect data on the importance level, which may not have been done in collecting data on LSS readiness in any sector.

KEYWORDS

Lean six sigma; readiness; fuzzy logic; Euclidean distance; TOPSIS; Hotel

Introduction

Lean Six Sigma (LSS) is widely recognized as a business strategy for implementing Continuous Improvement (CI) in both manufacturing and service companies (S. A. Albliwi et al., 2015; Antony et al., 2017; Tampubolon & Purba, 2021). The term LSS was introduced around the 2000s, where LSS talks about integrating both quality improvement methods, namely Lean Manufacturing and Six Sigma (Sheridan, 2000). The main focus of LSS is to improve quality and productivity in business (Singh & Rath, 2019). LSS has been widely applied in service companies and has shown a lot of success, although the application of LSS originated from manufacturing companies (Sunder et al., 2018). Some examples of the application of LSS in service companies and its success are in Norwegian healthcare, where LSS is used to solve problems in the medication process, resulting in a reduction of

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medication errors (Antony et al., 2019). Another example is demonstrated by Haerizadeh and Sunder (2019), who showed the ability of LSS to improve the educational system at a university in Iran, improving student satisfaction levels and the overall grade by 10%; they also reduced wait times for communication with students by 15% and increased tuition by 5%.

However, although many companies have successfully implemented LSS, many have been unsuccessful (Sreedharan et al., 2018. Sony et al., 2019) showed that out of 15 LSS projects conducted, three projects were successful, which is only 20% success. S. Albliwi et al. (2014) state that approximately 70% of LSS improvement projects fail, which is considered a high failure rate. Moreover, it is stated that about 70% of the LSS implementation failures are due to the fact that the organization is not ready for the application of the project (Antony et al., 2020; Leite et al., 2020). Some previous studies also discuss the importance of the readiness aspect and agree that being ready for LSS implementation is a prerequisite to the successful implementation of LSS projects (Garza-Reyes et al., 2015). Assessment of readiness for implementing LSS has been carried out in previous research on several company sectors, in manufacturing (Sreedharan et al., 2019), higher education (Antony & Thomson, 2020), and healthcare (Narayanamurthy et al., 2018, Vaishnavi & Suresh, 2020). Previous research mentions the need for specific exploration for readiness assessment for each sector. To the authors' knowledge, an assessment evaluation readiness of LSS implementation in the hotel sector has not been found.

The hotel sector has a lot of pressure to continuously improve quality and reduce costs (Molina-Azorin et al., 2015; Rauch et al., 2015; Tsang et al., 2015). *Economic Impact Reports* (2023), based on data from 185 countries, show that the tourism industry, including the hotel sector, still lost 37% of GDP in 2019 and 13% of total jobs in 2019. One of the main causes of this leading COVID-19 pandemic has an impact on almost all sectors, especially the hotel sector. Several studies have tried to apply the principle of Continuous Improvement as a method for answering hotel challenges, one of which is LSS (Molina-Azorin et al., 2015; Rauch et al., 2015; Tsang et al., 2015). However, like other service companies, transactions in the hotel industry are intangible, heterogeneous, and perishable (Fiala & Thirumaran, 2021; Stefano et al., 2020)). In the manufacturing sector, process engineers can quickly reorganize a few worktables to shorten processing times and boost output. However, improving service procedures is more difficult because the service industry relies heavily on humans. It is necessary to consider soft elements, such as employee moods, the behaviors, and actions that follow from them. The process of enhancing services also needs to be carefully considered because there are no defined procedures in place (Fiala & Thirumaran, 2021). Thus, the application of LSS in service companies becomes more complex and subjective than its application in manufacturing companies. In response to these challenges, hotel

businesses need to assess readiness before implementing LSS (Garza-Reyes et al., 2015). For these reasons, this research focuses on creating a readiness assessment model specific to the hotel sector. Specifically, the first reason is that LSS needs readiness before implementation; the second is that sector-specific readiness is required; and the third is the need for successful implementation of LSS in the hotel industry.

Literature review

LSS implementation and readiness

The term LSS was invented around the 2000s. LSS talks about the integration of both quality improvement methods, namely lean manufacturing and six sigma. LSS increases the focus on lean manufacturing approaches with less emphasis on the need for statistical analysis that is usually included in the methodology (Sheridan, 2000). The implementation of LSS has shown much success both in manufacturing companies and in service companies (S. Albliwi et al., 2014; Sunder et al., 2018). However, although many companies have successfully implemented LSS, many have not (Sreedharan et al., 2019). Sony et al. (2019) showed that out of 15 LSS projects conducted, only 3 were successful, which is only 20% success. S. Albliwi et al. (2014) state that approximately 70% of LSS improvement projects fail, which is considered a high failure rate. Moreover, it is stated that about 70% of the LSS implementation failures are due to the fact that the organization is not ready for the application of the project (Antony et al., 2020; Leite et al., 2020). Some previous studies also discussed the importance of the readiness aspect and agreed that being ready for LSS implementation is a prerequisite for successful implementation (Antony, 2014; Garza-Reyes et al., 2015). Table 1 shows a list of literature about readiness in the application of LSS that many previous studies have conducted, but so far there has been no readiness research in the application of LSS to the hotel sector.

In 2020, the world faced a COVID-19 pandemic that impacted all business sectors, especially tourism. Data revealed by the *Economic Impact Reports* (2023) showed that the tourism sector in 185 countries, including the hotel sector, suffered a 49% loss compared to 2019. In 2020, 62 million people lost their jobs. The hotel sector has a lot of pressure to continuously increase

Table 1. Literature review LSS readiness.

Sector	Author(s)
Education	Antony (2014); Douglas et al. (2017)
Healthcare	Weiner et al. (2008); Radnor (2011); Al-Balushi et al. (2014); Narayanamurthy et al. (2018); Al-Najem et al. (2019); Vaishnavi and Suresh (2020); Vaishnavi and Suresh (2021)
Manufactur	Al-Najem et al. (2013); Gurumurthy et al. (2013); Garza-Reyes et al. (2015); Shokri et al. (2016); Sreedharan et al. (2019); Shokri et al. (2021)

profits by improving quality and reducing costs (Molina-Azorin et al., 2015; Rauch et al., 2015; Tsang et al., 2015).

LSS in hotel industry

LSS readiness

Readiness factors (RF) in sector hotels. The Readiness Factor (RF) was determined by conducting a literature review related to the application of LSS, especially in the Hotel sector, according to Figure 1. Literature was obtained from several databases, such as Emerald, Springer, Wiley, Taylor & Francis, and Science Direct. Determination of RF by looking at Critical Success Factors (CSF), Critical Failure Factors (CFF), and other RF that are important variables in the process. RF are also obtained from respondents who are competent and experienced in the hotel sector, as well as from respondents to validate RF from the results of the literature review.

