5th Asia Pacific Conference on Industrial Engineering and Operations Management
Tokyo, Japan, September 10-12, 2024
Publisher: IEOM Society International, USA DOI: 10.46254/AP05.20240045
Published: September 10, 2024

Lean Manufacturing Implementation in a State-Owned Company in South Africa

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Abstract

This research studied the impact of Lean Manufacturing (LM) on the safety and operational performance of a state-owned company in South Africa. It further identified the critical success factors (CSF) for implementing lean tools. LM uses various tools and techniques to eliminate waste, improve efficiency, and optimize processes. This study focused on three tools 5S, TPM, and Kaizen. Based on a thorough literature study, five CSFs have been studied. The main aim was to evaluate the impact of the LM tools on safety and operational performance. Additionally, to study the impact of CSFs on LM implementation. Research questions and hypotheses were formulated, and a mixed methods approach was used to gather and analyse data. Results show that LM has a positive impact on both safety and operational performance. The required critical success factors (CSFs) for LM implementation are employee involvement and empowerment, as well as leadership support and commitment. LM Tools have a positive impact on on both safety performance and operational performance.

Keywords

Lean manufacturing, Operational performance, Safety performance, critical success factor

1. Introduction

Manufacturing companies in South Africa (SA) operate in a highly competitive global environment characterised by rapid changes in technology and increasing customer demands. According to Ginindza (2021), SA's global competitiveness has dropped to position 62 from a total of 64 countries based on data from the 2021 World Competitiveness Yearbook. A number of problems have been cited, including the high unemployment rate, electricity issues, slow COVID vaccination rates and a struggling economy. Productivity SA indicated that SA's performance has deteriorated significantly since 2005 when it was ranked at position 37, its best performance (Raputsoane, 2020). SA's manufacturing industry has shrunk from 21% in 1990 to 12% in 2019 with more people employed within the manufacturing sector in 1969 than today (Venter, 2022). This presents a serious challenge as more people are losing jobs within the manufacturing sector at a time when SA needs to create employment.

According to Sahoo and Yadav (2017), global competition has led manufacturing companies to adopt cost-reduction strategies, focusing on achieving high quality and customer satisfaction. This has resulted in many companies adopting and implementing Lean Manufacturing (LM) as a continuous improvement approach to enhance their competitiveness. LM implementation has produced improvements to operational performance through the reduction

of waste (Shah and Ward, 2003; Nawanir et al., 2012; Panizzolo et al., 2012; Sahoo, 2021; Vinodh and Joy, 2012). Such improvements are linked to reductions in inventory, improved quality with less rework and rejects, improved flow, reduction of non-value-added work, reduced cycle time, improved employee engagement, continuous improvement and improved customer satisfaction. When both the technical and social aspects are considered, LM is also associated with improvements in health and safety performance (Longoni et al., 2013). According to Anvari et al., (2011), worker safety is enhanced by the development of empowered, informed and dynamic employees with the necessary expertise and knowledge to eliminate or reduce hazards in the work environment.
Lean Manufacturing has been widely practised in developed countries and has been accepted within the South African manufacturing environment mainly due to its adoption by multinational companies. Research has shown that successful implementation of LM is difficult and complex, with approximately only 10% of companies succeeding in the implementation of total productive maintenance (TPM) and other lean practices in the United Kingdom (Bhasin and Burcher, 2006). Successful implementation of LM offers competitive advantages. However, this is dependent on overcoming the various barriers and contextual factors that influence implementation (Jadhav et al., 2014; Shah and Ward, 2003; Ghobakhloo et al., 2018; Tortorella et al., 2018; Sahoo, 2021; Bashar et al., 2020).

Preliminary research indicates that LM improves both operational and safety performance, with the implementation process being complex and influenced by factors which either promote or retard the process. This has been documented in both the private and the public sector. However, there needs to be more literature for exploring LM within the context of state-owned companies in developing countries. A state-owned company has had a significant loss of market share, revenue and customer confidence caused by a number of safety-related incidents that resulted in the suspension of all operations. As such, research on LM implementation within the South African public sector is scarce and even scarcer in state-owned companies. This research aims to develop insight into the application of LM within the context of a South African state-owned company.

1.1 Objectives

The main aim of the research was to study the impact of implementing Lean Manufacturing on operational and safety performance within a South African state-owned company. A subsequent objective was to identify the critical success factors that influence LM implementation. Research questions and hypotheses were formulated to achieve these objectives.

2. Literature Review

2.1 Definition and evolution of LM

According to Belekoukias, Garza-Reyes and Kumar (2014), Lean Manufacturing (LM) is a management approach to increase the competitiveness of an organization through the reduction of cost and improved efficiency through the elimination of waste. This is facilitated through the key LM tools and methods that include just-in-time (JIT), TPM, value stream mapping (VSM), autonomation and kaizen/continuous improvement (CI). Shah and Ward (2003, 2007) proposed that LM is an "integrated socio-technical system" which aims to eliminate waste through the simultaneous reduction of internal, customer and supplier variability. This definition transfers the focus from the methods and tools towards the managerial aspects of LM. LM is described as a "business phenomenon" which encompasses the aspects of waste elimination, bundles of LM tools, a cultural transformation, a learning system and enterprise excellence (Åhlström et al., 2021). The "phenomenon-based perspective" believes that LM must be tailored to each company's specific needs and utilises practices and principles not normally associated with LM, such as Six Sigma, Theory of Constraints, Agile methods and Digital technologies (Åhlström et al., 2021; Dombrowski et al., 2019).

