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Lean Practices, Lean Culture, and the Industry 4.0 Implementation Process: Mediating Role of Green Practices in Pakistan's Manufacturing Industry

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Abstract

This research aims to determine the effectiveness of lean practices and culture on the Industry 4.0 implementation. This aim is achieved in the context of Pakistan's manufacturing industry keeping in view the mediating role of green practices. This is a quantitative study, positivism was used. The data was collected from 256 management-level professionals working in the manufacturing industry of Pakistan. Smart PLS was used for data analysis. Besides running structural and measurement models, some other advanced techniques namely Importance-Performance Map Analysis (IMPA) and PLS Predict were also utilized. The results revealed that lean practices and culture have a significant and positive effect on Industry 4.0 implementation in Pakistan's manufacturing industry. Furthermore, green practices significantly moderate their effects. However, job experience has an insignificant role in this relationship. By implementing Industry 4.0 in the manufacturing sector, costs can be reduced and international competition can be met. Moreover, the current study revalidates the resource-based theory. The findings can be utilized by the manufacturing industry to implement Industry 4.0, successfully. The significance of lean practices and lean culture is well-established. This research would be helpful in strategic planning and decision-making for managers working in the manufacturing industry of Pakistan.

***Keywords*:** green practices, implementation, Industry 4.0, lean culture, lean practices, manufacturing industry

Introduction

Inadequate technological progress is a major contributor to Pakistan's deteriorating economic state, among other causes. To remain competitive, Pakistan's manufacturing sector needs to implement Industry 4.0, as well as

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lean and environmentally friendly practices. Indeed, maintaining a cutting-edge technological infrastructure is crucial for the manufacturing sector of Pakistan (Khan et al., 2022; Pervez, 2022). The importance of business integration systems is paramount because of the uncertainty in the current business environment. Manufacturing firms are often positioned in a highly competitive environment where significant changes occur regularly, such as the introduction of innovative concepts and technology.

Due to competition, quality assurance of manufactured goods is essential along with their low cost. Cyber-physical systems (CPS) play a critical role to achieve this goal (Nafchi, 2020) Furthermore, any business should be able to adapt itself to cope with the market requirements. Various initiatives can be taken to guide the manufacturer to achieve this aim, such as lean practices and culture as well as the implementation of Industry 4.0 (Pagliosa et al., 2021). The implementation of Industry 4.0 is increasing (Pagliosa et al., 2021). Agriculture-based economies were transformed into automated manufacturing economies characterized by the emergence of large-scale industries after the industrial revolution (Ali & Xie, 2021). Since then, new technologies, scientific methods of organizing labor, and procedures to increase productivity have been adopted (Evans et al., 2007). Industry 4.0 has the potential to significantly enhance the adaptability of the manufacturing industry, as well as its ability to mass customize, improve quality, and increase productivity. As a result, it enables organizations to meet the challenges faced during manufacturing (Liu et al., 2022).

Cyber-physical systems (CPS), big data analytics, the Internet of Things (IoT), three-dimensional printing, and cloud computing are all examples of the technologies that make up the fourth industrial revolution, or Industry 4.0. Their implementation increases the performance of the firms. Improved quality, flexibility, latest procedures, cost reduction, and maxim output are the outcomes of these technologies (Moeuf et al., 2020). Despite them getting popular, many firms are still unsure as how to incorporate Industry 4.0 automation techniques and processes into their operations (Sanders et al., 2016).

It is essential to adopt Industry 4.0 techniques in the manufacturing sector (Tortorella et al., 2019). To fulfil the above requirement, the current research addresses the following research questions.

1. Does lean culture affect the Industry 4.0 implementation process?

2. Do green practices mediate the effect of lean practices on the Industry 4.0 implementation process?
3. Do green practices mediate the effect of lean culture on the Industry 4.0 implementation process?
4. Does job experience moderate the effect of lean practices on Industry 4.0 implementation process?

This study has the following five objectives.

1. To ascertain the impact of lean manufacturing strategies on the Industry 4.0 implementation process .
2. To examine the effect of lean culture on the Industry 4.0 implementation process.
3. To investigate the effect of green practices as a mediator between lean practices and the Industry 4.0 implementation process.
4. To investigate the effect of job experience as a moderator between lean culture and the Industry 4.0 implementation process.