The total literature review conducted included 29 articles hotel. The most common sector for which literature reviews are carried out is the hotel sector, with a total of 15 literature reviews, or 52% of the total literature reviewed. The first RF collection from the review results amounted to 228 RF related to hotel readiness for implementing LSS. The initial data was reviewed several times,

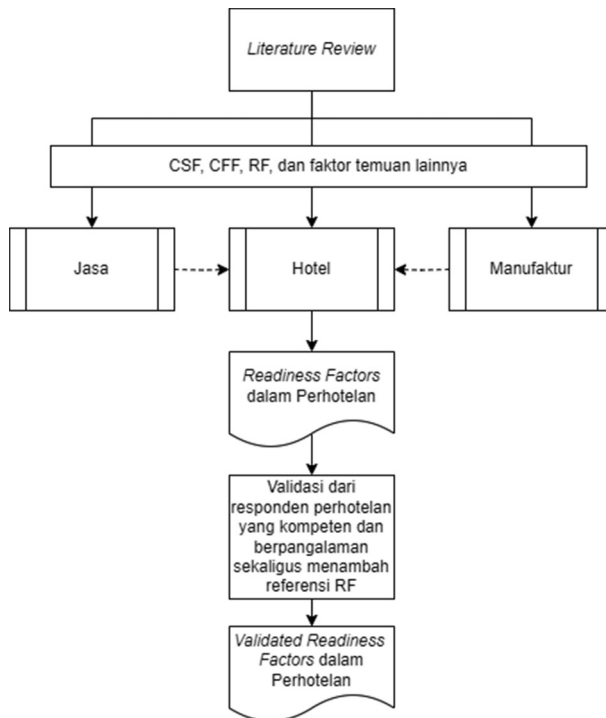


Figure 1. Readiness factor determination flowchart.

eliminated for similar factors, selected for the most factors taken as references from several other literatures, and approved via the Delphi method by eight hotel industry professionals and specialists, the majority of whom hold director and general manager roles and have over nine years of experience in the industry, resulting in total of 34 RF. Table 2 shows the list of RF from the literature review, and Table 3 shows the visualization of RF based on their literature references. RF is divided into five categories: customer focus, employee engagement, LSS Implementation, Supplier Management, and Top Management and Leadership.

Fuzzy logic

In order to depict the processing of non-statistical uncertainty data and information, L. Zadeh (1965) originally created fuzzy logic. Fuzzy techniques help in overcoming data that has the nature of imprecision, vagueness, partial truth, or many possibilities simultaneously (L. Zadeh, 1965; L. A. Zadeh, 2015). Antony (2014) stated that the subjective nature of most LSS readiness assessments leads to imprecision and vagueness in decision-making for practitioners. Fuzzy logic has been used in evaluating the best choice in decision-making, such as readiness level and assessment index (Sreedharan et al., 2019; Vaishnavi & Suresh, 2020). Therefore, the application of fuzzy logic has proven to be effective in handling ambiguous and somewhat vague information in an assessment.

Linguistic terms, scale, and fuzzy numbers need to be determined. Linguistic terms are the answer options for each question. Linguistic terms for readiness level are very ready (SSP), ready (SIP), somewhat ready (ASP), neutral (NES), somewhat unready (ATS), not ready (TSP), and very unready (STS). Meanwhile, linguistic terms for the level of importance are very Important (SPT), important (PTG), somewhat important (APT), neutral (NEP), somewhat unimportant (ATP), unimportant (TPT), and very unimportant (STP). The linguistic scale for readiness level is 0.00–10.00, while for importance level it is 0.00–1.00, with a fuzzy number shown in Table 4 (Narayanamurthy et al., 2018).

Methods

LSS readiness assessment model in the hotel sector

The LSS readiness assessment model in the hotel sector begins with hotel respondents filling in hotel readiness questionnaire data. The results of filling in the processed data are first translated into triangular fuzzy, then the readiness level calculation is carried out using Equation (1) along with the level of importance data determined by hotel practitioners and becomes the basis for the level of

Table 2. Lists of readiness factors.

ID	Category	Readiness Factor	Description
RF1.1	Customer Focus	Customer satisfaction has a major impact	The hotel bases its strategy on the idea that the "Customer Satisfaction" indicator has a significant impact on the establishment.
RF1.2	Customer Focus	Customer satisfaction survey	In order for the hotel to concentrate on enhancing the caliber of hotel services, customer satisfaction surveys are periodically done to examine and establish client wants.
RF1.3	Customer Focus	LSS improves service quality	LSS was adopted at the hotel with the intention of raising the standard of service.
RF1.4	Customer Focus	Customer's needs	The hotel is aware of its clients' particular needs, allowing it to tailor its services to meet those needs.
RF1.5	Customer Focus	The chance for customers to voice their opinions	Customers have the option to offer comments and ideas, and the hotel will pay attention to them and take the relevant action.
RF2.1	Employee engagement	a secure work environment	Employees can work peacefully in a secure setting at the hotel.
RF2.2	Employee engagement	Employee's commitment	Employees are dedicated to the hotel's success and to implementing LSS.
RF2.3	Employee engagement	Employees have the chance to voice their opinions	Employees are given the chance to offer comments and recommendations.
RF2.4	Employee engagement	Employees are receptive to change	Changes are easily accepted by employees because of the positive environment and circumstances.
RF2.5	Employee engagement	Promotions and bonuses	Promotions and bonuses are provided to workers in accordance with their performance.
RF2.6	Employee engagement	Employees actively improve the quality of the company	Employees actively participate in actions that increase quality.
RF2.7	Employee engagement	LSS knowledge	Employees comprehend the idea, intent, implications, and use of LSS
RF2.8	Employee engagement	Employee's training	Employees receive regular training, particularly in the area of quality improvement.
RF3.1	LSS Implementation	Detailed LSS implementation strategy	The hotel makes comprehensive and detailed plans for the process of implementing LSS, including the length of the project, the number of projects that must be finished, the number of staff needed, and the type of training that must be done.
RF3.2	LSS Implementation	Project LSS based on ROI	Choosing a LSS project based on return on investment
RF3.3	LSS Implementation	LSS Ad Hoc Team	The hotel created an ad hoc LSS team with members from several departments, a range of skills, a focus on the customer, and an understanding of how to use LSS.
RF3.4	LSS Implementation	Waste reduction	Regular review or other quality improvement activities are used in the work process to decrease waste.
RF3.5	LSS Implementation	Change initiative	Customer, supplier, and employee needs and expectations are what motivate change initiatives and LSS implementation.
RF3.6	LSS Implementation	Quality Culture	The hotel has a quality culture that is understood and practiced by employees.
RF3.7	LSS Implementation	Regular LSS meeting	LSS meetings are held regularly with all employees or related employees to discuss everything related to LSS, including the progress of its implementation.
RF3.8	LSS Implementation	Experience of change	Employees can be better prepared for the new LSS deployment in the hotel because the hotel has past experience with change. The implementation plan can be improved to better prepare for the effective deployment of LSS, and mistakes made during the implementation of prior modifications can be learnt from and avoided.
RF4.1	Supplier = management	Cooperation with suppliers	In order for suppliers to deliver high-quality goods and services, hotels and suppliers maintain a healthy working relationship.