According to Hines, Holweg and Rich (2004), "LM has evolved considerably over time". They document that LM has progressed from an awareness phase with a focus on tools to a quality phase where best practices and benchmarking are adopted. LM transitioned into the lean enterprise phase, which was a shift away from the traditional production environment to the entire organisation based on value and partnerships (Bhasin and Burcher, 2006). LM then evolved into a strategic phase, which focused on integrated processes, and then shifted to a leadership and culture phase. This phase focused on the role of the leader and the creation of a continuous improvement culture through the engagement of employees (Sahoo, 2021; Tortorella et al., 2018). LM matured into the enterprise excellence phase that focused on integration with "six sigma, agile, green practises and industry 4.0" (Åhlström et al., 2021;

Dombrowski et al., 2019). This evolution of LM realises a shift from the automotive sector to general manufacturing, later to the service sector and now to all sectors (Åhlström et al., 2021; Antony et al., 2021).

Based on the above, there is no consensus amongst researchers on the exact meaning of LM, however, the authors find that the definition proposed by Shah and Ward (2003; 2007) which describes LM as an "integrated socio-technical system whose main objective is to eliminate waste by concurrently reducing or minimising supplier, customer, and internal variability" captures the essence of LM.

2.2 Lean Manufacturing Tools and Methods (11 font)

LM tools, techniques and methods have been developed over the years by various organisations and researchers on their lean journey. There is an excess of LM tools and techniques for waste elimination, that are selected based on the environment and waste targeted (Bhamu and Sangwan, 2014). The most frequently mentioned lean tools are TPM and JIT, followed by 5S and visual control. Kaizen / CI, Kanban and VSM are ranked third. LM implementation is, therefore, a long-term strategic journey for a company, and the selection of the correct LM tools is dependent on the various stages of implementation. There is a risk of focusing on the introduction of too many tools without the proper training and support, which may lead to incorrect application and inconsistent results. The TPM, 5S, and Kaizen / CI LM tools have been selected for further discussion as the authors are of the opinion that 5S should form the basis of LM implementation, followed by Kaizen, then TPM.

2.3 LM Impact on Operational Performance

5S

5S is an important LM tool for organisations in the workplace and leads to efficiency improvements (Hines et al., 2008; Sá et al., 2021). In its most basic form, 5S represents good housekeeping and involves cleaning to remove clutter, unused items and equipment, then storing them in the correct place. According to Gapp, Fisher and Kobayashi (2008), most Western companies view 5S as a housekeeping tool and only focus on the technical aspects. Japanese organisations, on the other hand, regard 5S to have both philosophical and technical components that are applied holistically "to create a better workplace" as it influences both organisational and management decision-making.
According to Gupta and Jain (2013), implementing 5S improves quality, productivity and efficiency. 5S also contributes towards a safer work environment and better housekeeping. Jiménez et al. (2015) found that the 5S application improved the work environment and staff motivation. Hines et al. (2008) agree with these comments and indicate that 5S is the starting point for LM implementation. The ability to sustain a successful 5S system should be the foundation of Lean success.

Total Productive Maintenance (TPM)

TPM is a total maintenance system that serves to optimise equipment effectiveness, eliminate equipment breakdowns and promote maintenance autonomy by operators (Hooi and Leong, 2017). TPM has been utilised as a strategy to achieve a goal of "zero breakdowns, zero abnormalities, zero defects, and zero accidents" (Habidin et al., 2018). The cooperation of both the operational and maintenance departments is essential to optimise equipment availability and utilisation (Sahoo and Yadav, 2020). According to Mendez and Rodriguez (2017), accurate and reliable data collection is vital to identify the root cause of equipment failures and define effective corrective actions that, in turn, lead to more effective utilisation of maintenance resources. TPM has a significant impact on operational performance in the pharmaceutical industry where the implementation of TPM resulted in reduced waste and better quality (Modgil and Sharma, 2016). Konecny and Jörn-Henrik (2011) researched the influence of TQM and TPM on operational performance and identified that TPM-based practices led to improved performance. According to Ahuja and Khamba (2008), the successful implementation of TPM will improve production efficiency, reduce operational costs and extend the life of equipment.

Kaizen / Continuous improvement

According to Janjić, Todorović and Jovanović (2020), Kaizen means "improvement or change for the better". Continuous improvements are small, incremental innovations that become significant over the long term. Kaizen is an engagement process where employees participate in process improvement activities, which fosters a culture that empowers employees to solve problems (Suárez-Barraza et al., 2011). In 2020, Janjić, Todorović and Jovanović stated that kaizen improves cost, productivity, efficiency, quality and safety. However, the main benefit is employee empowerment. Gupta and Jain (2014) agree with these sentiments. Their research in India found that kaizen implementation improves morale and job satisfaction and creates an environment where employee suggestions are valued. Habidin, Hashim, Fuzi and Salleh (2018) studied the association between Kaizen, TPM and innovation

performance in Malaysia, and their findings were that the combined effect of Kaizen and TPM enhanced the innovation performance of these companies. Belekoukias, Garza-Reyes and Kumar (2014) found that Kaizen had a modest contribution to the overall operational performance, which can be explained by Kaizen's role in sustaining the lean strategy through incremental improvements.

2.4 LM impact on safety performance

According to Anvari et al., (2011), employee safety is dependent on the development of empowered, knowledgeable, skilled and dynamic employees who are able to identify, reduce and eliminate risk. Accidents in the workplace are influenced by demotivated employees, a lack of instructions and training, poorly defined procedures and inadequate management commitment to safety (Marques et al., 2021). Marques (2021) notes that LM will reduce waste in the form of employee absenteeism, insurance claims and expenses due to damaged equipment.
Companies that adopt the LM philosophy, where both the social and technical aspects are practised, show improved employee safety and operational performance (Longoni et al., 2013). A study by Sá et al. (2021) found that the adoption of 5S and visual management resulted in productivity increases together with improvements in ergonomics, job satisfaction and safety when LM is implemented in a holistic manner. Srinivasan et al. (2015) also find that 5S implementation improves productivity and safety. Their study found that the levels of management commitment and employee involvement increased during the 5S activities with an improved safety climate of employees. Brawner et al. (2022) confirm that 5S has a positive safety and ergonomic impact.

