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Leveraging Data-Driven Six Sigma with Lean Practices for Aviation Process Optimization

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A R T I C L E I N F O

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A B S T R A C T

The quality of service in the aviation industry is one of the most crucial elements to consider, having a significant impact on the overall aviation sector as it is a service-based industry. This research is built to prove the importance of implementing the Six sigma methodology along with the Lean practices to prove the major effect it has on the overall performance of conducting business within the aviation industry. The research utilized data from 198 respondents and conducted statistical analysis using SmartPLS 4.0. Six Sigma, known for its emphasis on defect reduction and process optimization, is integrated with Lean Practices, which prioritize waste reduction and continuous improvement. This study explores the synergy of these two methodologies within the unique context of aviation. In addition, the idea of implementing Six sigma and Lean practices and how merging both concepts help in improving the quality of their processes thus leading to better processes and business improvement. This research also involves a change of managerial culture which requires a high level of planning, organizing, decision making, and controlling to be able to benefit from all the possible strengths and revoke all the risk factors and weaknesses throughout

1. INTRODUCTION

The aviation industry is renowned for its commitment to safety, efficiency, and precision. In an era marked by technological advancements and increasing global connectivity, the imperative to optimize operational processes while maintaining the highest standards of safety has never been more crucial. In pursuit of these objectives, aviation organizations have begun to explore the integration of Six Sigma methodology with Lean practices, aiming to achieve a synergistic approach to process improvement. This empirical research delves into the application of Six Sigma and Lean methodologies in the aviation sector, seeking to uncover the potential benefits, challenges, and transformative impact of this innovative approach on aviation process improvement.

Moreover, the Six Sigma methodology, initially developed by Motorola and popularized by industry giants like General Electric, focuses on reducing process defects and variability through data-driven decision-making and rigorous statistical analysis. On the other hand, Lean practices, inspired by the Toyota Production System, emphasize waste reduction and continuous improvement to enhance efficiency. In theory, the combination of these two proven methodologies offers the aviation industry a unique opportunity to optimize operations, reduce costs, improve safety, and elevate the overall quality of service. However, lean practices, six sigma and overall continuous improvement investigated to have a positive correlation between them. This research tends to show the link between the three of them and how it can lead to process

improvement. The data from this research will be quantitative data collected from questionnaires and previous statistics as well, done in the aviation industry with the chosen population (Airports). Six sigma will help improve business processes by making it defective free by 99.9%. This methodology is often used for problem solving techniques throughout the DMAIC phases (Define, Measure, Analyze, Improve, Control) which can help in continuous and incremental process improvement. As for Lean practices acting as a mediating role; it is a systemic approach to help reduce waste throughout processes and only keep the steps that add in value and is considered important for achieving consumer satisfaction. Those three variables will add in any business and will improve processes. Therefore, this research will director businesses to acknowledge the importance of the six sigma processes and lean ractices and their impact on process and business improvement.

2. UNDERPINING THEORIES

Six Sigma: As defined by (Setiyaningrum, F., Pujiyanto, E., & Herdiman, 2019), a methodology that improves process capability by reducing the number of defects in each process by improving process variation based on data driven statistics.

The starting phase of any Six Sigma project where the whole project is defined in terms of it the problem statement, the stakeholders included the introduction and developing a project charter to summarize the purpose if the project (Nawanir et al., 2013). The measure phase is used to collect all the data and the statistics to measure the current performance baseline, and to identify the variation of process represented through the bell where it will be analyzed in the following phase and all the problems will be identified through different techniques like the root cause analysis, or the fishbone diagram, and after analyzing the problems causing the variation within the process, necessary solutions will be developed in the improve phase to fix the problems and decrease process variation for process improvement. Finally, the control phase is maintaining the progress with the upper and lower control limits and ensuring this progress is maintained throughout and is applied on a daily basis (Sokovic et al., 2005).

Lean Practices: Lean practices and Lean Production/management is a practice and a transformational thinking implemented by the organization that tends to improve the organization and planning of activities whilst the utmost minimization or elimination of waste for the purpose of increased process productivity and efficiency (Aburayya et al., 2020).

