

AN ASSESSMENT OF INDUSTRY 4.0 FOR SMEs MATURITY LEVEL IN SELECTED DISTRICTS OF PUNJAB

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Abstract: This research focused on the assessment of the organisational maturity level of SMEs in four different districts of Punjab, India. For the purpose of this research, focused on the analysis of both primary and secondary data. This research further provided a clear understanding of the benefits, challenges, and barriers of Industry 4.0 with respect to the operations of SMEs in Punjab. Further, this study represented the contribution of different pieces of literature with respect to the importance of the maturity model and awareness levels of innovative technologies. The research successfully identified key factors impacting Industry 4.0 adoption in Punjab's SMEs, including awareness levels, fiscal incentives, data security, and decision-making effectiveness. It emphasized that higher awareness about data security and fiscal incentives positively influences the prioritization of smart factories and advanced technologies. Informed decision-making was found to be pivotal for successful technology implementation. Despite challenges, Industry 4.0 offers significant benefits, such as enhanced operational efficiency and cost savings, which can drive progress in Punjab's steel industry. The research provides practical insights for policymakers, industry leaders, and SMEs, facilitating informed decisions and potential growth in the industrial sector.

Keywords: SMEs, Punjab, Maturity level, Industry 4.0, Benefits, Challenges, Innovative practices, Technological implementations.

1. Introduction

Punjab is a home for different manufacturing enterprises with a common corporate vision to generate more growth and attain better competitive advantages. This further resulted in the development of a comprehensive business environment focused on SMEs (Small and Medium-sized Enterprises) (Goel *et al.* 2022). This comprehensive business environment in Punjab including different SMEs, has been known to be the backbone of the Punjab economy (Suranga and Rahman, 2014). This research has been conducted to find out the maturity level of SMEs in different districts of Punjab. Implementing Industry 4.0 in the Indian and Punjab steel sectors involves integrating cutting-edge technologies and digitalization to boost efficiency, productivity, and competitiveness. Key steps include deploying IoT sensors for real-time data collection, automating tasks through robotics, harnessing big data and machine learning for optimization, and adopting digital twins for process simulation. Efficient supply chain management, cybersecurity, and energy-saving measures are paramount. Workforce training, government support, and industry partnerships facilitate smooth transition. Punjab, as an industrial hub, can leverage these strategies to lead the industry 4.0 revolution in India's steel industry, fostering growth and sustainability. For the purpose of this study, the perspective of Industry 4.0 has been addressed for better understanding. Concerning this, this research identified four objectives to meet by the end and these are:

“To identify the benefits, challenges and barriers to Industry 4.0 in the selected industries of Punjab”

“To explore the awareness among selected industries of Punjab to build smart factories using innovative technologies”

Based on these identified research objectives, this research has been conducted.

2. Literature Review

Small business enterprises in Punjab, India are known to be influenced by financial leverage (Iqbal and Ahmad, 2021). The financial leverage of SMEs in Punjab India has been identified to have several relationships between family, tax, sales and many other organisational, personal and governmental

aspects (SINGH *et al.*, 2019). SMEs in Punjab regarding this concept have identified customer loyalty to be a determinant factor (Kumar *et al.* 2022). Customer loyalty can influence organisational performance and thus can help improve financial growth (SINGH *et al.*, 2019). Alongside this, organisational flexibility, design and other aspects help to increase overall efficiency and effectiveness which further contribute towards organisational maturity (Ali and Johl, 2022). The maturity level of an organisation defines the interrelation capabilities of multiple dimensions of that respective organisation (Sharma and Mishra, 2021). The organisational maturity level can also be linked with manufacturing processes and the organisational activities regarding Industry 4.0. The Indian steel industry is the second-largest producer of crude steel in the world, with a production capacity of 142.3 million tonnes in 2020. The industry has been growing at a CAGR of 5.2% over the last decade and is expected to continue growing at a similar rate in the coming years (India Brand Equity Foundation, 2020). Despite the COVID-19 pandemic, India's crude steel production increased by 25.6% YoY in 2020, reaching 111.2 MT. The industry's growth has been fairly organic, and it can provide an economic boost to India (PwC, 2019).