TPM has a positive effect on employee health and safety (Longoni et al., 2013) . This is attributed to a focus on employee training, employee involvement in problem-solving and preventative maintenance, resulting in less frequent breakdowns, hence reducing their potential for injury. Brawner et al., (2022), find that TPM has both a positive and negative impact on safety. The simplification of work mitigates the associated hazards and reduces stress. However, work intensification increases stress. The adoption of JIT practices has a negative safety and ergonomic outcome (Brawner et al., 2022). According to Longoni et al. (2013), the adoption of JIT without human resource practises is akin to increasing waste removal and reducing cycle time with an unskilled and disengaged workforce. This, in turn, negatively influences the safety climate and performance.

The adoption of LM without the social element can have an undesirable impact on worker health and safety, where studies have identified "lean is mean" to employees, linking LM to higher levels of stress, poor health and increased injury (Longoni et al., 2013). Hasle et al. (2011) share this view as their research found that LM has adverse impacts on the safety, health and well-being of employees in manual, low-complexity jobs. This study also found that employee behaviour is influenced by the extent of employee involvement during the implementation process, with involved employees displaying lower levels of stress.

2.5 Critical success factors for LM implementation

LM transformation is a journey and, like other productivity improvement ventures, is difficult to implement, with few companies being successful at implementing LM (Jadhav et.al., 2014; Gupta and Jain, 2013; Netland, 2015). According to Bhasin (2008), less than ten percent of organisations in the United Kingdom have successfully implemented LM. While resistance to change is normal human behaviour, LM implementation requires both a cultural and attitude shift (Jadhav et. al., 2014). CSFs are the "few things that must go well" for the successful adoption of LM (Netland, 2016). Achanga et al. (2006) identified the CSFs essential for LM implementation within small and medium-sized organisations in the United Kingdom as management and leadership, expertise and skills, finance and organisational culture. This research indicated that leadership and management commitment are essential CSF, and the lack of financial resources results in low-skilled employees with limited training (Achanga et al., 2006).

LM must be integrated into the organisational strategy for successful implementation (Emiliani and Stec, 2005). This strategy should clearly indicate the organisation's vision and direction (Alefari et al., 2017). According to Hines et al., (2008), Hoshin Kanri is the Japanese term for policy and strategy deployment, which is a strategic management function that relates the organisational goals to all employees. Hoskin Kanri is an integral part of Japanese management, but it is invisible to outsiders as there is nothing to see, even though it may be functioning all around them (Nicholas, 2016). The Hoskin Kanri process involves breaking down the overall company objectives into smaller manageable departmental objectives to ensure alignment of all employees towards the organisational goals (Netland, Powell and Hines, 2019). A study by Gagnon and Michael (2003) found that blue-collar production employees who

were knowledgeable of the company's strategic objectives showed higher levels of job commitment, trust and job satisfaction.

Management or leadership commitment and involvement are identified as a CSF for LM implementation in most studies, irrespective of the contingencies (Netland, Powel and Hines, 2019). Lean transformation can be a challenging and long journey, with leadership responsible for guiding this process (Alefari et al., 2017). Leaders need to drive change by remaining true to the lean principles and values and maintaining the long-term vision. Visionary leaders with passion and integrity can be the reason for a successful Lean transition (Sahoo, 2018).

Organisational culture influences employee behaviour and their response to change (Hines et al., 2008). According to Zhou (2016), a supportive organisational culture that promotes communication, work, and growth is essential for successful LM implementation. However, the change from a traditional approach is challenging. According to Hines et al., (2008), employee engagement depends on the characteristics of the employees themselves, communication, training and the organisational culture. This process starts with employee acceptance of change. Employees will be resistant to the change if they do not have awareness and a clear understanding of the LM philosophy. According to Sahoo (2019), a factor that influences the negative perception of LM is that employees fear their positions may become redundant once LM is implemented. Managers need to address these fears with training and redeployment of the impacted employees (Sahoo, 2019). According to Hamja et al. (2019), organisational support during LM implementation will improve job involvement, awareness, and commitment and reduce employee's intention to leave. Training is a crucial part of the LM implementation process with all staff included regardless of department, position or role (Sahoo, 2019). Lean training will assist with the basic knowledge and skills required for improvement activities (Jadhav et al., 2014). Panizzolo et al. (2012) found that developing countries often lack the required technical skills. Therefore, expert consultants are recruited to close this knowledge gap. Local employees need to be trained to serve as lean specialists in pilot projects and further champion the case for LM.

Vermaak (2008) analysed the CSFs for LM implementation in SA. This research indicated that trade unions have a positive impact on LM success, when involved as a partner from the start of the LM implementation journey. There must be a relationship based on mutual trust, with open and honest communication and both parties focused on the sustainability of the company. Shah and Ward (2003), however, found that unionised plants did not have a significant impact on the implementation of Lean practices in the United States. Contrary to the previous two studies, Ebrahim (2011) found that trade unions are a barrier to LM implementation in the Eastern Cape, SA. Trade unions were rarely involved in the implementation process and, when involved, had limited information, knowledge and understanding of the outcomes from these Lean initiatives. Trade unions also viewed the training investment and the potential for salary increases as unfair if it led to additional work for employees.

3. Theoretical Framework

To address the objectives, these research questions are put forward: Can the implementation of LM improve safety performance and operational performance? as well as, what are the CSFs for LM implementation in the state-owned company under study? Seven hypotheses were formulated around the questions. A theoretical framework for evaluating the impact of the LM Tools (5S, TPM and Kaizen) on safety and operational performances and the CSFs that influence the implementation process was developed.