Kaizen: It is a Japanese word that describes better change and continuous improvement in the organization that includes all the personnel in the business.

Visual management: A proper methodology used through visual aid for labeling items, places, locations, signs etc.

The five laws of Lean(5S): a systematic approach followed by implementing the laws of Lean to improve the workplace environment developing the following culture of Sorting, Setting, Shining, Standardizing, Sustaining.

Process improvement: The six-sigma methodology that is used with its tools to improve the process' output by increasing the process efficiency and effectiveness. Process improvement is the product of lean practices and six sigma methodology. Reduction in the process variation and bias result for better and improved processes within the organization (Nowak et al., 2022).

FMEA: The "Failure Modes and Effects Analysis" is used as a tool for process improvement by analyzing the risk factors that can take place in a process and reviewing any components that can result to the potential failure as well as their causes and effects in a process (Gupta and Antony, 2017).

Departmental process improvement: The constant improvements added within the different processes that takes place in different departments in the aviation industry. i.e., operations department, manufacturing, etc.

Management support: the organizational culture that involves a supportive top management to be able to assess and develop and implement process and business improvement.

3. LITERATURE REVIEW

H1: Six Sigma Methodology has a statistical impact on Lean Practices in the aviation industry

The impact of six sigma on the lean practices implemented within an organization is very much favorable for any business. It attempts at helping in identifying a lot of opportunities in six sigma to improve the lean practices within any organization and

not only towards operational excellence but is there to also claim and act on the responsibilities they have towards the environment as a collective effort by all parties. This impact can emphasize on how a methodology like six sigma can do to improve lean practices and/or reduce waste. For instance, waste produced in manufacturing shows the overall process where six sigma is applied for waste reduction (Oke, 2012).

H2: Six Sigma Methodology has a statistical impact on process improvement in the aviation industry

The literature review related to the second hypothesis, as the impact six sigma has on the performance of the organization tends to overshow the benefits six sigma and what it has on the continuous performance.

The aviation industry in the recent days needs continuous improvement to increase the levels of consumer satisfaction overall.

In this instance, there are different tools used by six sigma to help impact and improve the process performance of the organization, one of which includes a tool called TQM (Total quality management). Both tools focus on collecting consumer's inputs and requirements and how to implement the use of Quality function deployment in designing all of their products and services (Raid A. Al-Aomar, 2011). Moreover, the relationship focuses on how both share ownership of the process and providing clear and well-defined process mappings. Both approaches identify the need of top-level management and the types of leadership and support. ((Scott, n.d.)

S.M. Shafer, S.B. Moeller / Journal of Operations Management 30 (2012) 521–532

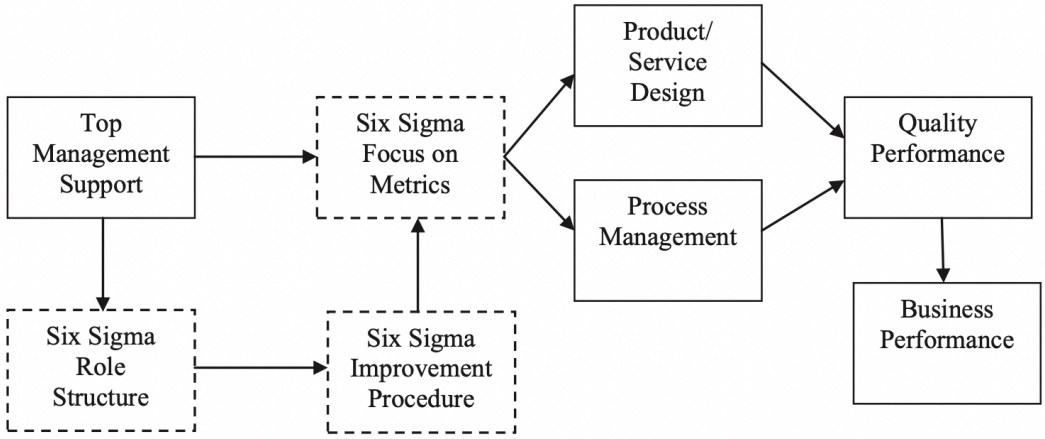

Fig. 1. Theoretical model of relationship between Six Sigma and organizational performance.