(Continued)

Table 2. (Continued).

ID	Category	Readiness Factor	Description
RF4.2	Supplier management	Evaluation of suppliers	Clearly defined and routinely carried out supplier evaluation procedures for quality, delivery, and cost
RF4.3	Supplier management	Supplier financial support	Without placing an undue burden on the suppliers, financial help is given to them for the fast payment system and continuing supply of essential products.
RF4.4	Supplier management	The chance for supplier to voice their opinions	Suppliers are given the opportunity to provide feedback and suggestions for the hotel.
RF4.5	Supplier management	Training supplier	To enable them to deliver goods and services that satisfy the needs of the hotel, suppliers are trained.
RF5.1	Top management and leadership	LSS-savvy management	In order for the implementation and goals of LSS to be in accordance with the business plan, hotel management must have a thorough awareness of the culture, concepts, and application of LSS as well as its methods for reaching profitable goals for the hotel.
RF5.2	Top management and leadership	LSS is in line with the company's vision and mission	The objectives and tactics for putting LSS into practice are consistent with and support the hotel's vision and mission.
RF5.3	Top management and leadership	Management support to employees	Employees receive guidance, support, and encouragement from management.
RF5.4	Top management and leadership	Leadership skills	Management has good leadership skills.
RF5.5	Top management and leadership	Management and employee communication	Management and staff have open lines of communication so that both parties are aware of the situation at the hotel and its direction as well as the demands of the staff.
RF5.6	Top management and leadership	Management Training	Management often undergoes training in order to enhance their leadership skills and knowledge of how to improve hotel quality.
RF5.7	Top management and leadership	Change resources	own the resources to carry out improvements, such as implementing LSS in the hotel.
RF5.8	Top management and leadership	Management commitment	The management is dedicated to putting LSS into practice.

importance in Indonesian hotels. The next process is the calculation of HLSRI Total, HLSRI Sub-category RF, and HLSRI Category RF using Equation (2). HLSRI Total is translated into Linguistic Terms using Euclidean Distance according to Equation (3) to determine the status of hotel readiness for implementing LSS. Sub-category RF and Category RF are ranked using TOPSIS by computing fuzzy positive ideal solution (FPIS) and fuzzy negative ideal solution (FNIS) using Equations (4) and (5), then adding the result to Equation 6 for TOPSIS. The output of the model is that the hotel knows the status of LSS readiness and the ranking of sub-category RF and category RF in the hotel.

Results

Data collection on the level of importance

Each RF has a different level of importance. The importance weight is obtained by collecting data from hotel practitioners while validating each RF. There

Table 3. List of references for the readiness factor.

Literature	1.1	1.2	1.3	1.4	1.5	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	4.1	4.2	4.3	4.4	4.5	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	
Kokkranikal et al. (2012)	v	v		v										v		v					v						v							v	
Viada-Stenger et al. (2010)	v			v											v					v		v	v	v								v	v		
Baldacchino (1995)																																			
Vaishnavi & Suresh (2020)	v			v		v				v				v	v	v	v					v					v					v	v	v	
Sreedharan et al. (2019)		v		v		v	v			v	v		v	v					v								v					v	v		
Chelangat (2010)				v	v	v		v		v			v	v	v																			v	
Zhang et al. (2012)					v	v								v																				v	
Doolen & Hacker (2005)						v		v																			v								v
Harrington & Keating (2006)	v			v													v			v															
Jeyaraman & Kee Teo (2010)	v				v	v	v									v												v							v
Vinodh & Chintha (2011)											v	v																v							
Coronado & Antony (2002)	v	v	v	v		v				v			v	v	v																	v			v
Getty's & Getty (2003)																		v																	
Arasli (2012)					v	v		v	v									v										v							v
Al-Balushi et al. (2014)			v			v																													

(Continued)

(Continued)

Table 4. Linguistic variables & fuzzy numbers (Narayanamurthy et al., 2018).

Linguistic Variable	Fuzzy Numbers		
Readiness			
Very Ready (SSP)	7.00	8.00	9.00
Ready (SIP)	6.00	7.00	8.00
Somewhat Ready (ASP)	5.00	6.00	7.00
Neutral (NES)	4.00	5.00	6.00
Somewhat Unready (ATS)	3.00	4.00	5.00
Not Ready (TSP)	2.00	3.00	4.00
Very Unready (STS)	1.00	2.00	3.00
Importance			
Very Important (SPT)	0.85	0.95	1.00
Important (PTG)	0.70	0.80	0.90
Somewhat Important (APT)	0.50	0.65	0.80
Neutral (NEP)	0.30	0.50	0.70
Somewhat Unimportant (ATP)	0.20	0.35	0.50
Not Important (TPT)	0.10	0.20	0.30
Very Unimportant (STP)	0.00	0.05	0.15

were 13 hotel practitioners selected, but only 8 were willing to serve as resource persons in determining the importance of each RF. The selected practitioners have positions mostly between General Manager (37.5%) and Director (37.5%) with work experience in the hotel sector, mostly more than 9 years (95%). The hotel workplaces of the practitioners are in Surabaya (50%), Jakarta (37.5%), and Bali (12.5%), which are mostly five-star hotels (75%). Data is collected using the Delphi method, where practitioners are given questions in two stages according to their agreement. The results of Stage 1 will be shared with practitioners, who were allowed to change their answers in Stage 2 based on the results that have been known in Stage 1.

Table 5 shows the fuzzy number from the questionnaire results for the level of importance. This fuzzy number is obtained by equalizing the questionnaire results with the determination of the fuzzy number of importance levels contained in Table 4 using an interpolation approach. Table 5 also shows that the three factors with the highest importance scores are RF1.1, RF1.2, and RF1.5. and the three factors with the lowest level of importance are RF2.7, RF3.2, and RF2.8. Table 6 shows the importance score of RF grouped into RF categories. Table 6 shows that the Customer Focus (RF1) category is the category with the highest importance score in the implementation of LSS and the LSS Implementation category (RF3) is the category with the lowest level of importance compared to other categories.

Case study A

The subject of case study A is a 4-star hotel in Surabaya that has been operating for more than 5 years and is one of the branches of a national network brand

Table 5. Level of importance based on the questionnaire results.

