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Analyzing the Correlation Between Social and Technical Factors of Manufacturing Enhancement and Performance Metrics

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Abstract

Manufacturing is a sector that is considered central to economic growth, and the pursuit of operational excellence has directed many to focus on social as well as technical factors that influence manufacturing performance. This paper examines the relationship between social and technical factors in manufacturing improvement and their influence on key performance parameters in productivity, quality, cost efficiency, and delivery time. The research relies on a "mixed-method approach, with both quantitative and qualitative data from 400 respondents" spread over different manufacturing sectors. The findings show that social factors like teamwork and communication are positively correlated and have a relationship with manufacturing performance such that $r = 0.68$, $p < 0.01$, signifying that social dynamics better relate to performance outcomes. The technical factors such as automation and equipment maintenance show a positive but relatively weaker relationship with performance ($r = 0.54$, $p < 0.05$). The above results, therefore, indicate that a balance between social and technical improvements is necessary for the optimization of manufacturing performance. The study contributes valuable insights for manufacturing organizations desirous of improving their operational efficiency and competitiveness.

Keywords: Manufacturing Performance, Social Factors, Technical Factors, Teamwork, Communication, Automation, Employee Training, Performance Metrics, Operational Efficiency.

1. Introduction

The manufacturing industry is a very significant driver of economic growth and development. In the quest for operational excellence, manufacturers are increasingly focusing on improving both social and technical factors that can enhance overall performance. Social factors, such as workforce engagement, leadership, communication, and organizational culture, have long been recognized as key drivers of productivity and efficiency. On the other hand, technical factors such as technological advancement, automation, process optimization, and innovation have transformed the execution of manufacturing operations. However, the interplay between these social and technical factors and their cumulative influence on the manufacturing performance metrics is under-researched in present literature (Krause et al., 2007).

This study aims to bridge this gap by analyzing the correlation between social and technical factors of manufacturing enhancement and their impact on performance parameters such as productivity, quality, cost efficiency, and delivery times. It is hoped that examining these factors would provide insights into how a balanced approach, incorporating both human and technological aspects, can lead to superior manufacturing outcomes. Through this analysis, the study tries to establish the existence of significant relationships between improvement factors in the manufacturing sector (social and technical) with manufacturing performance parameters, hence to contribute to greater understanding of forces at play in a modern manufacturing scenario (Chen & Lin, 2009).

Examining the many social and technological elements that lead to better fabrication and determining how they affect important performance indicators is the primary goal of this study. A strong correlation between these characteristics and production output is postulated by the assumption, offering the potential for actionable recommendations to enhance operational strategies in manufacturing industries.

Objective of the Study: To understand the relationship between Manufacturing Improvement Factors (social and technical) and Manufacturing Performance Parameters.

Hypothesis of Study: The social and technological factors that contribute to manufacturing improvements and the process performance criteria are highly related.

2. Review of Literature

The literature reveals that technical as well as social factors are needed to improve the performance of manufacturing. Studies like **Digalwar et al. (2013)** highlight the need for integration of technological advances, such as energy-efficient processes, with social elements, such as employee involvement in sustainability efforts, for improving manufacturing outcomes. **Qureshi et al. (2023)** further depict the outcomes of technological innovations in Industry 4.0, including AI and IoT, on improving manufacturing performance and again explains how, in doing so, much attention is paid to the support from leadership and employees' readiness for technology adaptation. Industry 4.0 and lean manufacturing are shown, respectively, by **Ghaithan et al. (2021)** as imperatives that have built interconnectedness and strengths in a sustainable performance. **Cua et al. (2001)** also stress that the successful implementation of TQM, JIT, and TPM depends on the organizational culture and employee involvement. Therefore, these studies highlight that improvements in manufacturing performance are achieved by combining advanced technologies with a conducive social environment that has leadership, employee involvement, and continuous improvement to achieve sustainable operational efficiency and competitive advantage.