Literature Review

Theoretical Underpinning

The resource-based theory (RBT) theory evolved from the resource-based view (RBV). This theory is more concerned with business unit performance than with achieving competitive edge. Without solid isolation methods, RBT enables the diffusion of practices among enterprises (Tiwari et al., 2020). Lean and green practices are associated with RBT in this study to understand the role of these practices in the Industry 4.0 implementation process. Using these processes enables the firms to gain competitive advantage; moreover, the firms can also compete in prices, quality, timeliness, and distribution. Therefore, the implementation of Industry 4.0 is crucial to enhance firm performance (Hasan, 2021).

Lean Practices

Lean is a socio-technical approach that strives for continuous improvement (Pagliosa et al., 2021). Lean practices are not only a method; they are also a creative approach to critical thinking. It fosters an environment that directs workers inside the organization towards better operations . (Shahin et al., 2020). In the manufacturing industry, lean practices have a unique importance as they provide counteractive solutions to various problems, such as eliminating process waste, reducing lead time and set-up time, reducing inventory and process costs, and improving firm operations, all of which ultimately lead to operational excellence and an overall enhanced business performance (Ciano et al., 2021). According to Nath and Agrawal (2020), firms applying the lean philosophy can improve their standards of internal manufacturing and enhance efficiency. Furthermore, they can reduce operational costs and increase profitability.

Industry 4.0

In recent years, the idea of 'all things' being interconnected has advanced to the point that the objective of achieving the Fourth Industrial Revolution appears to be closer than ever (Shahin et al., 2020). Through the use of the technologies and principles of Industry 4.0, it is possible to realize real-time communication and connection between people, goods, and machinery (Pagliosa et al., 2021). The Fourth Industrial Revolution, also known as Industry 4.0, is a significant development for the world economy that has the potential to influence a diverse array of businesses and bring about a major shift in the manner in which goods are manufactured, distributed, and maintained (Ralston & Blackhurst, 2020). The Industry 4.0 mechanisms smartly and intelligently integrate the components of firm business operations through automation and digitalization, providing open access to real-time information in order to create value and convert the traditional manufacturing environment into a more competitive and fully integrated value chain network (Kamble et al., 2021). According to Ali and Xie (2021), Industry 4.0 fosters the advancement of automated processes, as well as the gathering of technology and data, which improves many activities of the value chain, from production to marketing and logistics.

Lean Practices and Industry 4.0

Working towards lean principles and practices makes it possible to adopt Industry 4.0. This is because of their high level of compatibility with one another and their shared objectives of maximizing value creation while minimizing waste (Ajamo, 2023). Lean practices such as eliminating waste, process standardizing, reducing process variance and cost, and focusing on customer value are fundamental in implementing and adopting Industry 4.0 (Rosin et al., 2020). Their application in the manufacturing industry ensures the effectiveness of operations and gives strength to implement Industry 4.0.

There is a dearth of statistically supported and established literature regarding the effects of lean methods on the Industry 4.0 implementation process in the manufacturing sector (Ciano et al., 2021). Rossini et al. (2019) emphasized that lean approaches offer a foundation for the implementation of Industry 4.0 to achieve manufacturing excellence (Mofolasayo et al., 2022). So, the following hypothesis is proposed for Pakistan's manufacturing industry.

H1: Lean practices positively affect the Industry 4.0 implementation process.

Lean Culture and Industry 4.0

Organizational culture is an asset for any organization. It contributes to the successful execution of any strategy within the organization (Pozzi et al., 2023). Organizational culture is made of common values, norms, practices, and beliefs (Iranmanesh et al., 2019). Most firms' culture does not support lean, since it is difficult to deploy the philosophy, with a claimed adoption failure rate of up to 90% (Dorval et al., 2019). Companies must build a lean culture to successfully change over to lean manufacturing, which is a time-consuming process (Iranmanesh et al., 2019). Lean culture has been used as an explanation, a cause, and a substantial remedy for constant application of advanced technologies (Nafchi, 2020; Taifa, 2020).