RF	Phase 1	Phase 2	%	RF	Phase 1	Phase 2	%
RF1.1	7.00	7.00	0.0%	RF3.5	5.66	5.58	1.4%
RF1.2	7.00	6.81	2.6%	RF3.6	6.24	6.17	1.0%
RF1.3	6.24	6.25	0.1%	RF3.7	5.35	5.22	2.5%
RF1.4	6.77	6.60	2.5%	RF3.8	6.35	6.28	1.1%
RF1.5	7.00	6.81	2.6%	RF4.1	6.05	5.97	1.4%
RF2.1	6.81	6.43	5.6%	RF4.2	6.31	6.28	0.6%
RF2.2	6.56	6.55	0.2%	RF4.3	5.93	5.88	0.8%
RF2.3	6.50	6.49	0.2%	RF4.4	5.67	5.68	0.2%
RF2.4	6.44	6.28	2.5%	RF4.5	5.83	5.84	0.2%
RF2.5	5.72	5.67	0.9%	RF5.1	5.96	5.89	1.2%
RF2.6	6.39	6.52	2.1%	RF5.2	6.41	6.36	0.7%
RF2.7	4.59	4.47	2.5%	RF5.3	6.38	6.32	0.9%
RF2.8	5.11	4.96	2.9%	RF5.4	6.44	6.38	0.9%
RF3.1	5.57	5.38	3.3%	RF5.5	6.69	6.67	0.3%
RF3.2	4.94	4.88	1.2%	RF5.6	6.43	6.39	0.6%
RF3.3	5.20	5.21	0.3%	RF5.7	5.52	5.44	1.5%
RF3.4	5.93	5.88	0.9%	RF5.8	6.10	6.17	1.1%

Table 6. Level of importance score based on RF category.

RF	Importance Score
RF1	6.70
RF5	6.20
RF4	5.93
RF2	5.92
RF3	5.58

that has been established for more than 20 years. Respondents are hotel employees with a minimum supervisory level who have more than 3 years of work experience. Readiness level data was collected using a questionnaire given to six respondents. Table 7 shows the level of readiness of one of the factors, namely RF2.3. Each answer from the respondents is converted into a fuzzy number according to what has been determined in Table 4. For instance, if the respondent's answer is "Very Ready," then the fuzzy number is (7, 8, 9), according to Table 4.

$$RL_{ecb} = R_{ecb} \times I_{ecb} \quad (1)$$

$$HLSRI_{ec} = \frac{\sum_{ec=1}^f (R_{ec}(\cdot) I_{ec})}{\sum_{ec=1}^f R_{ec}} \quad (2)$$

Table 7. A snapshot of case study A's readiness level based on the questionnaire results.

Sub-Category RF	Respondent	Readiness	FS1	FS2	FS3
RF2.3	A	SSP	7	8	9
RF2.3	B	SIP	6	7	8
RF2.3	C	SSP	7	8	9
RF2.3	D	SIP	6	7	8
RF2.3	E	SSP	7	8	9
RF2.3	F	ASP	5	6	7

Table 8 shows the readiness level of each sub-category RF obtained using Equation 1. RL_{ecb} is the readiness level of respondent b in sub-category RF c, which is in category RF e. R_{ecb} is the readiness score of respondent b is in sub-category RF c, which is in category RF e. I_{ecb} is the importance score of respondent b in sub-category RF c, which is in category RF e. Table 9 shows the overall HLSRI using Equation 2. $HLSRI_{ec}$ is hotel LSS readiness index from sub-category RF c, which is in category RF e. HLSRI for the study case A subjects are 6.59, 7.58, and 8.57.

HLSRI is calculated by Euclidean distance to translate the fuzzy number of HLSRI into linguistic terms, according to Table 4. The Euclidean distance

Table 8. Readiness level sub-category RF study case A.

Sub-Category RF	FS1	FS2	FS3	FP1	FP2	FP3	RL1	RL2	RL3
RF1.1	7.00	8.00	9.00	0.85	0.95	1.00	5.95	7.60	9.00
RF1.2	6.67	7.67	8.67	0.82	0.92	0.98	5.48	7.07	8.51
RF1.3	6.83	7.83	8.83	0.74	0.84	0.92	5.04	6.56	8.17
RF1.4	6.50	7.50	8.50	0.79	0.89	0.96	5.14	6.68	8.16
RF1.5	6.83	7.83	8.83	0.82	0.92	0.98	5.62	7.22	8.67
RF2.1	6.67	7.67	8.67	0.76	0.86	0.94	5.09	6.63	8.17
RF2.2	7.00	8.00	9.00	0.78	0.88	0.96	5.48	7.06	8.60
RF2.3	6.33	7.33	8.33	0.77	0.87	0.95	4.90	6.41	7.91
RF2.4	6.33	7.33	8.33	0.74	0.84	0.93	4.70	6.17	7.73
RF2.5	6.50	7.50	8.50	0.63	0.75	0.87	4.12	5.63	7.37
RF2.6	6.67	7.67	8.67	0.78	0.88	0.95	5.19	6.73	8.25
RF2.7	6.17	7.17	8.17	0.39	0.57	0.75	2.44	4.09	6.10
RF2.8	6.33	7.33	8.33	0.49	0.64	0.80	3.12	4.73	6.64
RF3.1	6.50	7.50	8.50	0.58	0.71	0.84	3.75	5.30	7.12
RF3.2	6.33	7.33	8.33	0.48	0.63	0.79	3.02	4.64	6.57
RF3.3	6.17	7.17	8.17	0.54	0.68	0.82	3.34	4.88	6.70
RF3.4	6.67	7.67	8.67	0.68	0.78	0.89	4.50	5.99	7.69
RF3.5	6.67	7.67	8.67	0.62	0.74	0.86	4.11	5.65	7.44
RF3.6	6.67	7.67	8.67	0.73	0.83	0.92	4.84	6.33	7.95
RF3.7	6.17	7.17	8.17	0.54	0.68	0.82	3.35	4.89	6.71
RF3.8	6.17	7.17	8.17	0.74	0.84	0.93	4.58	6.04	7.58
RF4.1	6.50	7.50	8.50	0.69	0.79	0.90	4.51	5.96	7.62
RF4.2	6.50	7.50	8.50	0.74	0.84	0.93	4.82	6.31	7.89
RF4.3	6.17	7.17	8.17	0.68	0.78	0.89	4.16	5.60	7.25
RF4.4	6.50	7.50	8.50	0.64	0.75	0.87	4.14	5.65	7.38
RF4.5	6.17	7.17	8.17	0.67	0.78	0.88	4.12	5.56	7.22
RF5.1	6.83	7.83	8.83	0.68	0.78	0.89	4.63	6.14	7.85
RF5.2	7.00	8.00	9.00	0.75	0.85	0.94	5.28	6.83	8.42
RF5.3	6.83	7.83	8.83	0.75	0.85	0.93	5.11	6.64	8.23
RF5.4	6.83	7.83	8.83	0.76	0.86	0.94	5.18	6.72	8.29
RF5.5	6.83	7.83	8.83	0.80	0.90	0.97	5.47	7.05	8.54
RF5.6	6.67	7.67	8.67	0.76	0.86	0.94	5.06	6.58	8.14
RF5.7	6.17	7.17	8.17	0.59	0.72	0.84	3.63	5.13	6.89
RF5.8	6.83	7.83	8.83	0.73	0.83	0.92	4.95	6.46	8.10

Table 9. Readiness level sub-category RF case study A.