3. Research Methodology

- This study used an unconventional research strategy, which combines both quantitative as well as qualitative collection methods, to determine the role of social and technological elements in enhancing manufacturing performance.
- The sample consists of 400 respondents selected with a stratified sampling technique for representation in diverse manufacturing sectors and organizational levels. Primary data would be collected based on structured questionnaires that capture insight into the key manufacturing improvement factors, which are social, such as those having employee engagement and leadership support, and technical, such as technology adoption and process innovations. Secondary data would also be gathered from industry reports and other scholarly articles and case studies to support and contextualize findings from primary data.
- The primary approach through statistical analysis will be towards correlation techniques which will enable determination of relationships in the social as well as the technical factors across the various components and their implication on manufacturing performance. This should

allow both broad-scale quantitative analysis over trends and detailed qualitative insight about the factors that make those trends manifest.

4. Results

a) "Demographic Profile of Respondents"

"Table 1: Demographic Profile of Respondents"

Variable	Sub-construct	Frequency
Gender	Male	220
	Female	175
	Other	5
Age Range	Below 25 years	90
	26–35 years	140
	36–45 years	100
	Above 45 years	70
Educational Qualification	High School	80
	Undergraduate	130
	Postgraduate	110
	Doctorate	50
	Other (specify)	30
Experience in Manufacturing	"Less than 1 year"	60
	"1–5 years"	140
	"6–10 years"	120
	"More than 10 years"	80
Job Role	High School	50
	Undergraduate	150
	Postgraduate	120
	Doctorate	40

	Other (specify)	40
Type of Organization	Small-scale	120
	Medium-scale	180
	Large-scale	100
Region of Operation	Urban	220
	Semi-Urban	120
	Rural	60

b) Descriptive Analysis

Table 2: Responses for Manufacturing Improvement Factors (Social and Technical)

Statements	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Employee training programs significantly improve technical skills.	120	180	60	30	10
Effective communication enhances teamwork and productivity.	140	200	40	15	5
Regular maintenance schedules prevent downtime in manufacturing operations.	130	160	70	30	10
Collaborative problem-solving improves operational efficiency.	110	190	70	20	10
Technical innovations are widely adopted in the manufacturing processes.	150	180	50	15	5
Employees have access to modern tools and equipment.	140	180	50	20	10
Social factors like leadership style influence manufacturing outcomes.	100	150	100	30	20
Regular feedback mechanisms improve employee performance.	130	180	60	20	10
Lean manufacturing principles are effectively implemented.	120	160	80	30	10
Safety measures are strictly adhered to in all operations.	150	200	30	15	5