Organizational innovation requires human creativity and inventiveness. The management system of a firm has a considerable impact on its culture, which is one of the most fundamental variables that influence how things are done in a company (Rachman, 2021). Culture demonstrates how a company pervades its employees' thoughts, feelings, and perceptions to implement a new technology, such as Industry 4.0. In the same way, lean culture provides the basis for process improvement and employee involvement in this implementation process (Pozzi et al., 2023). So, the following hypothesis is proposed for the manufacturing industry.

H2: Lean culture positively affects the implementation process of Industry 4.0.

Mediating Effect of Green Practices

Green practices are described as new or improved processes, systems, and products that have a low environmental impact and focus on eliminating waste from the environment (Sharma et al., 2023). Green practices include a variety of green strategies and approaches, including creating systems and products that consume less energy and material, substituting input materials, eliminating unwanted outputs, and recycling (Dieste et al., 2020; Vrchota et al., 2020). There is no doubt that lean practices enhance the green practices of the firms. By minimizing overproduction, lean practices can assist organizations in pooling items that consumers require, rather than supplying each client with a specific product. Firms' environmental performance is generally improved by adopting green practices after implementing and practicing lean principles (Dieste et al., 2020). In this study, the mediating role of green practices in the Industry 4.0 implementation process is analyzed. Green practices play a key role in Industry 4.0 implementation from both environmental and performance perspectives (Umar et al., 2022). So, the following hypothesis is proposed for the manufacturing sector of Pakistan.

H3: Green practices positively mediate the effect of lean practices on the Industry 4.0 implementation process.

Firms need a supporting environment in the form of lean and green practices for Industry 4.0 implementation, so that they can increase their operational and environmental performance (Aslam & Siddiqui, 2023). Firms using green activities and practices within a supporting culture of lean may provide a successful basis to implement Industry 4.0 (Antony et al., 2023). In this study, green practices act as a mediating variable between lean culture and the Industry 4.0 implementation process.

H4: Green practices positively mediate the effect of lean culture on the Industry 4.0 implementation process.

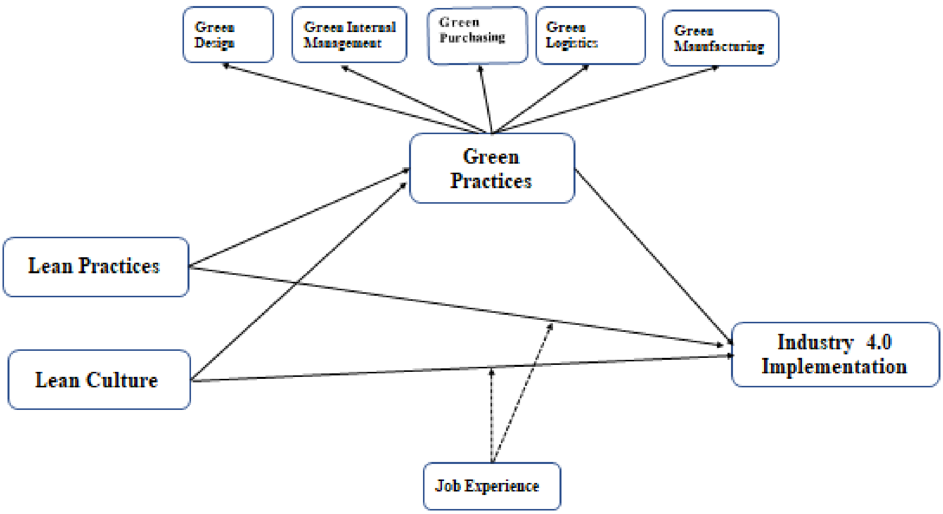
Moderating Role of Job Experience

Employee work involvement stems from individual-specific circumstances and organizationally assigned positions (Abdulrahamon et al., 2018). Age is a crucial statistic. According to research on growth and advancement, more experienced workers adapt by valuing socially coordinated tasks that are personally gratifying (Fung et al., 1999). They invest more time and energy into projects that appeal to their values and interests (Beier & Ackerman, 2001). Employment experience is often evaluated in empirical investigations of job performance; however, it is usually employed as a control variable in research on how other variables impact performance (Ng & Feldman, 2013). The association between lean practices and the industry 4.0 implementation process is thus either strengthened or weakened by the presence of employment experience as a moderating variable.