4. Research Approach

The study used a mixed methods approach. Primary data was selected over secondary data, as previous literature did not address South African state-owned companies. It was conducted at a state-owned company in SA who will remain anonymous due to confidentiality issues. Both qualitative and quantitative methods were used. Primary data was collected using questionnaires, and the gathered data was quantitatively analysed. The study population consisted of all employees who directly interact with the production department. The target population were employees within the maintenance, operations, laboratory, safety, waste management and engineering departments. The total number of identified participants was 45, and they were all included due to the small sample frame. The control variables in the study are the length of service and position in the company. Respondents ranked their current position in the organisation as operator, technician, supervisor, manager or executive manager using ordinal scales. Continuous scales were utilised to capture the respondent's length of service in the company.

The variables LM Tools, operational performance and safety performance were measured using the employee's perception of productivity, preventative maintenance, training, continuous improvement and employee involvement

in the state-owned company. The questionnaire provided statements that related each variable to the measurement criteria and requested respondents to rank these statements on a five-point Likert scale. The employee completely disagrees with the statement by rating it 1 while a rating of 5 indicates complete agreement. The performance measures for the CSFs for LM implementation variables are shown in Table 1. The critical success factors variables similarly used the employee's perception of the measurement criteria.

Table 1. CSFs variables and measures

Variable	**Measurement**	**Source**
Trade unions	Attitude	(Shah & Ward, 2003)
Employee involvement & empowerment	employee involvement	(Longoni et al., 2013), (Netland, 2015)
	employee empowerment	(Longoni et al., 2013),(Shah & Ward, 2007)
Leadership support and commitment	lead actively	(Netland, 2015)
	participate personally	(Netland, 2015)
Training and resources (financial, time and human)	resources	(Ghobakhloo et al., 2017)
	training	(Netland, 2015)
Strategy & Alignment	communication	(Netland, 2015)

Data from the questionnaire was analysed with IBM SPSS software. The quantitative data was initially captured in Microsoft Excel, then later coded and transferred to IBM SPSS to analyse the data. Statistics was utilised to describe the data and identify the relationships between the variables. The reliability was tested using Cronbach's alpha which gives a measure of the internal consistency of the test. A minimum value of 0.6 is regarded as adequate (Bougie and Sekaran, 2020).

5. Results and Discussion

A total of 32 completed surveys were received. However, one survey was neglected from the study, as the participant did not return the consent form. The response rate was 69%. A total of 45.2% had worked at the state-owned company for less than five years, while 48 % of the respondents were technicians.

The reliability analysis results are presented in Table 2.

Table 2. Reliability results

Variable	**No. of items**	**Cronbach's alpha**	**Items deleted**
LM Tools	9	0.692	0
Safety performance	9	0.807	0
Operational performance	9	0.834	0
Trade unions	2	0.610	0
Employee involvement and Empowerment	5	0.725	0
Leadership support and Commitment	3	0.856	0
Training and Resources	2	0.742	0
Strategy and Alignment	2	0.887	0

The descriptive statistics for the participants' length of service showed a mean of 12.7 years and a standard deviation of 12.3 years. A high standard deviation indicates that the data distribution is over a wide range, with employee's length of service varying from 1 year to 43 years. The frequency distribution for the position of respondents in the state-owned company revealed that 11. 48% of all respondents were technicians. So, the results of the study may be biased towards Technicians in the company and not represent the entire population.

For all the independent variables, data was gathered around the mean for all items, as the standard deviations were lower than the means for all items. For the variable LM tools, most of the respondents believed that the root cause analyses of incidents or failures were identified and that they could be more productive. Similarly, communications and training on the corrective actions from investigations were resoundingly received. Most of the participants were

satisfied with the housekeeping standards and affirmed that critical equipment rarely fails. Overall employee improvement suggestions are valued, and a majority strive to improve the processes. There was also a general awareness of the key performance indicators.

The descriptive statistics analyses for trade unions revealed that there was a lack of trust in the relationship between the trade unions and the state-owned company. Participants thought that trade unions would, however, support the implementation of LM. With regard to the variable employee involvement and empowerment, participants believe that they are encouraged to share ideas on improving processes and that they are involved in problem-solving and recognized for outstanding work. Although participants echoed that they receive training to improve their skills, they do not see opportunities within the organization.

For leadership commitment and support, it was observed that participants feel that leaders do not participate personally and do not lead actively. Participants cited a general lack of support for problem-solving and process improvement. The availability of leaders on shop floors was also lacking, and their role as role models was not visible. The descriptive statistics for training and resources showed that resources are not readily available for both improvement projects and training. Most respondents are aware of their contribution to the overall company strategy

The descriptive statistics analysis for the three dependent variables, namely, safety performance, operational performance and influence on LM implementation, had data clustered close to the mean for all items as the standard deviation was lower than the mean. Failure of critical equipment increases the risk of safety incidents, while ordinarily, process improvement leads to improved safety. Most respondents agreed that the communication and training of corrective actions reduce the possibility of re-occurrence while the re-occurrence of failure reduces productivity. For LM implementation, trade unions are concerned with the sustainability of the company.

5.1 Hypothesis Testing

Correlation Analysis

The Spearman correlation analysis can be found in Table 5, where the correlation coefficients for a significant number of independent variables have a strong to moderate relationship that may signify multicollinearity problems. Multicollinearity can be a problem in a multiple regression model when two or more independent variables are highly correlated which can lead to unreliable estimates of the regression coefficients (Bougie and Sekaran, 2020). According to Bougie and Sekaran (2020), multicollinearity can be identified using the variance inflation factor (VIF) with a common threshold of less than 10 being acceptable.