As per the diagram above, the role of six sigma and its impact defines and emphasizes on the reducing the variation that happens in organizational processes which thus clears how such practices shown in figure 1, could contribute to improving business performances. Six Sigma aims to enhance the processes by further research on decreasing the variation within the process (Mason et al., 2015). The lesser the variation, the better the quality performance and better outcomes in terms of yield percentages, lead times, and quality.

A good example of this relationship implemented in the airports of Xiao Shan Airport, post implementation of this methodology, the business performance has increased within the check in service. It received a positive response from the staff, management, and the passengers (Almehareb and Graham-Jones, 2010). Due to Six Sigma, the overall check in time/procedure has reduced as the variation of the process has been reduced, leading to a decrease from 60 to 40 seconds which is 33.3% reduction. It shows that the significant process improvement was proved after implementing the DMAIC of six Sigma to the check-in service. Referring to the DMAIC process that is behind the business process improvement within the organization, it usually starts off with the first step which is the define phase. It requires to identify and define the sole purpose of the whole project as to reduce the timing in the check-in service, why is it important and what kind of effect it has on the business performance generally. Who are the team members, stakeholders included, collect data from a consumers Point of view and identify what needs most attention to work on? In this case, it will be the time spent in the

check-in service in the airport.

Next follows the measuring phase where you measure the current performance known as baseline performance. In this stage, you gather the data and try to measure the current performance. Next comes the analysis phase where you analyze all the data collected and you dig into the roots of the problem, where is the problem and what caused. Usually, tools like the cause-and-effect diagram comes into action in this phase (Tiamaz et al., 2018). After analyzing the root causes to the problem, you start planning different ways to improve and provide a plan of action to come up with the proper solutions to solve and improve the current situation. After the improvement have been implemented, you control the improved process and try to maintain that improvement that developed into a continuous business process improvement (Kumaresh and Baskaran, 2010).

Therefore, as six sigma is based on statistical improvement and proven numbers for process improvement, the benefits yielded from it is surprising. Business performance shares a positive correlation with the implementation of the six-sigma methodology as mentioned in the above hypothesis.

H3: Lean Practices has a statistical impact on Process improvement in the aviation industry

Moving onto the third hypothesis where it emphasizes the positive relationship between the lean practices used and the positive increase in business performance. To clarify more the common relationship between the level of lean practices implemented onto the crucial performance measures within the organization, researchers have displayed statistical methods and techniques such as regression models and structural equation models (Abu Salim et al., 2018).

For instance, a couple of researchers managed to display a model of the effect of cutting the costs it had on Just in Time purchasing (Tiamaz et al., 2018). Other researchers managed to explain the variation of almost 23% in the operational performance using a comparable relationship between lean methods and operational performance parameters (Trattner et al., 2019). A few studies show that adopting lean principles improves performance in several ways. JIT procedures have a beneficial impact on operational performance such as efficiency and delivery (Klein et al., 2023).

As for other practices like 5s, which is a systematic approach that is based sorting things, standardize, to clean, to set in order and to sustain which helps in improving a work environment. It is a successful key specially to lean manufacturing. Manufacturing in the aviation industry is in dire need of such tools to be able to sense some positive changes with their workflows and a total quality environment.

The use of 5S improves the ‘transparency’ in any business working environment making sure that they develop a great first impression by all stakeholders and especially new external customers. This Japanese practice is applicable to any industry or sector in the industry and its use and implementation increases the efficiency and productivity and the level of quality as well. 5S is a base for continuous improvement in the organisations. 5S is a way to improve the performance in any organization. A researcher identified the several benefits of 5s, resulting little to no incidents in the workplace, improved discipline behavior in employees, and better management in their inventory. In addition to that, the 5s practice does not only add the above benefits in term of the physical environment, but also it adds to clearing and process of thinking and decision making as well.