H5: Job experience moderates the effect of lean culture on the industry 4.0 implementation process.

H6: Job experience moderates the effect of lean practices on the industry 4.0 implementation process.

Figure 1
Conceptual Framework



The above model depicts that there is a direct and positive relationship of lean practices and lean culture with the Industry 4.0 implementation process. Both mediating and moderating variables have a direct and positive relationship with the Industry 4.0 implementation process.

Methodology

In this research, the quantitative approach was used along with the survey method for data collection. Further, purposive sampling technique was used to find the causal relationship between study variables (Alharahsheh et al., 2020). This research used the deductive approach, relying on theoretical explanations based on observable events and hypothesis testing. Such a strategy is used to establish a causal link between the variables, test hypotheses, and to generalize the regularities of human social behavior (Saunders et al., 2009). The questionnaire consisted of 31 items and 256 samples were gathered. Structural Equation Modeling (PLS-SEM) was chosen as the method for statistical analysis since it has both explanatory and predictive powers that can be used for non-normal data distribution. The purpose of the conceptual model is to see how accurately it can predict outcomes (Sarstedt et al, 2019).

PLS-SEM has several distinct advantages including increased data flexibility as well as its appropriateness for theory building (Legate et al., 2021). The main advantage of PLS-SEM is to enable the researchers to build complex models using many constructs at the same time, without any hindrance (Hair et al., 2018). In this study, the reliability of individual items was checked through overloading and construct validity was checked through composite reliability. Reliability signifies internal consistency and stability among the items and constructs. Often, reliability is evaluated for the individual items and constructs in a given model to determine their internal consistency (Härdle, 2011). Since the sampling frame was unknown, the study used a nonprobability, purposive sampling strategy (Thomas, 2022). Samples were taken only from the manufacturing industry. One screening question was provided at the beginning of the questionnaire since responders must meet the requirements to be included in the sample.

Measures

The survey questionnaire is based on four parts namely lean practices, green practices, lean culture, and Industry 4.0. (Yu et al., 2020). The data was gathered through a questionnaire using Likert- type scale, Green practices (Schmidt et al., 2017), lean culture (Iranmanesh et al., 2019), Industry 4.0 (Kamble et al., 2020), and job experience was taken as moderating variable.

Results

The data was analyzed through Smart PLS. The data was not normally distributed (Sarstedt et al, 2019). The current study measured the casual correlation among the constructs. The model tested for this study is complex and accommodates all kinds of variables, including moderating and mediating variables. This is the reason for using the PLS-SEM path model to evaluate the results (Sarstedt et al, 2019). Due to the complexity of the model, the path model is the preferred approach to be employed. According to (Hair et al., 2019), PLS-SEM is appropriate to utilize the latent variable scores in the subsequent analysis.

Sample Description and Demographics

The information was gathered between 2nd July 2022 and 4th September 2022. Of the 319 survey questionnaires administered during this period, 257 remained usable. For data collection, a Google form was created and distributed through a variety of platforms. The demographic information of the respondents is shown below in Table 1.

Table 1

Demographic Profile

		Frequency	Percentage
Designation	Staff Level Manager	28	10.9
	Lower Level Manager	33	12.9
	Middle-Level Manager	112	43.8
	Senior Level Manager	50	19.5
	Top/ Executive Level	33	12.9
	Total	256	100.0
Job Experience	3-5 years	93	36.8
	6-10 years	62	24.5
	11-15 years	67	26.5
	16-20 years	12	4.7
	Above 20 years	19	7.5
	Total	253	100.0
Education	Matriculation	02	0.8
	Intermediate	08	3.0
	Graduate	160	62.3
	Masters	85	33.1
	PhD	02	0.8
	Total	257	100.0

Data Screening

Multivariate normality was calculated (Mardia's multivariate skewness and kurtosis) through web power and data was found to be not normally distributed. Consequently, the use of the non-parametric statistical tool namely Structural Equation Modeling (PLS-SEM) remains justified (Hair et al., 2019), as shown in Table 2 below.