Category RF	FS1	FS2	FS3	FP1	FP2	FP3	RL1	RL2	RL3
RF1	6.77	7.77	8.77	0.80	0.90	0.97	5.44	7.02	8.50
RF2	6.50	7.50	8.50	0.67	0.79	0.89	4.36	5.91	7.58
RF3	6.42	7.42	8.42	0.61	0.74	0.86	3.93	5.46	7.22
RF4	6.37	7.37	8.37	0.68	0.79	0.89	4.35	5.81	7.47
RF5	6.75	7.75	8.75	0.73	0.83	0.92	4.90	6.44	8.05
HLSRI							6.59	7.58	8.57

calculation shows the closest distance between two points using Equation 3. $d(HLSRI_{ec}, HLSR_i)$ is the distance between $HLSRI_{ec}$ and $HLSR_i$. $HLSRI_{ec}$ is hotel LSS readiness index from sub-category RF c, which is in category RF e. $HLSR_i$ is hotel LSS readiness from linguistic terms readiness i . $fHLSRI_{ec}(x)$ is fuzzy number from the hotel LSS Readiness Index from sub-category RF c, which is in category RF e. $fHLSR_i(x)$ is fuzzy number hotel LSS Readiness from linguistic terms readiness i . Table 10 and Figure 2 show the results of the closest distance between HLSRI and HLSR, which is “Very Ready” with a value close to 0, which is 0.73.

$$d(HLSRI_{ec}, HLSR_i) = \sqrt{\left[\sum_{x \in p} (fHLSRI_{ec}(x) - fHLSR_i(x))^2 \right]} \quad (3)$$

Table 11 shows the RF sub-category that have been ranked using TOPSIS by computing fuzzy positive ideal solution (FPIS) and fuzzy negative ideal solution (FNIS) using Equations (4) and (5), then adding the result to Equation (6) for TOPSIS. FPIS is the highest number per fuzzy column, and FNIS is the lowest number per fuzzy column. $d(FPIS, RL_{ec})$ is the distance between FPIS and RL_{ec} . While $d(FNIS, RL_{ec})$ is the distance between FNIS and RL_{ec} . The closeness coefficient (CC_{ec}) represents the distances to the FPIS and the FNIS simultaneously. The RF sub-category closest to the positive ideal solution and furthest from the negative ideal solution are RF1.1, RF1.5, and

Table 10. Euclidean distance HLSRI & HLSR case study A.

Distance label	Value
$d(HLSRI, \text{Ready})$	1.00
$d(HLSRI, \text{Somewhat Ready})$	2.73
$d(HLSRI, \text{Neutral})$	4.47
$d(HLSRI, \text{Somewhat Unready})$	6.20
$d(HLSRI, \text{Not Ready})$	7.93
$d(HLSRI, \text{Very Unready})$	9.66

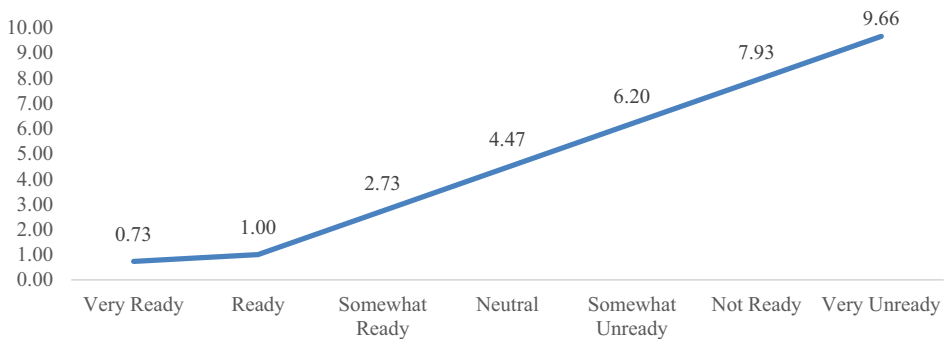


Figure 2. Euclidean distance HLSRI & HLSR study case A.

Table 11. TOPSIS sub-category RF study case A.

Sub-Category RF	RL1	RL2	RL3	d(FPIS, RL)	d(FNIS, RL)	CC	Rank
RF1.1	5.95	7.60	9.00	0.00	5.75	1.00	1
RF1.5	5.62	7.22	8.67	0.60	5.15	0.90	2
RF2.2	5.48	7.06	8.60	0.82	4.93	0.86	3
RF1.2	5.48	7.07	8.51	0.86	4.89	0.85	4
RF5.5	5.47	7.05	8.54	0.86	4.89	0.85	5
RF5.2	5.28	6.83	8.42	1.17	4.58	0.80	6
RF5.4	5.18	6.72	8.29	1.37	4.38	0.76	7
RF2.6	5.19	6.73	8.25	1.37	4.38	0.76	8
RF5.3	5.11	6.64	8.23	1.48	4.27	0.74	9
RF1.4	5.14	6.68	8.16	1.49	4.27	0.74	10
RF2.1	5.09	6.63	8.17	1.54	4.21	0.73	11
RF5.6	5.06	6.58	8.14	1.61	4.15	0.72	12
RF1.3	5.04	6.56	8.17	1.62	4.13	0.72	13
RF5.8	4.95	6.46	8.10	1.76	3.99	0.69	14
RF2.3	4.90	6.41	7.91	1.93	3.83	0.66	15
RF3.6	4.84	6.33	7.95	1.98	3.77	0.66	16
RF4.2	4.82	6.31	7.89	2.04	3.71	0.65	17
RF2.4	4.70	6.17	7.73	2.28	3.48	0.60	18
RF5.1	4.63	6.14	7.85	2.28	3.47	0.60	19
RF3.8	4.58	6.04	7.58	2.52	3.25	0.56	20
RF3.4	4.50	5.99	7.69	2.53	3.22	0.56	21
RF4.1	4.51	5.96	7.62	2.58	3.17	0.55	22
RF3.5	4.11	5.65	7.44	3.11	2.64	0.46	23
RF4.4	4.14	5.65	7.38	3.12	2.64	0.46	24
RF2.5	4.12	5.63	7.37	3.15	2.60	0.45	25
RF4.3	4.16	5.60	7.25	3.20	2.56	0.44	26
RF4.5	4.12	5.56	7.22	3.27	2.50	0.43	27
RF3.1	3.75	5.30	7.12	3.69	2.06	0.36	28
RF5.7	3.63	5.13	6.89	3.99	1.77	0.31	29
RF3.7	3.35	4.89	6.71	4.40	1.36	0.24	30
RF3.3	3.34	4.88	6.70	4.41	1.35	0.23	31
RF2.8	3.12	4.73	6.64	4.68	1.07	0.19	32
RF3.2	3.02	4.64	6.57	4.83	0.92	0.16	33
RF2.7	2.44	4.09	6.10	5.75	0.00	0.00	34
FPIS	5.95	7.60	9.00				
FNIS	2.44	4.09	6.10				

Table 12. TOPSIS category RF study case A.