The independent variables that indicate a strong relationship are Leadership support and commitment and employee involvement and empowerment ($r = 0.764$, $p < 0.01$) and Leadership support and commitment and training and resources ($r = 0.842$, $p < 0.01$). The independent variables that show a moderate relationship are: Leadership support and commitment and trade union ($r = 0.478$, $p < 0.01$), Employee involvement and empowerment and training and resources ($r = 0.683$, $p < 0.01$), Employee involvement and empowerment and trade union ($r = 0.492$, $p < 0.01$), Training and resources and Strategy and Alignment ($r = 0.425$, $p < 0.05$), Training and resources and trade union ($r = 0.401$, $p < 0.05$).

The independent variables that show a moderate relationship are: Leadership Support and Commitment and Trade Union ($r = 0.478$, $p < 0.01$); Employee Involvement and Empowerment and Training and Resources ($r = 0.683$, $p < 0.01$); Employee Involvement and Empowerment and Trade Union ($r = 0.492$, $p < 0.01$); Training and Resources and Strategy and Alignment ($r = 0.425$, $p < 0.05$) and Training and Resources and Trade Union ($r = 0.401$, $p < 0.05$);

The Spearman correlation matrix for key variables indicates that: LM Tools has a strong positive statistically significant correlation to both Operational performance ($r = 0.858$, $p < 0.01$) and Safety performance ($r = 0.837$, $p < 0.01$); LM Implementation has a strong positive statistically significant correlation to the variables Employee Involvement and Empowerment ($r = 0.717$, $p < 0.01$), Leadership Support and Commitment ($r = 0.894$, $p < 0.01$) and Training and Resources ($r = 0.875$, $p < 0.01$); LM Implementation has a moderate positive statistically significant correlation to both Strategy and Alignment ($r = 0.446$, $p < 0.05$) and to Trade Unions ($r = 0.464$, $p < 0.05$).

Multiple regression analysis

The regression analysis for safety performance is shown in Table 3. The correlation analysis did not indicate any multicollinearity concerns for the safety performance variables. The VIF value for Model 1 is 1.130, and the Model

2 VIF range is 1.022 to 1.142. Thus, both these models are acceptable. Model 1 analyses the relationship between the control variables length of service (CV1) and position in the company (CV2) to the dependent variable safety performance (DV1).

$$DV1 = \beta 0 + \beta 1 CV1 + \beta 2 CV2$$

Model 2 analyses the relationship between the independent variable, LM Tools (IV1), and the dependent variable, safety performance.

$$DV1 = Model\ 1 + \beta 3 IV1$$

Table 3 Regression analysis for safety performance

Variables	**Dependent variable: Safety performance**	
	Model 1	**Model 2**
Constant	3.947***	0.93
Control variables		
CV1 - Service	0.112	0.033
CV2 - Position in company	0.024	0.073
Independent variable		
LM Tools		0.732***
R^2	1.10%	53.60%
ΔR^2	1.10%	52.50%
F-value	0.161	10.414***
ΔF-value	0.161	30.579***
VIF range	1.130	1.022 – 1.142

*p < 0.10; ** p < 0.05; *** p < 0.01

Model 1 displays the results associated with the control variables length of service and position in the company. The data shows a poor fit as the F value is not statistically significant (R2 =1.10%, F = 0.161, p > 0.1). The R2 indicated that the control variables account for 1.1% of the variation in the outcome of safety performance.

Model 2 assesses the additional impact of LM Tools. The model is a good fit and statistically significant (R2 =53.6%, F-value = 10.414, p< 0.01). LM Tools had a highly significant moderate positive impact (β = 0.732, p < 0.01) on safety performance. The LM Tools account for 52.5% of the variance in safety performance. The ΔR2 is also significant (ΔF = 30.579, p < 0.01). The control variables are not statistically significant.

The regression analysis for operational performance is displayed in Table 4. The correlation analysis did not indicate any multicollinearity concerns for the operational performance variables which was confirmed by the acceptable VIF values (VIF range 1.022 to 1.142).

Model 1 analyses the relationship between the control variables, length of service (CV1) and position in the company (CV2) to the dependent variable operational performance (DV2).

$$DV2 = \beta 0 + \beta 1 CV1 + \beta 2 CV2$$

Model 2 analyses the relationship between the independent variable LM Tools (IV1) and the dependent variable operational performance (DV2).

$$DV2 = Model\ 1 + \beta 3 IV1$$

Model 1 indicates the results associated with the control variables, length of service and position in the company. The data shows a poor fit as the F value is not statistically significant (R2 = 2.10%, F = 0.304, p > 0.1). The R2 indicated that the control variables account for 2.1% of the variation in the outcome of operational performance. The VIF is acceptable for Model 1.

Model 2 analyses both the control variables and LM Tools. The model is highly significant (R2 =72.8%, F value = 24.103; p < 0.01), with LM tools accounting for 70.7% of the variance in operational performance. The ΔR2 is also significant (ΔF = 70.198, p < 0.01). LM Tools had a highly significant positive impact (β = 0.85, p < 0.01) on operational performance. The VIF range for Model 2 is acceptable.

Table 4 Regression analysis for operational performance

Variables	**Dependent variable: Operational performance**	
	Model 1	**Model 2**
Constant	4.079***	0.002
Control variables		
CV1 - Service	0.09	-0.003
CV2 - Position in company	-0.089	-0.302
Independent variable		
LM Tools		0.85***
R^2	2.10%	72.80%
ΔR^2	2.10%	70.70%
F-value	0.304	24.103***
ΔF-value	0.304	70.198***
VIF range	1.130	1.022 – 1.142

*p < 0.10; ** p < 0.05; *** p < 0.01.