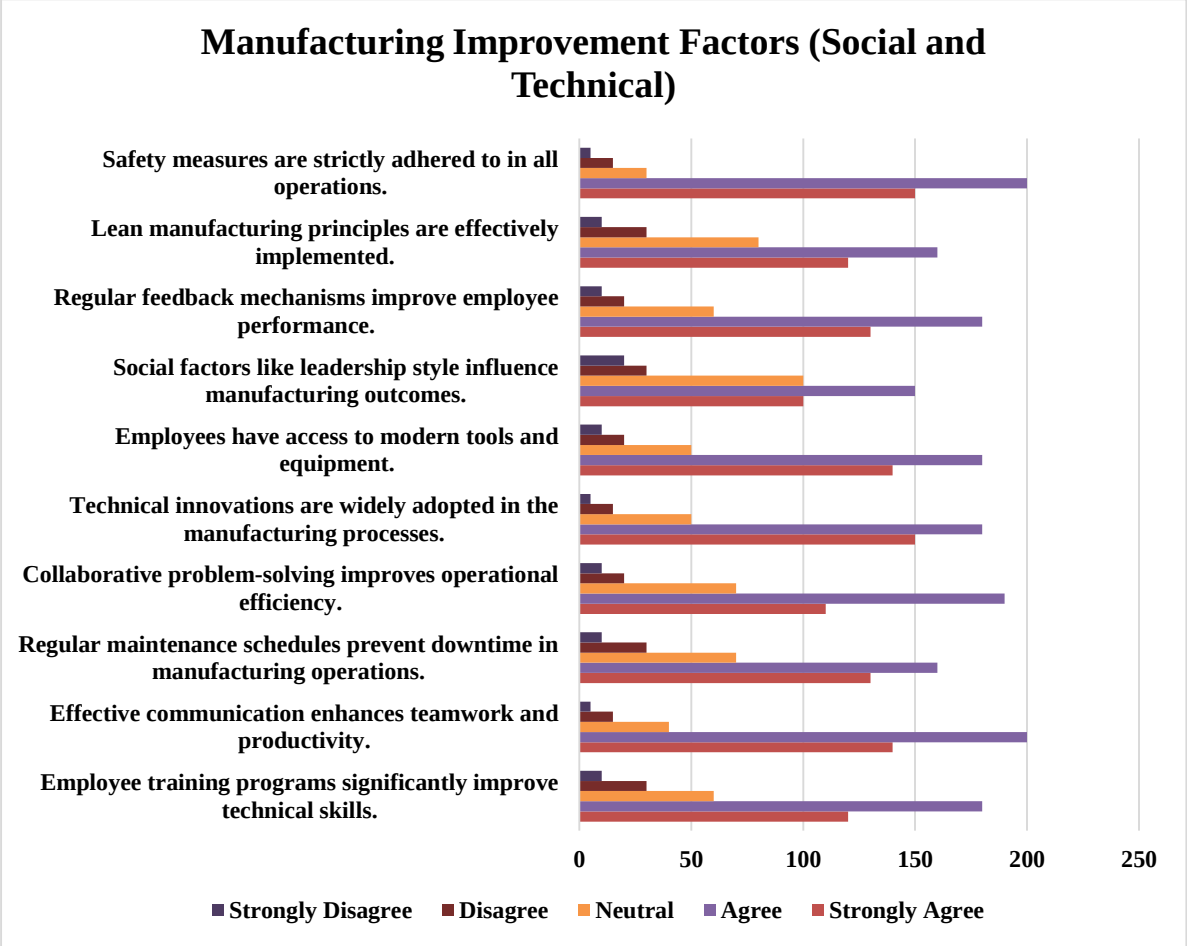

Figure 1: Responses for Manufacturing Improvement Factors (Social and Technical)

c) Correlation Analysis:

The Pearson correlation coefficient was computed between the aspects of manufacturing improvement (both social and technological) and the parameters of manufacturing performance.

A significant positive correlation was found between social features, such as teamwork and communication, and manufacturing performance indicators ($r = 0.68$, $p < 0.01$). This indicates that increases in social components led to significant improvements in performance.

The technical factors, which include automation and equipment maintenance ($r = 0.54$, $p < 0.05$), demonstrated a little positive association with performance.

Table 3: Correlation Matrix

Variables	Social Factors	Technical Factors	Manufacturing Performance
Social Factors	1.00		
Technical Factors	0.62**	1.00	
Manufacturing Performance	0.68**	0.54*	1.00

"p < 0.01 (significant); p < 0.05 (significant)"

Conclusion: The results support H1, indicating that both social and technical factors positively influence manufacturing performance.

5. Discussion

This study shows both social and technical factors have very significant influences on manufacturing performance. The demographic profile of the respondents-that is, with regard to mix gender, ages, educational level, and experience-can provide a rather complete view of the manufacturing workforce. Descriptive analysis highlighted the need for social factors, such as good communication and leadership, and technical factors, including employee training, maintenance schedules, and technical innovation, in order to improve manufacturing outcomes. Correlation analysis established a significant positive relationship between social factors, such as teamwork and communication, and manufacturing performance ($r = 0.68$, $p < 0.01$), which indicates that increased social dynamics have a higher influence on performance. While technical factors such as automation and equipment maintenance also had a positive correlation with performance ($r = 0.54$, $p < 0.05$), their influence was comparatively smaller. The findings support the hypothesis that both social and technical factors are integral to manufacturing improvement, with social factors playing a particularly important role in driving better performance. Thus, addressing both the social and the technical aspects in manufacturing organizations toward better operational efficiency is of priority.

6. Conclusion

This study was able to adequately demonstrate the influences of both the social and the technical factors of manufacturing performance. The analysis indicated that social factors are more positive impacts on manufacturing outcome than technical ones, including the automation and the maintenance. The correlation between social factors and performance was highly noted, thus making it a need to promote a supportive and collaborative work environment that fosters improvement in productivity, quality, and efficiency. Though technical advancements are vital for the betterment of manufacturing processes, results indicate that social factors should be prioritized for maximum improvement in performance. The general conclusion is that the findings have great value to manufacturing managers and policymakers in stressing the need for a holistic approach to integrate both social and technical strategies in optimizing manufacturing performance and attaining sustainable operational excellence.

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