Table 2
Mardia's Multivariate Skewness and Kurtosis

	B	*Z*	*p*-value
Skewness	8.36163	353.975689	0.025
Kurtosis	115.15316	-2.493104	0.012

Common Method Bias (CMB)

Harman's single-factor analysis revealed that there was no common method variance, as the highest ranking factor explained only 36.73% of the variance (Podsakoff et al., 2003). Furthermore, CMB was also evaluated. It was ensured by VIF (Kock, 2015). The VIF values depicted in Table 3 point to the fact that they are less than 3.3, ensuring no CMB.

Table 3
Full Collinearity Test

Construct	VIF
Green Practices	2.360
Industry 4.0	1.452
Lean Culture	1.739
Lean Practices	1.944

Measurement Model

According to Sarstedt et al. (2019), an alternative to the concept of repeatedly using indicators is the two-stage strategy outlined below. In this strategy, researchers are provided with a framework composed of higher-order constructs (hierarchical component models) that allows them to model a construct on a more abstract dimension (referred to as a higher-order component) and its more concrete sub-dimensions (referred to as lower-order components) in the context of PLS-SEM. In other words, higher-order constructs provide a framework for modeling a construct.

In the first phase of the process, a model is created and estimated that links all of the lower-order components (both exogenous and endogenous factors). In the first stages of model assessment, the primary emphasis is placed on reflecting the measurement models of the lower-order components. In the second step, stage two models are created and estimated by making use of the latent variable scores obtained from the lower-order components in the first stage. Then, the researchers determine the higher-order constructs derived from the scores of the lower-order constructs. For this reason, scores of higher-order constructs are added as additional variables to the dataset. The findings remain similar to those obtained by utilizing the repeated indicators technique, except for the fact that the estimations of the route coefficient remain considerably different. At the beginning of the second stage assessment, the researchers concentrate on the reflective measurement model for the higher-order constructs. They examine the loadings of the lower-order constructs to determine the loadings of the higher-order constructs. Then, they utilize the coefficients to analyze the composite reliability and Average Value Extracted (AVE) to build indicator reliabilities and AVE. These results establish reliability and convergent validity above the crucial Cronbach's alpha value of 0.5, as well as composite reliability and AVE.

The purpose of the measurement model is to establish the reliability and validity of constructs and items. (Härdle, 2011). A construct is considered reliable if the standardized loading is 0.708 or above; otherwise, the items are not considered reliable. However, according to Steenkamp and Baumgartner (1995), items should be retained even at a loading of 0.50 or above. For this study, all those items that had an outer loading of less than 0.50 were excluded, while the remaining were included.

Composite reliability of the items was also evaluated. The threshold value for composite reliability is 0.70 or above. A construct with a lower value is considered not reliable (Sarstedt et al, 2019). All the construct had thresholds above 0.70.

Along with construct reliability, convergent validity was ascertained through AVE. The cut-off value for convergent validity is 0.50 or higher. Constructs with a lower value are not considered good for convergent validity. The discriminant validity of the measurement model was determined by the HTMT ratio,. A value of 0.85 or below serves as the criterion for discriminant validity (Hair et al., 2019).

The detailed results for outer loadings, composite reliability, convergent validity, and discriminant validity are stated in Table 4 and Table 5 below.

The cut-off value for reliability is 0.70 or higher. All constructs have more than the cut-off value. Convergent validity is also shown below in Table 4. The threshold value for convergent validity is 0.50 or above. All the convergent validity values are above the threshold value (Hair et al., 2018).

Table 4

First-Order Reflective Measurement Model Outer Loadings, Composite Reliability, and AVE (Convergent Validity)

Constructs	Items	Outer Loadings	Composite Reliability	Average Variance Extracted (AVE)
Green Design	GPD1	0.701	0.892	0.805
	GPD2	0.807		
Green Internal Management	GPI1	0.629	0.862	0.758
	GPI2	0.767		
Green Logistics	GPL1	0.806	0.877	0.782
	GPL2	0.766		
Green Purchases	GPP1	0.837	0.901	0.820
	GPP2	0.788		
Industry 4.0	IM1	0.559	0.883	0.523
	IM2	0.826		
	IM3	0.786		
	IM4	0.739		
	IM5	0.776		
	IM6	0.645		
	IM7	0.694		
Lean Culture	LC1	0.666	0.893	0.546
	LC2	0.745		
	LC3	0.758		
	LC4	0.725		
	LC5	0.684		
	LC6	0.779		
	LC7	0.804		
Lean Practices	LP1	0.722	0.864	0.515
	LP2	0.7		
	LP3	0.766		