Table 5 shows the regression analysis for LM implementation. The correlation analysis indicated multicollinearity concerns for the following variables:

- Leadership support and commitment and employee involvement and empowerment,
- Leadership support and commitment and training and resources,
- Leadership support and commitment and trade unions,
- Employee involvement and empowerment and training and resources
- Employee involvement and empowerment and training and trade union
- Training and resources and Strategy and Alignment
- Training and resources and trade union

These variables were considered for regression analysis due to the VIF values being within the acceptable range (VIF < 10).
Model 1 describes the influence of the control variables, length of service (CV1) and position in company (CV2) to dependent variable LM implementation (DV3).

$$DV3 = \beta 0 + \beta 1 CV1 + \beta 2 CV2$$

Model 2 analyses the relationship between the control variables and the independent variable employee involvement and empowerment (IV2).

$$DV3 = Model\ 1 + \beta 3 IV2$$

Model 3 analyses the relationships between independent variables leadership support and commitment (IV3), employee involvement and empowerment (IV2) and control variables.

$$DV3 = Model\ 2 + \beta 4IV3$$

Model 4 analyses the relationship between independent variables training and resources (IV4), leadership support and commitment (IV3), employee involvement and empowerment (IV2) and control variables.

$$DV3 = Model\ 3 + \beta 5IV4$$

Similarly, Model 5 evaluates independent variables strategy and alignment (IV5), training and resources (IV4), leadership support and commitment (IV3), employee involvement and empowerment (IV2) and control variables.

$$DV3 = Model\ 4 + \beta 6IV5$$

Model 6 analyses the relationship between independent variables trade union (IV6), strategy and alignment (IV5), training and resources (IV4), leadership support and commitment (IV3), employee involvement and empowerment (IV2) and control variables.

$$DV3 = Model\ 5 + \beta 7IV6$$

Table 5 Regression Model for LM Implementation

Variables	**Dependent variable: LM Implementation**					
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
Constant	3.246***	0.571	0.211	0.313	0.377	0.374
Control variables						
CV1 - Service	0.082	-0.017	0.77	0.037	0.052	0.056
CV2 - Position in company	-0.173	0.135	0.302***	0.251**	0.171	0.155
Independent variable						
Employee Involvement and Empowerment		0.846***	0.22	0.182	0.09	0.079
Leadership Support and Commitment			0.83***	0.675***	0.744***	0.722***
Training and Resources				0.203	0.119	0.125
Strategy and Alignment					0.175	0.18
Trade Union						0.035
R^2	4.60%	63.70%	85.20%	86.20%	87.80%	87.90%
ΔR^2	4.60%	59.10%	21.50%	1.00%	1.60%	0.10%
F-value	0.556	12.87***	30.184***	24.93***	22.811**	18.645***
ΔF-value	0.556	35.815***	30.448***	1.432	2.55	0.104
VIF range	1.122	1.139 – 1.283	1.180 - 3.206	1.342 - 5.621	1.356 - 5.910	1.377 - 6.628

$^{*}p < 0.10$; $^{**}p < 0.05$; $^{***}p < 0.01$

Model 1 shows the influence of control variables length of service and position in company on LM implementation. The model is a poor fit with a statistically insignificant F value ($F = 0.556$, $p > 0.1$). The R2 indicates that 4.6% of the variation in LM implementation is due to the control variables.

Model 2 includes the independent variable Employee involvement and empowerment. The model is a good fit and statistically significant (R2 =63.7%, F value = 12.87; $p < 0.01$) with Employee involvement and empowerment accounting for 59.1% of the variance in LM Implementation. The ΔR2 is also significant ($\Delta F = 35.815$, $p < 0.01$).

Employee involvement and empowerment had a highly significant positive impact ($\beta = 0.846$, $p < 0.01$) on LM Implementation. The VIF range for Model 2 is acceptable

Model 3 tests the additional impact of Leadership support and Commitment. The data shows a good model fit ($R2 = 85.2\%$, F value = 30.184, $p < 0.01$). Leadership support and Commitment accounts for 21.5% of the variance in LM implementation. The $\Delta R2$ is also significant ($\Delta F = 30.448$, $p < 0.01$). Leadership support and Commitment had a highly significant positive impact ($\beta = 0.83$, $p < 0.01$) on LM Implementation. The control variable position in the company has a highly significant moderate positive impact ($\beta = 0.302$, $p < 0.01$). The VIF range for Model 3 is acceptable.

Model 4 assesses the addition of Training and resources. Although the data shows a good model fit ($R2 = 86.2\%$, F value = 24.93, $p < 0.01$), Training and resources accounts for 1.0% of the variance in LM implementation. $\Delta R2$ is not significant ($\Delta F = 1.432$, $p > 0.1$) and there was no significant impact of Training and resources on LM implementation ($\beta = 0.203$, $p > 0.1$). The addition of Training and resources resulted in the following:

- Position in the company had a significant weak positive impact ($\beta = 0.251$, $p < 0.01$).
- Leadership support and Commitment had a significant moderate positive impact ($\beta = 0.675$, $p < 0.01$).
- There was no significant impact of Length of service and Employee involvement and Empowerment on LM implementation.

The VIF range for Model 4 is acceptable.

Model 5 tests the influence of Strategy and Alignment. The data shows a good model fit ($R2 = 87.8\%$, F value = 22.811, $p < 0.05$). Strategy and Alignment accounts for 1.6% of the variance in LM implementation. $\Delta R2$ is not significant ($\Delta F = 2.55$, $p > 0.1$) and there was no significant impact of Strategy and Alignment on LM implementation. The addition of Strategy and Alignment resulted in the following:

- Leadership support and Commitment had a significant moderate positive impact ($\beta = 0.744$, $p < 0.01$).
- There was no significant impact of Length of service, Position in Company, Employee involvement and Empowerment and Training and resources on LM implementation.

The VIF range for Model 5 is acceptable

Model 6 assesses the additional impact of the Trade union. The data is a good model fit ($R2 = 87.9\%$, F value = 18.645, $p < 0.01$). Trade unions account for 0.1% of the variance in LM implementation. The $\Delta R2$ is insignificant ($\Delta F = 0.104$, $p > 0.1$), and there was no significant impact of the Trade Union on LM implementation. The addition of Trade Union resulted in the following:

- Leadership support and Commitment had a significant moderate positive impact ($\beta = 0.722$, $p < 0.01$).
- There was no significant impact on Length of service, Position in the Company, Employee involvement and Empowerment, Training and resources and Strategy and Alignment on LM implementation.