Due to the diversification of technologies included in the concept of Industry 4.0, it can also incur several challenges to SMEs irrespective of their operational industries (Hussain *et al.* 2021). Organisations can integrate the mitigation techniques of the identified challenges into their organisational culture which may benefit Industry 4.0 (Farooq and Vij, 2018). Organisations in this context can further take guidance to form a company-specific Industry 4.0 organisational vision (Din *et al.* 2022). This organisational vision can further help to increase their chances of attaining higher organisational maturity levels (Tripathi *et al.* 2022). These can further help to identify and cater to the challenges in the production and distribution aspects of the organisations. Organisations in Punjab are identified to take different approaches to Industry 4.0 (Nazim *et al.* 2022). Considering these approaches, SMEs in Punjab can be seen to focus on the organisational vision of the implementation of technology (Tang *et al.* 2022). This further proves a mediating role between organisational performance and organisational entrepreneurial orientation (Farooq and Vij, 2018). Small and medium-sized enterprises in Punjab can be found to focus on organisational performance and are trying to achieve so through the implementation of relevant practices relating to Industry 4.0 (Kumar *et al.* 2022).

Information and Communication Technology (ICT) has become a critical aspect of organisational growth in Industry 4.0 (Akkaya *et al.* 2021). Along with ICT, IoT (Internet of Things) and other IT (Information Technology)-related technologies have become the main implementation contexts for SMEs in Punjab (Chadha *et al.*, 2018). These technological implementations with regard to Industry 4.0 can be defined to benefit organisations in increasing their respective maturity levels (Javaid *et al.* 2021). SMEs in Punjab can also be seen to be run by family generations which further can be defined as a benefit towards increasing the maturity level (Cetinkaya and Unsacar, 2021).

Based on the identified research objectives, the below-mentioned hypotheses have been developed.

Hypothesis for Objective 2

H0a: "There are no benefits, challenges and barriers to Industry 4.0 in the selected industries of Punjab"

H1a: "There are benefits, challenges and barriers to Industry 4.0 in the selected industries of Punjab"

Hypothesis for Objective 3

H0b: "There is no significant impact of awareness on building smart factories using innovative technologies"

H1b: "There is a significant impact of awareness on building smart factories using innovative technologies"

3. Methodology

This research has focused on a descriptive research design to assess the manufacturing SMEs of Punjab. While doing so, this research further focused on a primary data collection technique which included a questionnaire. For the purpose of gathering responses to the questionnaire, this research focused on four different districts in Punjab namely "Ludhiana, Mohali, Kapurthale and Fatehgarh". From these districts, manufacturing industries that are adopting or planning to adopt Industry 4.0 practices have been included in this research. With respect to this, a Cochran formula has been used for the determination of the sample size to be included in this research.

The formula for the evaluation of the sample size for this research has been $n_0 = z^2pq / e^2$. This formula included “e” which represented the level of precision (Margin of error), “p” which defined the estimated proportion of the whole population, and “q” represented the value of (1-p). From this formula, the evaluated sample size has been calculated which resulted in the sample size to be 385.

The 385-sample size cannot be able to ensure reliability of the whole population and thus a sample size of 500 has been used for this research. Depending on this sample size and the four different districts, 125 respondents have been decided to be included in the survey from each district. Categorised responses have been collected from consultants, other experts, managers, administrative personnel and technicians. This research has included primary data collection through a well-structured questionnaire. For the purpose of secondary data collection, an analysis has been decided to be followed in this research. For further evaluation, different inferential and descriptive tools have been used. SPSS and MS Excel have mostly been used in this research.

4. Result and Analysis

The frequency table shows the frequency of the four identified districts. From the above representation, it can be evaluated that all gathered responses from the identified districts are valid. It can further be derived that among the responses, Ludhiana accumulated 23%, Mohali 50%, Fatehgarh 73% and Kapurthala 100%.