Category RF	RL1	RL2	RL3	d(FPIS, RL)	d(FNIS, RL)	CC	Rank
RF1 Customer Focus	6.77	7.77	8.77	0.00	3.97	1.00	1
RF5 Top Management & Leadership	4.90	6.44	8.05	2.40	1.61	0.40	2
RF2 Employee Engagement	4.36	5.91	7.58	3.27	0.72	0.18	3
RF4 Supplier Management	4.35	5.81	7.47	3.37	0.60	0.15	4
RF3 LSS Implementation	3.93	5.46	7.22	3.97	0.00	0.00	5
FPIS	6.77	7.77	8.77				
FNIS	3.93	5.46	7.22				

RF2.2 and for the otherwise are RF2.7, RF3.2, and RF2.8. Table 12 shows the RF based on categories that have been sorted using TOPSIS. The RF that is closest to the positive ideal solution and furthest from the negative ideal solution is RF1 and for the otherwise is RF3 or LSS Implementation.

Table 13. TOPSIS category RF case study B.

<i>Sub-Category RF</i>	FS1	FS2	FS3	FP1	FP2	FP3	RL1	RL2	RL3
RF1.1	6.60	7.60	8.60	0.85	0.95	1.00	5.61	7.22	8.60
RF1.2	7.00	8.00	9.00	0.82	0.92	0.98	5.76	7.38	8.83
RF1.3	6.20	7.20	8.20	0.74	0.84	0.92	4.57	6.03	7.58
RF1.4	6.60	7.60	8.60	0.79	0.89	0.96	5.22	6.77	8.26
RF1.5	6.80	7.80	8.80	0.82	0.92	0.98	5.59	7.19	8.64
RF2.1	6.80	7.80	8.80	0.76	0.86	0.94	5.20	6.74	8.30
RF2.2	6.40	7.40	8.40	0.78	0.88	0.96	5.01	6.53	8.02
RF2.3	6.80	7.80	8.80	0.77	0.87	0.95	5.26	6.81	8.35
RF2.4	6.40	7.40	8.40	0.74	0.84	0.93	4.75	6.23	7.79
RF2.5	6.20	7.20	8.20	0.63	0.75	0.87	3.93	5.40	7.11
RF2.6	5.60	6.60	7.60	0.78	0.88	0.95	4.36	5.80	7.24
RF2.7	5.40	6.40	7.40	0.39	0.57	0.75	2.13	3.66	5.53
RF2.8	5.60	6.60	7.60	0.49	0.64	0.80	2.76	4.25	6.05
RF3.1	6.00	7.00	8.00	0.58	0.71	0.84	3.46	4.95	6.71
RF3.2	5.80	6.80	7.80	0.48	0.63	0.79	2.76	4.30	6.15
RF3.3	6.00	7.00	8.00	0.54	0.68	0.82	3.25	4.77	6.57
RF3.4	6.40	7.40	8.40	0.68	0.78	0.89	4.32	5.78	7.46
RF3.5	6.20	7.20	8.20	0.62	0.74	0.86	3.82	5.31	7.04
RF3.6	6.20	7.20	8.20	0.73	0.83	0.92	4.50	5.95	7.52
RF3.7	6.40	7.40	8.40	0.54	0.68	0.82	3.48	5.05	6.90
RF3.8	6.20	7.20	8.20	0.74	0.84	0.93	4.60	6.07	7.61
RF4.1	6.40	7.40	8.40	0.69	0.79	0.90	4.44	5.88	7.53
RF4.2	6.20	7.20	8.20	0.74	0.84	0.93	4.60	6.06	7.61
RF4.3	6.40	7.40	8.40	0.68	0.78	0.89	4.32	5.78	7.46
RF4.4	6.20	7.20	8.20	0.64	0.75	0.87	3.95	5.42	7.12
RF4.5	6.40	7.40	8.40	0.67	0.78	0.88	4.27	5.74	7.42
RF5.1	6.20	7.20	8.20	0.68	0.78	0.89	4.20	5.64	7.29
RF5.2	6.20	7.20	8.20	0.75	0.85	0.94	4.67	6.15	7.68
RF5.3	6.00	7.00	8.00	0.75	0.85	0.93	4.49	5.94	7.46
RF5.4	6.20	7.20	8.20	0.76	0.86	0.94	4.70	6.17	7.69
RF5.5	6.20	7.20	8.20	0.80	0.90	0.97	4.96	6.48	7.93
RF5.6	6.20	7.20	8.20	0.76	0.86	0.94	4.70	6.18	7.70
RF5.7	6.20	7.20	8.20	0.59	0.72	0.84	3.65	5.16	6.92
RF5.8	6.40	7.40	8.40	0.73	0.83	0.92	4.64	6.11	7.70

Table 14. HLSRI case study B.

Category RF	FS1	FS2	FS3	FP1	FP2	FP3	RL1	RL2	RL3
RF1	6.64	7.64	8.64	0.80	0.90	0.97	5.34	6.91	8.38
RF2	6.15	7.15	8.15	0.67	0.79	0.89	4.12	5.64	7.27
RF3	6.15	7.15	8.15	0.61	0.74	0.86	3.77	5.26	6.99
RF4	6.32	7.32	8.32	0.68	0.79	0.89	4.32	5.78	7.43
RF5	6.20	7.20	8.20	0.73	0.83	0.92	4.50	5.98	7.55
HLSRI							6.29	7.28	8.27

$$d(FPIS, RL_{ec}) = \sqrt{\left[\sum_{x \in p} (f_{FPIS}(x) - f_{RL_{ec}}(x))^2 \right]} \quad (4)$$

$$d(FNIS, RL_{ec}) = \sqrt{\left[\sum_{x \in p} (f_{FNIS}(x) - f_{RL_{ec}}(x))^2 \right]} \quad (5)$$

$$CC_{ec} = \frac{d(FNIS, RL_{ec})}{d(FNIS, RL_{ec}) + d(FPIS, RL_{ec})} \quad (6)$$

Case study B

The subject of case study B is a 5-star hotel in Surabaya that has been operating for almost 30 years and is one of the branches of an international network brand that has been established for more than 50 years. Respondents are hotel employees with a minimum supervisory level. Readiness level data was collected using a questionnaire given to several respondents. Each calculation process in Study Case B is also like Study Case A in accordance with Figure 3. The HLSRI for study case B subjects are 6.29, 7.28, and 8.27. Tables 14 and 15 and Figure 4 shows the results of the closest distance between HLSRI and HLSR, which is “Ready” with a value close to 0, which is 0.49. The RF sub-elements closest to the positive ideal solution and furthest from the negative ideal solution are RF1.2, RF1.5, and RF1.1, and for the otherwise are RF2.7, RF2.8, and RF3.2. Table 17 shows the RF based on

