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Rationalizing the cost of quality through lean and agile operations practices: Evidence from Aviation industry

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This research aims to account for the cost of quality through lean and agile operations strategies with empirical evidence from the Aviation industry in the UAE. The cost of quality improvement through lean and agile strategies was not researched enough in the aviation industry. This research will contribute with great knowledge in the aviation industry. The research design used a descriptive, explanatory, causal, and analytical method. A cluster sampling technique was used with a valid sample size of 251 respondents for analysis by multiple regression using ANOVA. Results indicated the significant relationship between lean and agile operations strategies on the cost of quality. There is a direct positive significant relationship between the cost of quality and SC strategies to get quality products cost-effectively. This research was limited to the lean and agile strategies and cost of quality analysis in the aviation industry in one city in the UAE. In contrast, it requires detailed research to explore other cities and assess the aviation industry's challenges while implementing lean and agile strategies. Cost elimination with high-quality production is fundamental for a successful business; lean and agile operations can reduce airline companies' costs and propose the criteria to adopt the strategic implementation efficiently.

1. Introduction

In today's era, achieving a competitive advantage in the market is crucial, and every organization tries to adopt other approaches to improve business operations (Alolayyan, Al-Qudah, et al., 2022). However, the main problem or issue faced by the organizations is providing high-quality products or services cost-effectively (Awadhi et al., 2021). It is important to examine the impact of lean and agile operations on the cost of quality as these operational approaches have been studied for a long time, and there is limited evidence of their impact on cost quality (Lee et al., 2022). Moreover, the lean operation focuses on reducing waste and cost, increasing customer satisfaction and staff motivation, and making production cost-effective (Aityassine et al., 2022; Alolayyan, Al-Rwaidan, et al., 2022). On the other hand, the agile operations strategies increase quality by taking time in customized orders to reach the customer's ultimate satisfaction (Kurdi et al., 2022). The airline industry greatly impacts the world and is recognized as one of the industries with the fastest growth rates globally. Implementing lean and agile operations in complicated business-like aerospace is easier. Based on several studies, the aviation industry faces challenges such as workflow inefficiencies, difficulties with work prioritization, and poor team coordination. This research investigates how implementing lean and agile operations can cost-effectively increase productivity (Shakhour et al., 2021; Shamout et al., 2022). Therefore, the present research will analyze the empirical evidence of the cost of quality through lean and agile operations strategies. The aviation industry in the UAE was targeted to assess the strategic implication and their manufacturing using supply chain strategies to facilitate efficient production.

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2. Theoretical framework

2.1 Lean Operations Strategies

In developing an integrated quality network for lean operations systems, quality systems within a competitive & complex environment need to consider an integrated iterative approach. Developing lean quality methods for multiple phases or stages helps produce an integrated quality system. These types of systems employ extending and blending lean quality techniques to multiple phases of the transformation system to synthesize and a versatile quality system (Lyons & Ma'Aram, 2014). Furthermore, the research about the strategic adoption of lean in aviation maintenance repair and overall industry Ayeni has determined, Ball and Baines (2016) that the key decision areas highly influenced by the lean strategy are "planning and control" (waste reduction, cost reduction, customer satisfaction) and "process & technology" (Ayeni et al., 2011).

2.2 Agile Operations Strategies

Despite having less well-defined industrial origins, agility has become an advanced skill set. Even though its industrial origins are less obvious, agility has become a general phrase with strong aspirational connotations (Breu et al., 2002). Agile supply is often referred to as a fundamentally different paradigm from lean supply, more concretely defined and strongly related to "rapid response." Innovative products and erratic demand are typical characteristics of agile supply drivers (Ali et al., 2022). The agile paradigm emphasizes the need to supply various products with variable demand that helps achieve ultimate customer satisfaction (H. M. Alzoubi & Yanamandra, 2020; Stratton & Warburton, 2003).

2.3 Cost of Quality

Cost of quality is described as programs for improving the quality, including monitoring and controlling (Alshamsi et al., 2021; Alzoubi et al., 2021). The cost of the quality estimate can be used to determine the budgetary limits (Aburayya et al., 2020). The cost of quality analysis assists organizations in identifying, quantifying, and containing the effects of low quality (Kau & Nel, 2019). To ensure that the product meets the specified level of quality and satisfies the client in terms of cost competitiveness, organizations must identify, measure and analyze its performance (Ramakrishna & Alzoubi, 2022). The total cost of quality (COQ) includes all expenses associated with a product's design, development, implementation, operation, and maintenance and any resources devoted to ongoing product improvement (Titov et al., 2016).