The VIF range for Model 6 is acceptable.

5.2 Discussion of Results

The correlation analysis indicated that the LM Tools have a strong positive statistically significant correlation to safety performance ($r = 0.837$, $p < 0.01$). The regression model found that the LM Tools had a highly significant moderate positive impact ($\beta = 0.732$, $p < 0.01$) on safety performance, with the LM Tools accounting for 52.5% of the variance in safety performance. The regression model thus supported Hypothesis 1 that LM Tools will have a positive influence on safety performance. Srinivasan et al., (2015) found that the implementation of 5S in the United States resulted in improved safety. These findings are consistent with a study by Longoni et al. (2013), who found that LM improved the health and safety of employees in Canada when adopted holistically with both the technical and human components.

The LM Tools have a strong positive statistically significant correlation to operational performance ($r = 0.858$, $p < 0.01$) as proposed by the correlation analysis. The regression model found that LM Tools had a highly significant moderate positive impact ($\beta = 0.85$, $p < 0.01$) on operational performance, with LM Tools accounting for 70.7% of the variance in operational performance. These findings thus support Hypothesis 2 that LM Tools have a positive impact on operational performance. This is consistent with a study by Longoni et al., (2013), who also found that LM implementation leads to improved safety and operational performance. Shah and Ward (2003) found that LM practices contribute positively to operating performance, especially when implemented in bundles. Sahoo and Yadav (2017)

concur with this notion, and their studies have found that simultaneous implementation of both TPM and TQM leads to better operational performance than if implemented separately.

The correlation analysis indicated that the correlation coefficients for a number of independent variables have a strong to moderate relationship that may point towards multicollinearity problems. These variables are:

- Leadership Support and Commitment, as well as Employee Involvement and Empowerment,
- Leadership Support and Commitment, together with Training and Resources,
- Leadership Support and Commitment and Trade Union,
- Employee Involvement and Empowerment, as well as Training and Resources
- Employee Involvement and Empowerment and Training and Trade Union
- Training and Resources and Strategy and Alignment
- Training and Resources and Trade Union

The high correlation coefficient between these variables may indicate that they coexist and are interdependent in this state-owned company. The VIF values were within the acceptable range for regression analysis. Hypothesis 3 proposed that Employee Involvement and Empowerment has a positive influence on LM implementation. This hypothesis was supported by the correlation analysis, Employee Involvement and Empowerment has a strong positive statistically significant correlation to LM implementation ($r = 0.717$, $p < 0.01$). The regression analysis supported this finding that Employee Involvement and Empowerment has a highly significant positive impact ($\beta = 0.846$, $p < 0.01$) on LM implementation. This finding is consistent with research by Alefari et al., (2020), Yuik et al., (2020) and Netland (2016), who have identified Employee Involvement and Empowerment as the CSFs for LM implementation.

Hypothesis 4 predicted that Leadership Support and Commitment has a positive impact on LM implementation was supported by both the correlation and regression analysis. The correlation analysis found that Leadership Support and Commitment has a strong statistically significant correlation to LM implementation ($r = 0.894$, $p < 0.01$). The regression analysis reinforced this finding that Leadership Support and Commitment has a highly significant positive impact ($\beta = 0.83$, $p < 0.01$) on LM Implementation. This finding is consistent with literature as studies by Achanga et al., (2006), Netland (2019) and Tortorella et al., (2018) all identified Leadership Support and Commitment is the most important CSFs.

Hypothesis 5 proposed that Training and Resources was positively related to LM Implementation was not supported. The correlation analysis supported this proposition finding a strong positive statistically significant correlation ($r = 0.875$, $P < 0.01$) between the variables. However, the regression analysis did not find a statistically significant impact on LM Implementation ($\beta = 0.203$, $p > 0.1$). This is inconsistent with previous research by Netland (2016), Sahoo (2019) and Jadhav et al., (2014), who find that training and resources is a CSF. According to research by Lai et al., (2022), workers' attitudes towards LM training programs are dependent on the benefit and reward that they anticipate from the training activity, with positive outcomes linked to both rewards and benefits. This study also finds that employees' attitudes and participation in training programs may be influenced by constraints from the work environment. The respondents indicated that there is a lack of recognition and growth opportunities within the company, which could negatively influence their attitude towards training. This could possibly explain this deviation from the previous research.

Hypothesis 6 posited that Strategy and Alignment is positively related to LM Implementation was not supported. The correlation analysis indicated a moderate positive statistically significant correlation ($r = 0.446$, $p < 0.05$). However, this was not supported by the regression analysis that found no statistically significant impact of Strategy and Alignment on LM Implementation ($\beta = 0.175$, $p > 0.1$). According to Yuik et al., (2020), alignment to strategy is a CSF for LM implementation. Hines et al. (2008) share this view as Strategy and Alignment is a core cultural aspect of the SLIM model. Gagnon and Michael (2003), find that employees who are informed of the organisational strategy have a positive work attitude, are better performers and exhibit more trust. The employee attitude in the state-owned company is complex, with little trust in management as indicated in the survey, this may contribute towards this deviation from previous literature.