Such factors are very much contributing to the improving the processes in the organization. This, nonetheless, shows the positive relationship between the lean practices implemented and the way it positively improves the overall business environment and performances. Performances varying from the staff to the productivity and the efficiency of the business. To conclude this hypothesis, our evaluation of the literature reveals that adopting lean principles has a very much favorable impact on business performance.

H4: Six Sigma Methodology has a statistical impact on process improvement with the mediating effect of Lean Practices in the aviation industry

The fourth hypothesis which focuses on the impact all three variables have on each other can be very much summarized in figure 3. How lean practices contribute in reducing the leading times, by cutting all the waste and the unneeded processes that do not add value and six sigma’s attempt to reducing the variation in any process through statistical methods and techniques that lead to a problem-solving methodology. Both variables create a relationship to lead to a continued improved performance in the aviation industry. The overlap that happened between both variables is very significant as they both aim to a goal for improving performance. For instance, JIT manufacturing in civil aviation could lead to reducing cycle time which in this case many of their processes will not be able to adapt to the reduction in the sizes of their batches and

the inconsistency in their parts and workflows and therefore must go through a reduced variation prior their attempt to implement JIT. To ensure the quality within their small batch sizes, their processes thus should be more streamlined, done through stream value maps, and then it being more simplified and easier leading to a reduced variation. Since six sigma and lean are methodologies that have proven major success in the aviation industry, all stakeholders will benefit from being exposed to those concepts more often.

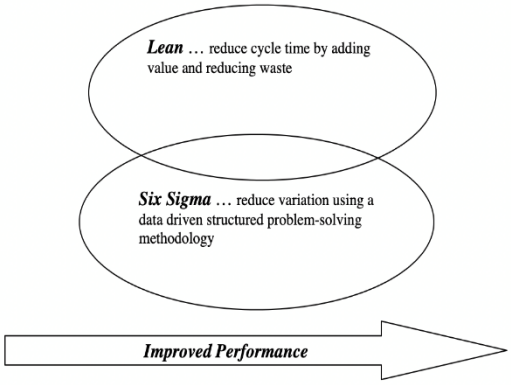

Figure 2: Lean and Six Sigma Work together

3.1. Problem statement and Research gap

The aviation industry is derived and based on services. The second reason of airlines' success, coming after its low rates of accidents and incidents, is customer satisfaction. The reason passenger comfort forms the crux of challenges faced by the airline industry is that no passenger is alike; at some point, a section of customers may always be dissatisfied. One of the most common challenges faced by the aviation industry is the difficulty to maintain passenger comfort and experience. This can have an impact on the consumer satisfaction throughout their travel journey in which can follow a domino effect on profit margins and business success. The implementation of Six Sigma with the significant impact it has on the lean practices followed can gradually improve customer experience by a good percentage.