2.4 Operational Definitions

Variables	Description	Reference
Lean Operations	Lean operations are how a business is run, primarily focusing on providing customer satisfaction and utilizing minimum resources. The objective of lean operations is to eliminate waste and create value for customers.	(Carvalho et al., 2011)
Agile Operations	Entails utilizing Agile principles within the organization, which assist in examining the effectiveness & speed of business responses to management information and business intelligence along with the quality of the subsequent decisions made.	(Gunasekaran et al., 2019)
Cost of Quality	COQ is the total costs incurred in the design, implementation, operation, and maintenance of a quality system, resources committed to continuous improvement, product failure, and all costs involved in achieving the quality of a product	(Kau & Nel, 2019)

2.5 Industry description

The UAE's economy relies heavily on the civil aviation industry, which supported approximately 800,000 employments in 2019 before the Covid-19 epidemic and contributed $47.4 billion to the economy, or about 13.3 per cent of the UAE's GDP. Although the Covid-19 pandemic dealt a serious blow to the aviation industry, it continues to be a vital part of the broader economy. Emirates and Etihad Airways are the two main airlines in the United Arab Emirates. By 2025, it is anticipated that ongoing airport development projects will increase capacity by about 100 million passengers annually. Therefore, it is crucial to investigate the strategic development and implementation by lowering cost factors and maintaining quality. Vast businesses require complex strategic implementations to achieve sustainable advantage. Thus, this research was conducted to assess the cost of quality through lean and agile operations.

3. Literature review

3.1 Relationship and impact of lean operations practices on the cost of quality

Every manufacturing company must consider the Cost of Quality (COQ) as the leading strategy. Adopting various quality strategies includes monitoring and controlling the manufacturing process (Lyons & Ma'Aram, 2014). Therefore, budgetary restrictions can be determined using an estimation of the cost of quality. Organisations can identify, assess, and manage the effects of low quality with the cost of quality analysis (Kau & Nel, 2019). Limited studies investigated the relationship of lean operations strategies with the cost of quality. However, the investigated research showed a positive relationship between lean strategy and the cost of quality by reducing waste; thus, reducing cost and customer satisfaction directly impacts the cost of production by maintaining the product quality.

H_1: *Lean operations strategies significantly impact the cost of quality.*

3.2 Relationship and impact of agile operations strategies on the cost of quality

As opposed to traditional acquisition projects, an agile environment necessitates a more iterative, integrated, and collaborative approach to cost of quality. Cost of quality is an essential task in production that adopts Agile operations strategies that increase the total quality, flexibility, and lean time (Ahmed & Huma, 2021). In support of the article "Enabling technologies and implementing framework for agile" manufacturing by Ringstad, Dingsøyr and Moe (2011), Agile operations or manufacturing systems were developed as a solution to a society with a dynamic and unpredictable demand with a great level of mass communication in its product. It was identified that various organizations are adopting agile as a solution to the new market opportunities and to reduce the production cost by maintaining the quality of products (Khataie & Bulgak, 2013).

H_2: *Agile operations strategies significantly impact the cost of quality.*

3.3 Relationship and impact of lean and agile operations strategies on the cost of quality

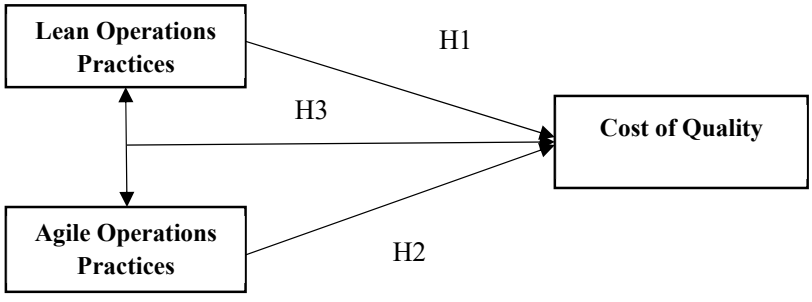
Business excellence via advanced manufacturing technology and lean agile manufacturing that automobile makers need to deal with dynamic changes in the market. To deal with these changes, the aviation industry manufacturers can use lean operations to increase profit and competitiveness by reducing manufacturing costs and optimizing resource utilization (H. M. Alzoubi & Aziz, 2021). Lean manufacturing helps enable information flow among internal procedures & interpreting operational, strategic and tactical information in a more accurate and timely manner within the organization by identifying waste and uncontrolled costs (Khataie & Bulgak, 2013). Therefore, COQ is considered a tool to assist enterprises in lowering the manufacturing cost to achieve the ultimate satisfaction of the customer and profitably gain a competitive advantage.