Table 1: Frequency Analysis based on District Factor

	Frequency	Percent	Cumulative Percent
Ludhiana	119	23	23
Mohali	142	27.5	50.5
Fatehgarh Sahib	120	23.2	73.7
Kapurthala	136	26.3	100
Total	517	100	

The gender frequency table defines all responses to be valid and male respondents accumulated to be around 49.3% whereas females accumulated to be 100%.

Table 2: Frequency Analysis based on Gender Factor

	Frequency	Percent	Cumulative Percent
Male	255	49.3	49.3
Female	262	50.7	100
Total	517	100	

The frequency table for professionals has also shown validity and responses from managers accounted for around 24.4%, technician 50.7%, administrative 74.9% and consultant 100%.

Table 3: Frequency Analysis based on Professional Level

	Frequency	Percent	Cumulative Percent
Manager	126	24.4	24.4
Technician	136	26.3	50.7
Administrative	125	24.2	74.9
Consultant	130	25.1	100
Total	517	100	

“To identify the benefits, challenges and barriers to Industry 4.0 in the selected industries of Punjab”

Table 4: Pearson Correlation

		Adopting Industry 4.0 technologies essential for success	benefits of implementing Industry 4.0 technologies	Operational efficiency, innovation and competitiveness.	advantage of building smart factories	Industry 4.0 drives greater visibility	increase the revenue of the organization
	Sig. (2-tailed)	0	0	0	0	0	
	N	517	517	517	517	517	517
resistance to change, organizational culture, or cyber security concerns	Pearson Correlation	.967**	.914**	.956**	.946**	.959**	.971**
	Sig. (2-tailed)	0	0	0	0	0	0
	N	517	517	517	517	517	517
Lack of unified leadership is a huge challenge	Pearson Correlation	.885**	.809**	.940**	.949**	.958**	.946**
	Sig. (2-tailed)	0	0	0	0	0	0
	N	517	517	517	517	517	517
is facing challenges in adopting Industry 4.0 technologies	Pearson Correlation	.953**	.891**	.955**	.963**	.971**	.977**
	Sig. (2-tailed)	0	0	0	0	0	0
	N	517	517	517	517	517	517
Overcoming the challenges related to Industry 4.0	Pearson Correlation	.955**	.915**	.953**	.881**	.925**	.950**
	Sig. (2-tailed)	0	0	0	0	0	0
	N	517	517	517	517	517	517
active exploration of ways to overcome the challenges	Pearson Correlation	.961**	.906**	.967**	.972**	.958**	.977**
	Sig. (2-tailed)	0	0	0	0	0	0
	N	517	517	517	517	517	517

“Adopting Industry 4.0 technologies essential for success” attained a mean score of 2.17 which proved this factor to be less critical. The “Clear roadmap and action plan for Industry 4.0” factor has a higher mean score which depicted moderate variability and a good amount of significance. The factor “Smart factories using innovative technologies strategic priority” has a mean score of 2.28 which also defined moderate importance considering some variations. The factors “Awareness about the importance of data

security and privacy”, “Willingness to invest in research, development”, “Awareness about fiscal incentives”, and “Operational efficiency, innovation and competitiveness” scored a good amount which depicted significant importance of these factors. On another hand, “Keen interest in learning” and “Benefits of implementing Industry 4.0 technologies” obtained lower scores which defines a lesser amount of importance.

Correlation ranged from -0.809** to -0.946** in this analysis which further can be defined as statistically significant due to the score being lower than 0.001. Depending on this, it can be said that organisations are facing challenges due to a lack of unified leadership and these organisations are less likely to adopt Industry 4.0. A similar result can be seen regarding the coefficient range for the identification of mitigation strategies. From this, it can be said that organisations are taking different approaches towards the reduction of these challenges. All values have been identified to be under 0.005 which defines the acceptance of “H1a”.