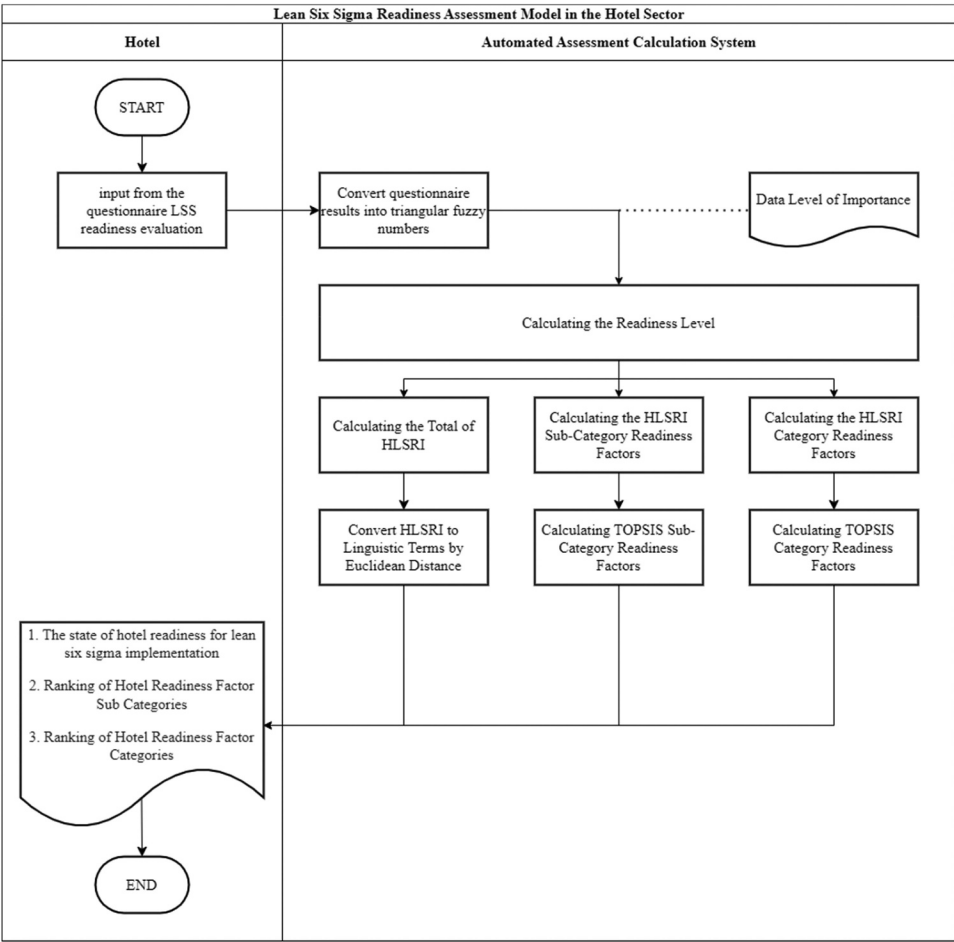
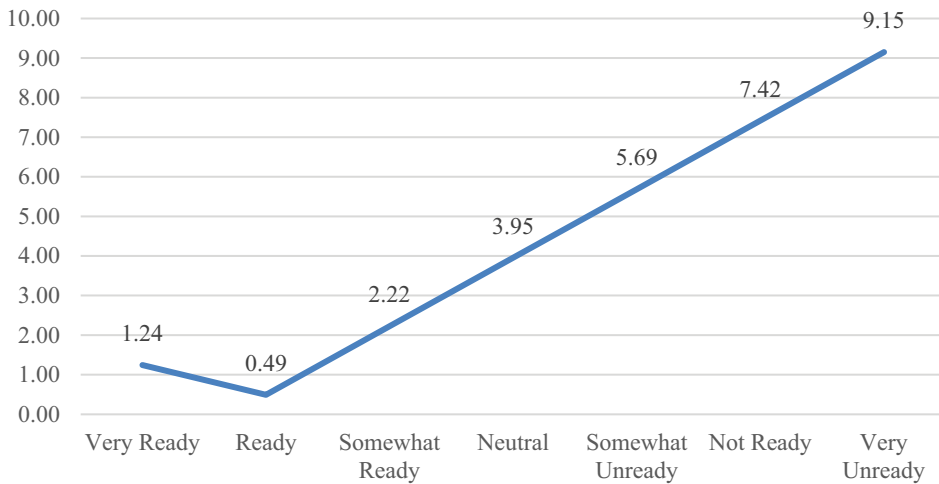


Figure 3. LSS readiness assessment model in the hotel sector.

Table 15. Euclidean distance HLSRI & HLSR case study B.

Distance label	Value
d(HLSRI, Very Ready)	1.24
d(HLSRI, Ready)	0.49
d(HLSRI, Somewhat Ready)	2.22
d(HLSRI, Neutral)	3.95
d(HLSRI, Somewhat Unready)	5.69
d(HLSRI, Not Ready)	7.42
d(HLSRI, Very Unready)	9.15

**Figure 4.** Euclidean distance HLSRI & HLSR case study B.

categories that have been sorted using TOPSIS. The RF that is closest to the positive ideal solution and furthest from the negative ideal solution is RF1 and the otherwise RF3.

Discussion

Evaluation of case studies on Hotel A and Hotel B

Case studies on Hotel A and Hotel B both show their readiness to implement LSS. HLSRI of hotel A is (6.59, 7.58, 8.57) which is translated to “very ready” via the Euclidean Distance Approach according to Table 4. HLSRI of Hotel B is (6.29, 7.28, 8.27), which is translated to “ready” via the Euclidean Distance Approach according to Table 4. Hotel A is a 4-star hotel in Surabaya that has been operating for more than 5 years and is one of the branches of a national network brand that has been established for more than 20 years. Meanwhile, Hotel B is a 5-star hotel in Surabaya that has

Table 16. TOPSIS sub-category RF case study B.

Sub-Category RF	RL1	RL2	RL3	d(FPIS, RL)	d(FNIS, RL)	CC	Rank
RF1.2	5.76	7.38	8.83	0.00	6.15	1.00	1
RF1.5	5.59	7.19	8.64	0.32	5.84	0.95	2
RF1.1	5.61	7.22	8.60	0.32	5.85	0.95	3
RF2.3	5.26	6.81	8.35	0.89	5.26	0.86	4
RF1.4	5.22	6.77	8.26	1.00	5.16	0.84	5
RF2.1	5.20	6.74	8.30	1.00	5.15	0.84	6
RF2.2	5.01	6.53	8.02	1.39	4.77	0.77	7
RF5.5	4.96	6.48	7.93	1.50	4.66	0.76	8
RF2.4	4.75	6.23	7.79	1.85	4.31	0.70	9
RF5.6	4.70	6.18	7.70	1.96	4.20	0.68	10
RF5.4	4.70	6.17	7.69	1.97	4.19	0.68	11
RF5.2	4.67	6.15	7.68	2.00	4.16	0.67	12
RF5.8	4.64	6.11	7.70	2.04	4.12	0.67	13
RF3.8	4.60	6.07	7.61	2.13	4.03	0.65	14
RF4.2	4.60	6.06	7.61	2.14	4.02	0.65	15
RF1.3	4.57	6.03	7.58	2.19	3.97	0.64	16
RF3.6	4.50	5.95	7.52	2.31	3.85	0.63	17
RF5.3	4.49	5.94	7.46	2.36	3.80	0.62	18
RF4.1	4.44	5.88	7.53	2.38	3.78	0.61	19
RF4.3	4.32	5.78	7.46	2.55	3.61	0.59	20
RF3.4	4.32	5.78	7.46	2.55	3.61	0.59	21
RF4.5	4.27	5.74	7.42	2.62	3.54	0.57	22
RF2.6	4.36	5.80	7.24	2.64	3.53	0.57	23
RF5.1	4.20	5.64	7.29	2.80	3.36	0.55	24
RF4.4	3.95	5.42	7.12	3.17	2.99	0.49	25
RF2.5	3.93	5.40	7.11	3.20	2.96	0.48	26
RF3.5	3.82	5.31	7.04	3.36	2.80	0.45	27
RF5.7	3.65	5.16	6.92	3.61	2.54	0.41	28
RF3.7	3.48	5.05	6.90	3.78	2.38	0.39	29
RF3.1	3.46	4.95	6.71	3.96	2.19	0.36	30
RF3.3	3.25	4.77	6.57	4.26	1.89	0.31	31
RF3.2	2.76	4.30	6.15	5.06	1.09	0.18	32
RF2.8	2.76	4.25	6.05	5.15	1.01	0.16	33
RF2.7	2.13	3.66	5.53	6.15	0.00	0.00	34
FPIS	5.76	7.38	8.83				
FNIS	2.13	3.66	5.53				