Hypothesis 7, which proposed that Trade Unions have a positive influence on LM Implementation, is not supported. The correlation analysis found a moderate positive statistically significant correlation ($r = 0.464$, $p < 0.05$) between the variables. The regression analysis did not find a statistically significant impact of trade unions on LM implementation ($\beta = 0.035$, $p > 0.1$). The influence of Trade Unions on LM Implementation in SA is dependent on the relationship between leadership and the trade union, organisational culture, political affiliations and an understanding of the LM

principles by both the trade union and leadership (Vermaak, 2008; Ebrahim, 2011). According to Vermaak (2008), Trade Unions have a positive influence on LM Implementation when involved as a partner at the start of the LM process, based on a relationship of mutual trust. Ebrahim (2011) however, identified Trade Unions as a barrier to LM Implementation who linked LM to exploitive labour practises. This research is consistent with the work of Shah and Ward (2003), who established that Trade Unions in the United States have no effect on LM Implementation.

5.4 Graphical Results

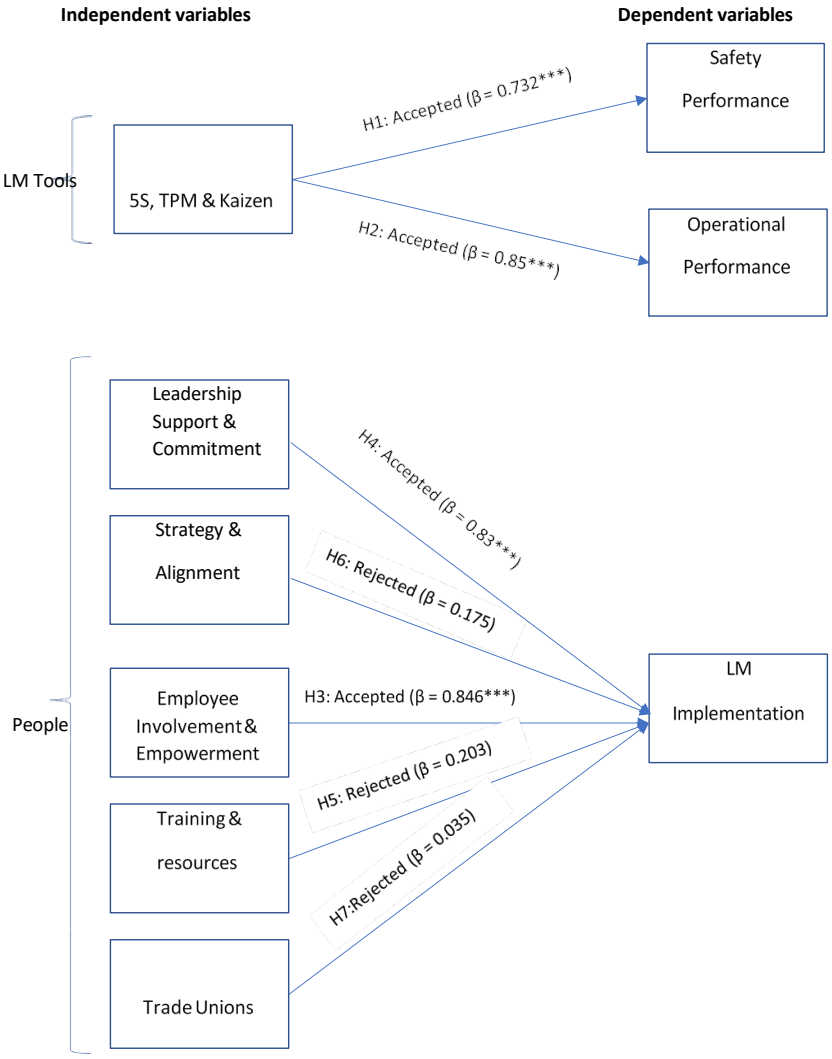

Figure 1: Summary Results

6. Conclusions

The goal of the research was to evaluate the impact of LM on safety and operational performance and then identify the CSFs that will influence implementation within a South African state-owned company. The research questions are reviewed to determine whether the study met its objectives.

Q1: Can LM improve safety performance?

This question was addressed by hypothesis (H1), which was tested using correlation and multiple regression analysis.

The results indicate that LM Tools have a positive impact on safety performance. This finding is consistent with research by Longoni et al., (2013), Srinivasan et al., (2015) and Marques et al., (2021), which found that LM improves occupational health and safety performance when implemented holistically.

Q2: Can LM improve operational performance?

Question 2 was addressed by hypothesis (H2), which was also tested using correlation and multiple regression analysis. LM Tools were found to have a positive impact on operational performance. This finding has been confirmed by a number of researchers: Shah and Ward (2003, 2007), Sahoo and Yadav (2020, 2017) and Bashar, Hasin and Jahangir (2020). The operational performance is enhanced when LM tools are implemented in bundles instead of individual tools (Shah and Ward, 2003; Sahoo and Yadav, 2020).

Q3: What are the critical success factors that influence LM implementation?

This question was addressed by the hypotheses H3, H4, H5, H6 and H7 that were tested using correlation and multiple regression analysis. The CSFs identified were Employee Involvement and Empowerment and Leadership Support and Commitment. According to Bashar et al., (2020), Yuik et al., (2020), Netland (2016) and Coetzee et al., (2016), Employee Involvement and Empowerment is crucial for sustainable LM implementation. Leadership Support and Commitment was also supported as a CSF, this is cited as the most important of all CSFs for LM Implementation (Netland et al., 2019; Sahoo, 2019 and Alefari et al., 2017). There was not sufficient evidence to support Strategy and Alignment, Trade Union and Training and Resources as CSFs. This research indicates that the CSFs applicable in other companies differ from that of the South African state-owned company, which may be influenced by its unique organisational culture.

7. Recommendations for Future Research

This research was conducted on the production and supporting services at the state-owned company, where the majority of respondents were Technicians, i.e. blue-collar workers. The results may, therefore, not be representative of the entire company or other state-owned companies. Future research may need to consider the entire company and include other state-owned companies. It may also be interesting to investigate the management behaviours, employee attitudes and organisational culture within these companies to determine how this influences LM implementation.

Add conclusion here. Make sure to address that all objectives are met and emphasize of unique research contribution (10 font)

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