H_3: *Lean and agile have a significant impact on the cost of quality.*

3.4 Problem statement and research gap

To achieve a competitive advantage in the market, every organization tries to adopt other approaches for improving business operations. However, organizations face the main problem or issue of providing high-quality products or services. It is important to examine the impact of lean and agile operations on the cost of quality as these operational approaches have been studied for a long time, and there is limited evidence about their impact on cost quality. Therefore, the present research will analyze the gap identified by the previous articles or studies and primary information.

3.5 General Research Model



3.6 Research Hypothesis

H_{O1}: *Lean Operations Practices have a statistical impact on the Cost of Quality in the UAE Aviation Industry at ($\alpha \leq 0.05$) level of significance.*

H_{O2}: *Agile Operations Practices have a statistical impact on the Cost of Quality in the UAE Aviation Industry at ($\alpha \leq 0.05$) level of significance.*

H_{O3}: *Lean Operations Practices and Agile Operations Practices have a statistical impact on the Cost of Quality in the UAE Aviation Industry at ($\alpha \leq 0.05$) level of significance.*

3.7 Research Methodology and Design

The methods used to analyze the research variables of assessing the empirical analysis of agile & lean operational methods impact the cost of quality; the research aims to collect data from the Aviation industry in UAE. To assess the variables, a survey questionnaire was used in a descriptive, explanatory, causal, and analytical research design. A cluster sampling technique was adopted due to the magnitude of the industry in Saudi Arabia city of the UAE. The Primary data was obtained from an online survey. The demographic, reliability, descriptive, correlative, regression, and hypothesis testing were analyzed using SPSS and ANOVA.

3.8 Population, Sample & Unit of Analysis

The top 31 aviation companies in the UAE targeted to collect the empirical evidence, including Air Arabia, Shutter-land Global Services and GCAA, were also listed as a sample for the research targeted population. Two hundred fifty-one

responses with valid data were received after 650 emails were sent to the correspondents (Administrative personnel, District sales manager and Airport management). A 31-item survey instrument with dimensions measuring waste reduction, customer satisfaction, cost reduction, and increased staff motivation for lean operations, agile operations strategies measured with dimensions improvement in flexibility, quality improvement, and lead time, and COQ measured with 10 items using a five-point Likert scale ranging from 1 strongly disagree to 5 strongly agree, was designed to gather responses.

4. Data analysis

4.1 Demographic Analysis

Fig. 2 presents details of the participants in this survey.

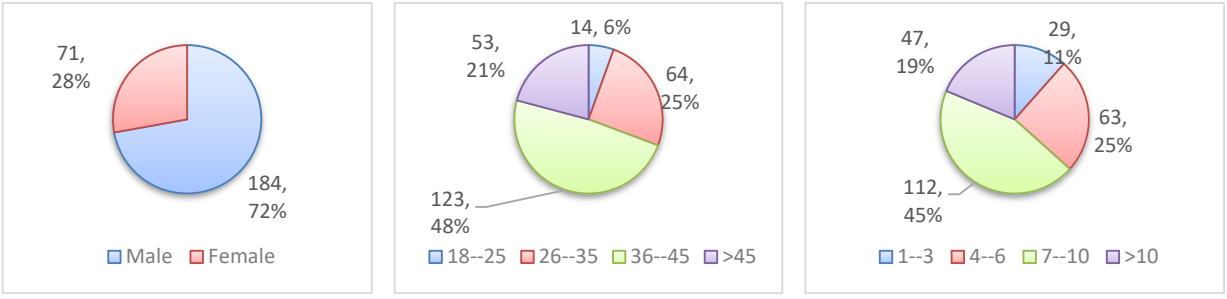


Fig. 2. Personal characteristics of the participants

4.2 Reliability analysis, Descriptive analysis, Correlation

The data analysis results show reliability using pilot testing for 7 items of each variable that demonstrate good reliability for lean strategy as .84, agile strategy .86 and .79 for the cost of quality. The descriptive statistics show the (M=4.38, SD=10%) for LS, (M=3.45, SD=66%) for AS and (M=3.34, SD=58%) for the cost of quality indicates a positive variance of the data set. The correlation coefficient results depict a strong positive correlation among variables at a significance level of P<0.05. The lean strategy shows a significant positive relationship with agile strategy .000** and a strong correlation with .892. Lean strategy with the cost of quality indicates a significant relationship and positive correlation by .770, and agile strategy indicates a good correlation with the cost of quality by .743. Table 1 shows the overall summary of the data.

Table 1
Overall summary of the main data.

Variables	Cronbach's Alpha	Mean	Std Deviation	LEAN	AGILE	CQ
Lean Strategy	.84	4.38	.10	1		
Agile Strategy	.86	3.45	.66	.892**	1	
Cost of Quality	.79	3.34	.58	.770**	.743**	1

*Correlation significance level at *P<0.01, **P<0.05*

4.3 Linear Regression Analysis

Regression analysis shows the lean strategy's dependency on the cost of quality by β= .770 and 59% variance of variables. The agile strategy depicts a good dependency on the cost of quality by β=.743 and 55% variance between the variables. Table 2 shows the summary of the data.