3.2. Research Model

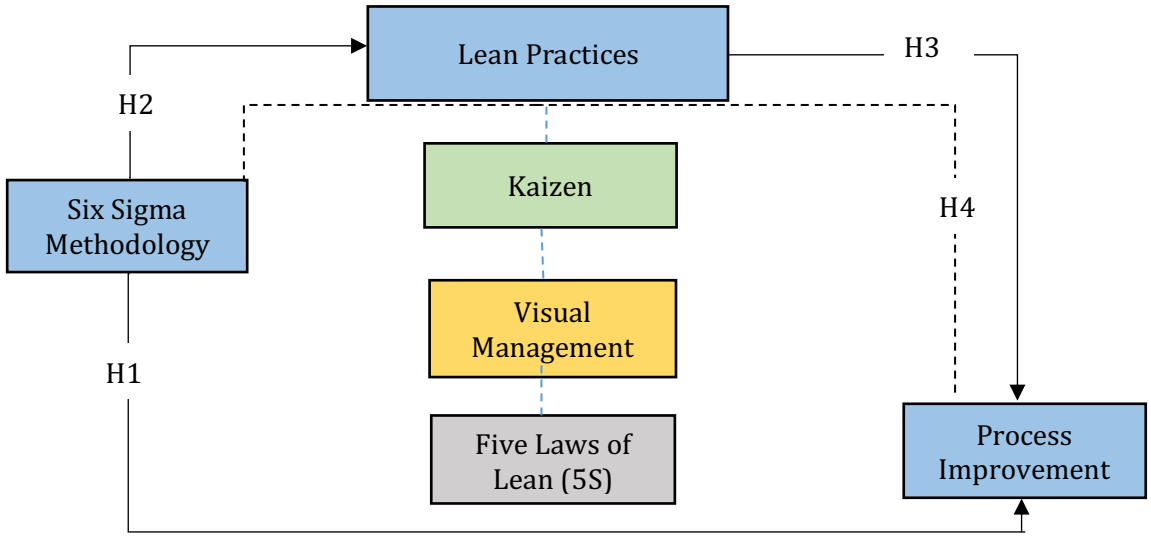

Figure 3: Conceptual Research Model

4. METHODOLOGY

This research was developed to examine all three variables, Six-sigma, lean and process improvement to enhance the operational construction of the aviation industry. To support this framework, a scenario was applied to it and more of a project was implemented in an airport in the UAE to validate this model. This conceptual model needed more support through constructing a questionnaire based on a convenience sampling approach, to reflect the relationship between the three variables and its dimensions. The scenario involved studying the difficulties faced in the airports and identifying the measurable parameters that can be used for the use of Lean management, Six-sigma methodology and process improvement. The data was collected from the questionnaires and the surveys, and the secondary

data collected from various articles and the software used in this research is Minitab. The research will include the DMAIC process and how it will add to the processes of the airports overall.

4.1. Research design

How can Six-sigma and Lean practices relate to provide a more efficient and improved business process? This describes the overall aim of this research. This research will be following a quantitative design approach. The type of design is correlational, testing the how the variables are strongly related. The population will be the airports that are in the aviation industry and our respondents will be the high-level managers who can provide related information for the construction of the research through the convenience sampling method. The survey method is the questionnaire distributed among the chosen population. The data collection procedure is to measure the relationship with Lean, six sigma and process improvement by developing a questionnaire with a 5 point Likert scale. There were a total number of valid respondents were 198 used to assess the research variables. The respondnets profile and demographic data were categorized through pie chart and the model data were assessed using SmartPLS 4.0.

5. DATA ANALYSIS

5.1. Demographic Data

Gender results showing a high ratio of male respondents than female in Figure 4 below.

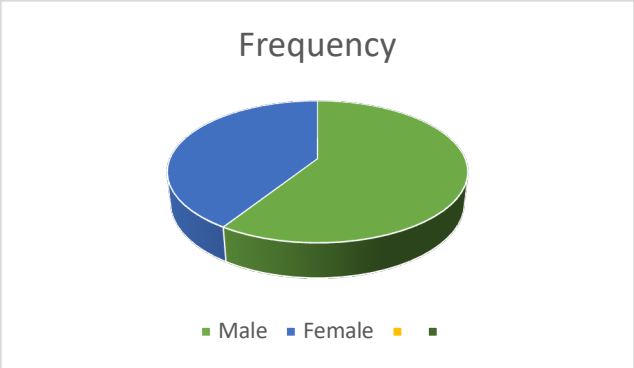

Figure 4: Demographics

Age: The majority of the respondents group is from 25-35 showing a higher rate from the aviation industry. Figure 5 shows the overall results

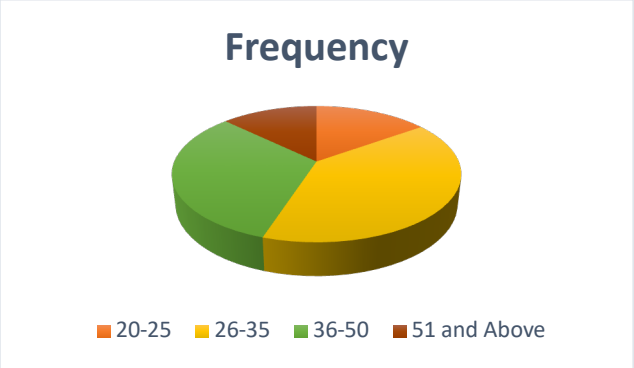

Figure 5: Age Percentage

Experience: The respondnets profile filled with data representing high experienced people working in aviation industry with high ratio. Figure 6 shows the overall results.