“To explore the awareness among selected industries of Punjab to build smart factories using innovative technologies”

Table 5: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.979 ^a	0.958	0.958	0.286
a. Predictors: (Constant), keen interest in learning , assisting them in decision making, aware about the importance of data security and privacy, aware about the Fiscal Incentives , seeking knowledge and expertise on building smart factories				

Table 6: ANOVA ANALYSIS

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	951.013	5	190.203	2327.615	.000 ^b
	Residual	41.757	511	0.082		
	Total	992.77	516			
a. Dependent Variable: smart factories using innovative technologies strategic priority						
b. Predictors: (Constant), keen interest in learning , assisting them in decision making, aware about the importance of data security and privacy, aware about the Fiscal Incentives , seeking knowledge and expertise on building smart factories						

Coefficients ^a						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-0.043	0.027		-1.606	0.109
	aware about the importance of data security and privacy	0.246	0.041	0.258	5.976	0
	aware about the Fiscal Incentives	0.255	0.039	0.261	6.531	0

assisting them in decision making	0.053	0.022	0.064	2.367	0.018
seeking knowledge and expertise on building smart factories	0.122	0.042	0.123	2.888	0.004
keen interest in learning	0.339	0.032	0.301	10.498	0
a. Dependent Variable: smart factories using innovative technologies strategic priority					

From the evaluated results, it can be said that organisations that are showing keen interest in learning, showing awareness of fiscal incentives and data security, and prioritising decision-making can be defined as more likely to implement innovative technologies. The p-value has been identified to be less than .005 which defines the significance level. Due to this, the null hypothesis (H0b) has been rejected whereas, the alternative hypothesis (H1b) has been accepted. Based on this, it can be evaluated that “there is a significant impact of awareness on building smart factories using innovative technologies”.

4.1 Discussion

Concerning the findings from the primary data, it can be evaluated that there are different benefits associated with Industry 4.0 technological implications. Along with these benefits, there are several challenges that SMEs in Punjab are trying to mitigate by applying different approaches and practices (Narwane *et al.* 2021). From the findings, it can also be found that there are several aspects related to the awareness levels of smart factories and innovative technological implementations for Industry 4.0 (Van Berkel, 2018). Concerning this, it can further be found that decision-making, fiscal incentives and data security are major aspects of awareness related to Industry 4.0 that can be defined as requirements. Based on primary data, Industry 4.0 offers advantages to Punjab's SMEs, including increased efficiency and cost reduction. Despite challenges, such as decision-making and data security, awareness of smart factories and technological advancements is vital. This awareness can lead to informed decisions, fiscal incentives utilization, and higher-quality steel production, ultimately benefiting Punjab's steel industry.

5. Conclusion

Depending on this research, it can be concluded that there can be different benefits, challenges and barriers associated with the implementation practices of Industry 4.0 in steel industry of Punjab. Based on this research, it can also be concluded that there can be different theoretical implications based on organisational needs and demands. This study further concluded that awareness levels related to fiscal incentives, decision making and data security can be major determinants for the adaptation capabilities of Industry 4.0 of organisations situated in different locations of Punjab. The research findings underscore the critical importance of several key factors in shaping the landscape of Industry 4.0 adoption within Punjab's SMEs. Notably, the study has demonstrated that heightened awareness levels, particularly concerning data security and fiscal incentives, are pivotal drivers in motivating SMEs to prioritize the implementation of smart factories and innovative technologies.

Furthermore, the research has illuminated the paramount significance of informed decision-making processes. Organizations that excel in this regard exhibit a greater propensity for the successful integration of Industry 4.0 technologies, thus positioning themselves for enhanced operational efficiency and substantial cost reductions. Despite the challenges faced by SMEs, the research highlights the substantial advantages that Industry 4.0 offers, presenting a promising avenue for the growth and development of Punjab's steel industry. These benefits include heightened competitiveness and improved production quality. Ultimately, the practical insights derived from this study hold substantial value for policymakers, industry leaders, and SMEs alike, offering a roadmap for overcoming challenges and capitalizing on the opportunities presented by Industry 4.0, thus driving progress and innovation in Punjab's industrial sector.

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