Table 2
Summary of data analysis – R^2 and P-value

Regression Weights	B	R^2	Adjusted R^2	p-value
LEAN→CQ	.770	.593	.591	.000
AGILE→CQ	.743	.552	.550	.000

Cost of Quality is the dependent variable. All results are standardized coefficients
Significance level at P<0.05.

4.4 Multiple Regression with ANOVA

The Multiple regression analysis is done by ANOVA for Lean and agile operations on cost of quality as shown in Table 3.

Table 3
Multiple regression analysis by ANOVA for Lean and Agile operations on Cost of Quality

	R	R²	F	Sig	df	Dimensions	β	t	Sig
Cost of Quality	.805	.647	.637	.000	7 .244 251	Customer satisfaction	.397	7.43	.000
						Cost Reduction	.021	.284	.000
						Waste Reduction	.019	.209	.004
						Improved Staff	.124	1.22	.000
						Improvement in	.152	2.58	.007
						Quality Improvement	.111	1.02	.000
						Improved Lead Time	.134	2.47	.000

**Level of Significance (α≤0.05)* ***Critical t-value (df/p) = 1.64*

4.5 Hypothesis Testing

Hypothesis testing results indicate that the lean strategy significantly impacts the cost of quality at a significance level of P<0.05, β=.770. The H1 is accepted. The agile strategy indicates a significant impact on the cost of quality at a significance level of P<0.05, β=.743, so H2 is also accepted. The third hypothesis shows the significant impact of lean and agile operations strategies on the cost of quality significance level at P<0.05, β=.780 indicates a significant positive relationship. H3 is also accepted. The data summary is mentioned in Table 4 below.

Table 5: Hypothesis Testing

Hypothesis	Regression Weights	β	R²	Adjusted R²	p-value	Hypothesis
H_1	LEAN→CQ	.770	.593	.591	.000	Supported
H_2	AGILE→CQ	.743	.552	.550	.000	Supported
H_3	LEAN+AGILE→CQ	.780	.608	.605	.000	Supported

**P<0.01, **P<0.05*

5. Discussion of the data

The focused researcher examined the major challenges an organisation faces while implementing Lean and Agile operations to maintain the cost of quality. The data analysis thorough multiple linear regression with ANOVA results indicates the significant relationship of lean strategies with the cost of quality at a significance level of P<0.05. The lean dimension "customer satisfaction" significantly impacts the cost of quality (β=.397, t=7.43). The second dimension, "cost reduction", significantly impacts the cost of quality (β=.021, t=.284). The third dimension, "waste reduction", also indicates a significant relationship with the cost of quality (β=.019, t=.209). Fourth, the dimension "Improved staff motivation" also depicts a significant relationship with the cost of quality (β=.124, t=1.22). The dimensions for agile operations were also assessed through multiple regression using ANOVA. The first dimension, "improved quality", shows a significant relationship with the cost of quality by (β=.11, t=1.02). Second, the dimension "improved in flexibility time" also indicated a significant relationship (β=.152, t=2.58). The positive critical value indicates a significant positive relationship. Third, "improvement in lead time" also has a significant relationship with the cost of quality. Previous research indicated that implementing quality expenses reporting has advantages for organisations. Cost of quality is a tool businesses use to increase productivity with lean and agile operations to get more benefit to the organisations (Krishnamurthy & Yauch, 2007).

6. Conclusion

The results identified the significance of Lean and Agile operations by concluding its strong relationship with the cost of quality in an organisation. The managers in several airlines identified via a survey that Lean and Agile operations reduce quality costs within the organisation, directly affecting business profit. The overall outcome of the research concludes that there is a strong relationship between Lean & Agile operations and cost of quality. These operations help reduce the cost of quality by avoiding business system failure and assist organisations in increasing profit. Following the implementation of the quality cost system, it was found that customer complaints, rework, scrap, warranty costs, and failure costs significantly decreased.

7. Recommendations/limitations

The research was limited to investigating the impact of lean and agile operations on the cost of quality, which was recognised as a major strategic implementation to get cost-effective production. The research data are primarily self-reports from middle or senior management in production. The sample size was limited to one city in the UAE aviation industry. It is recommended that future research explore other cities and airline companies that can focus on gathering information from various sources to achieve more reliable results. As further research on this topic is required, it is anticipated that this research may inspire or at least spark interest in upcoming studies in the aviation industry. Future research is also required to explore the challenges faced by the aviation industry while applying lean and agile strategies to achieve cost quality.

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