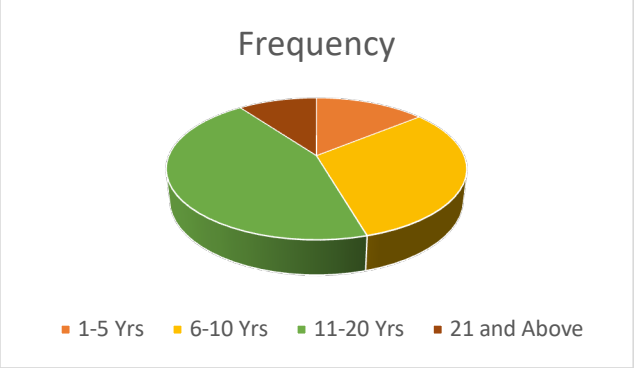

Figure 6: Experience

Validity and Reliability Analysis

SmartPLS assess the reliability of your measurement model by examining the outer loadings (factor loadings) of latent variables' indicators (observed variables). Table 1 illustrate the indicator reliability is satisfactory when the outer loadings are above 0.7. High loadings indicate that the indicators contribute significantly to the measurement of their respective latent constructs. Composite reliability assesses the internal consistency or reliability of the latent constructs in your model. CR values exceeding 0.7 or 0.8 are generally considered acceptable, indicating that the latent variables have good internal consistency. AVE values above 0.5 or 0.6 are indicative of good convergent validity, suggesting that the latent variables adequately explain the variance in their indicators.

Table 1: Composite Relibility, Convergent Validity & Discriminant Validity

Heterotrait- Monotrait Ratio (HTMT)						
	SSM	LP	PI	CA	CR	AVE

Six Sigma Methodology (SSM)	-			0.841	0.921	0.619
Lean Practices (LP)	0.542	-		0.852	0.937	0.584
Process Improvement (PI)	0.721	0.744	-	0.901	0.988	0.697

Table 2: Hypothesis Testing

Hypothesis	Path Coefficients	Sample Mean	Standard Deviation	t-Statistics	P-Value	Decision
H1 SSM→PI	0.381	0.384	0.134	3.45	0.001	Accepted
H2 SSM→LP	0.354	0.364	0.112	3.22	0.001	Accepted
H3 LP→PI	0.244	0.250	0.156	4.51	0.001	Accepted
H4 SSM→LP→PI	0.501	0.512	0.189	6.11	0.000	Accepted

In the Table 2, the total 5,000 bootstrapped samples of the estimated PLS-SEM were used to evaluate the study's hypotheses. Table 2 demonstrates that among the Six Sigma Methodology and Process Improvement (H1) and Lean Practices (H2) have a direct and statistically significant (p0.001) link. Additionally, Table 2 demonstrates that Lean Practices significantly impact process improvement (H3) (p0.001). Although it had a positive indirect effect on process improvement of lean practices between the relationship of six sigma methodology and process improvement (p0.000) Proven as accepted (H4).

Table 3: Coefficient of Determination (R^2) and Predictive Relevance (Q^2)

	Coefficient of Determination (R2)	Predictive Relevance (Q^2)
Six Sigma Methodology	-	-
Lean Practices	0.572	0.61
Process Improvement	0.618	0.24

The coefficient of determination (R^2) was utilised for each endogenous variable in the model to assess the goodness-of-fit of the calculated SEM (see Table 3). It is evident from Table 3 that 61.8% of the variance in Process Improvement was explained by six sigma practices, which is strong. A total of 57.2 % of the variation in lean practices was explained by six sigma methodology.

The model's predictive relevance (Q^2) was assessed. The route model's prediction accuracy is shown to be sufficient if Q2 values for a reflective endogenous concept are greater than zero. Table 3 demonstrates that the constructs' predictive relevance was above zero, which is within the permissible range for all endogenous constructs.