Table 17. TOPSIS category RF study case B.

Sub-Category RF		RL1	RL2	RL3	d(FPIS, RL)	d(FNIS, RL)	CC	Rank
RF1	Customer Focus	6.65	7.65	8.65	0.00	4.09	1.00	1
RF5	Top Management & Leadership	4.50	5.98	7.55	2.93	1.17	0.28	2
RF4	Supplier Management	4.32	5.78	7.43	3.23	0.87	0.21	3
RF2	Employee Engagement	4.12	5.64	7.27	3.51	0.59	0.14	4
RF3	LSS Implementation	3.77	5.26	6.99	4.09	0.00	0.00	5
FPIS		6.65	7.65	8.65				
FNIS		3.77	5.26	6.99				

been operating for almost 30 years and is a branch of an international network brand that has been established for more than 50 years. Hotel A is classified as being more ready to implement LSS compared to Hotel B. Although, hotel B operated longer than hotel A, has a bigger brand, and is a 5-star hotel compared to Hotel B, which is only 4-star, So, it can be said that, in this context, hotel stars, length of operation, and brand size do not significantly affect hotel readiness for implementing LSS.

Hotel A and Hotel B both show RF sub-elements that are closest to the positive ideal solution and furthest from the negative ideal solution, namely RF1.1, and RF1.5. RF1.1 (Tables 13 and 16). The strength of hotel A and Hotel B is “Customer Focus,” which shows the highest level of readiness compared to other RF categories. This is also supported by Wilkins et al. (2007), who argue that service quality is the core of the hotel sector and has an important role in the success of the sector itself. So, in other words, Hotel A and Hotel B are already moving in the right direction without losing the core of the hotel sector, namely the quality of service itself. This is also supported by the high importance score by eight credible hotel practitioners, namely the “Customer Focus” category, which is the RF category with the highest importance score in implementing LSS in the hotel sector.

Hotel A and Hotel B both have RF sub-elements that are furthest from the positive ideal solution and closest to the negative ideal solution as well, namely RF2.7, RF2.8, and RF3.2. The weakness of hotel A and hotel B as a whole is currently the understanding and implementation of LSS, where this is supported by the importance level of the “LSS Implementation” category, which has the lowest order compared to other RF categories. The LSS implementation category contains details in LSS implementation that are important to prepare, such as detailed hotel planning related to the LSS implementation journey, project selection based on ROI, ad hoc team formation, routine waste reduction, quality culture, change initiatives, routine coordination of LSS implementation, and previous change experience. This is also supported by the importance score given by eight credible hotel practitioners, namely that the “LSS Implementation” category is the RF category with the lowest importance score compared to other RF categories.

Practical recommendation for Hotel A and Hotel B

Hotel A and Hotel B need to set goals to be achieved and conduct a cost-benefit analysis to determine the return on investment (ROI) for lean six-sigma implementation projects and rational budget constraints. Never forget that Lean Six Sigma is a long-term investment. The next step is for both hotels to recruit a minimum of one person who holds a Black Belt Lean Six Sigma certification from a reputable certifying organization. Alternatively, it may be more cost-effective to designate a leader within the organization and arrange for outside Lean Six Sigma training. Additionally, for managers to fully support the adoption of lean six sigma and have a more comprehensive understanding of the methodology as leaders, both hotels must hold a minimum of green belt Lean Six Sigma training at the manager level. To ensure that every employee has a fundamental understanding of lean six-sigma, white and yellow belt lean six-sigma training is required. Finally, for the adoption of Lean Six Sigma, both hotels must establish an ad hoc team led by a PIC who

has been appointed and trained to lead the process with management's full support and commitment. Ad hoc teams consisting of individuals with varying backgrounds, skills, and customer-centric perspectives who are knowledgeable about implementing Lean Six Sigma.

Discussion of readiness model results

A readiness assessment of LSS implementation has been carried out in previous research on several company sectors, including manufacturing (Sreedharan et al., 2019), higher education (Antony & Thomson, 2020), and health (Narayanamurthy et al., 2018, Vaishnavi & Suresh, 2020). Previous research mentions the need for special exploration for readiness assessment for each sector, but so far researchers have not found a readiness assessment of LSS implementation in the hotel sector. Thus, this research focuses on the hotel sector.

Narayanamurthy et al. (2018) developed a readiness assessment model for the application of lean methods to the health sector. This research focuses not only on lean methods but also on LSS, which is a refinement and combination of lean manufacturing and Six Sigma. Narayanamurthy et al. (2018) provided data on the weight of importance to all hospital respondents, so that respondents who have low positions and less experience have the right to weight importance of their assessment. This is quite risky because it makes the overall data biased. In this study, the importance weights were taken by consensus with the Delphi method approach from 8 respondents who were experienced and had high positions, even the General Manager of a 5-star hotel who had worked for more than 5 years.

Limitations and recommendations for future research

This research has several limitations that need to be considered. The number of respondents in determining the level of importance in this study is limited to only 8 people who are all from one country, so in the future, respondents need to be reproduced and made more varied, for example, from various countries, so that the level of importance data is more accurate and can represent the assessment. The study case of this research is also only carried out at 4 and 5-star hotels, so in the future, it needs to be done for hotels with 1, 2, or 3 stars so that the assessment framework is more valid and represents most hotels. The next research recommendation is comparative research between hotels that have implemented LSS and have conducted readiness tests before and hotels that have implemented LSS but have not conducted readiness tests before. Thus, this will further sharpen the framework for assessing hotel readiness before implementing LSS by knowing the effectiveness of the LSS implementation assessment model. This is necessary because to

determine the effectiveness of a readiness assessment, one must see the end result after LSS is implemented within a certain period of time.

Disclosure statement

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