Outcome Model of Hypothesis Testing

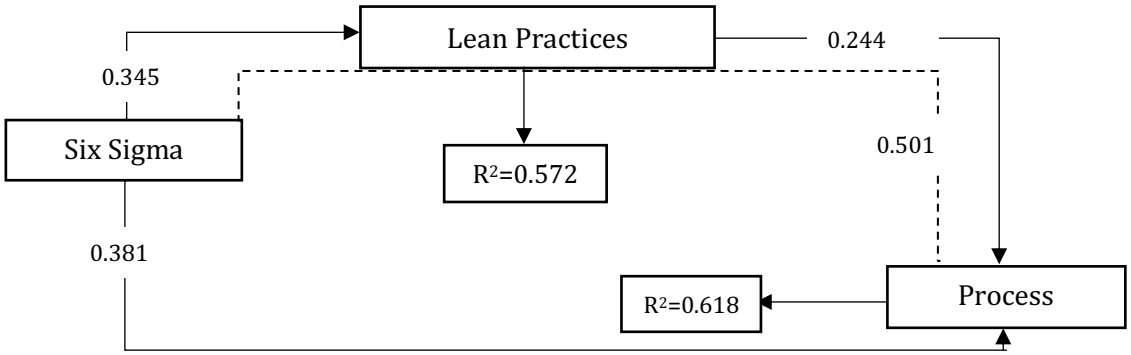

Figure 7: Structured Model Results

6. DISCUSION

The empirical research findings represent a compelling and relevant area of study within the field of aviation operations and management. Both Six Sigma and Lean methodologies have proven their worth in aviation industry for improving processes and enhancing overall efficiency. However, their application in aviation is not without challenges and limitations. In this research we examine the implementation of Six Sigma and Lean practices for aviation process improvement, as well as potential areas of improvement for future research. The significancant relationship highlights the positive side of the six sigma methodology by reducing defects and variation in processes, while Lean focuses on eliminating waste. Combining these approaches can lead to significant improvements in aviation processes, resulting in smoother operations and increased efficiency. The findings revealed lean practices often lead to cost savings by eliminating unnecessary steps and resources. When integrated with Six Sigma, which targets cost reduction through error reduction, the potential for cost savings in aviation operations is substantial.

In addition, safety is paramount in aviation, and Six Sigma's emphasis on reducing errors and Lean's focus on continuous improvement can enhance safety measures. Identifying and addressing safety concerns through this combined methodology can have a positive impact on the industry. The significant impact of lean practices identifies the lean principles, which aim to provide value to customers, can complement Six Sigma's focus on quality. When applied effectively in aviation, this combination can lead to improved customer satisfaction by reducing delays, improving on-time performance, and minimizing baggage mishandling. However, both Six Sigma and Lean rely heavily on data analysis. The integration of these methodologies encourages data-driven decision-making in aviation processes, enabling organizations to make more informed choices based on empirical evidence.

7. CONCLUSION

The research results significantly shows the impact of six sigma methodology on aviation process improvement through lean practices. In addition, the integration of Six Sigma and Lean practices for aviation process improvement holds great promise but comes with its share of challenges. The findings of this research suggest that there is significant potential for enhancing process efficiency, reducing costs, improving safety, and increasing customer satisfaction in aviation operations when Six Sigma and Lean practices are combined effectively. Addressing these challenges and conducting further research in key areas will be essential to ensure the successful application of these methodologies in the aviation industry, ultimately leading to safer, more efficient, and cost-effective aviation operations.

- Future Recommendations

Future studies should delve deeper into the role of organizational culture and employee attitudes in the successful implementation of Six Sigma and Lean practices in aviation. Exploring strategies to foster a culture of continuous improvement and overcome resistance to change is critical. Moreover, collect and analyze in-depth case studies of aviation organizations that have successfully implemented Six Sigma and Lean practices. These case studies can serve as valuable sources of best practices and practical insights for other aviation organizations seeking to follow suit.

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