Constructs	Items	Outer Loadings	Composite Reliability	Average Variance Extracted (AVE)
	LP4	0.709		
	LP7	0.675		
	LP8	0.732		

Discriminant validity was established through the HTMT ratio. It remains less than 0.90 against each construct (Henseler et al., 2015), except for green practices. The results are depicted in Table 5 below.

Table 5

Discriminant Validity

	GD	GIM	GL	GM	GPR	GP	IM	LC	LP
GD									
GIM	0.843								
GL	0.932	0.893							
GM	0.589	0.624	0.73						
GPR	1.014	1.028	1.10	0.793					
GP	0.859	0.837	1.01	0.798	1.055				
IM	0.642	0.547	0.61	0.357	0.636	0.69			
LC	0.656	0.634	0.64	0.546	0.698	0.70	0.574		
LP	0.737	0.827	0.78	0.54	0.804	0.76	0.586	0.61	

Note. LP, Lean Practices; LC, Lean Culture; IM, Industry 4.0; GD, Green Design; GPR, Green Practices; GIM, Green Internal Management; GL, Green Logistics; GM, Green Manufacturing; GP, Green Purchasing

Multicollinearity between constructs was checked through collinearity statistics and VIF values in PLS-SEM. A previous study revealed that for a reasonable degree of multicollinearity, the variance inflation factor (VIF) must be less than 3.3 (Hair, 2021). All VIF values in the study are less than 3.3,

Table 6

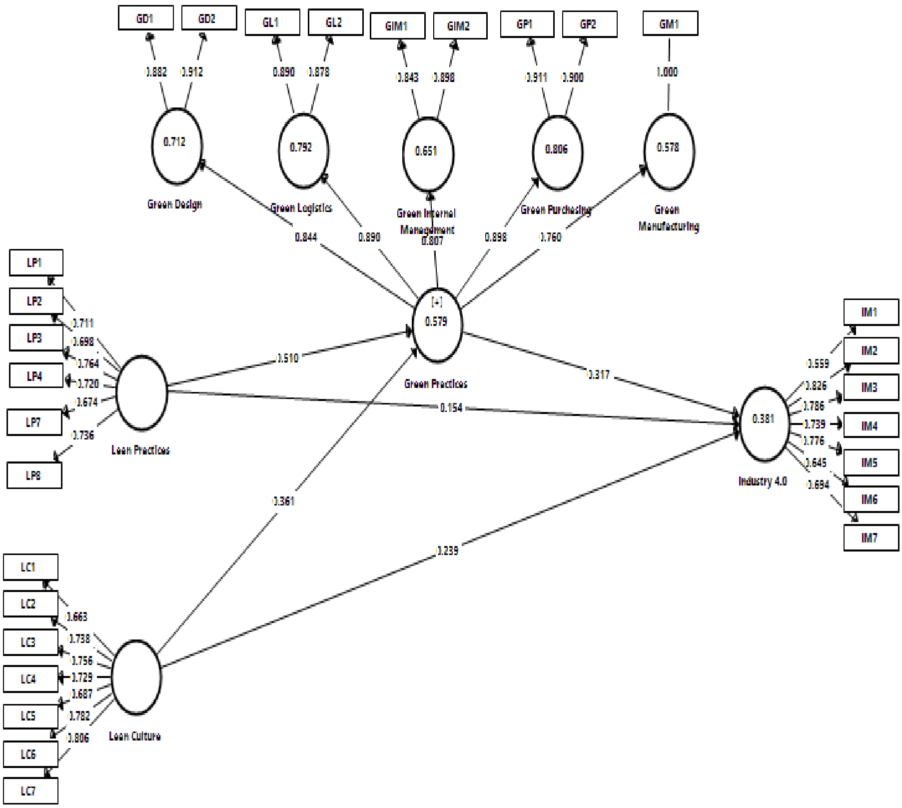
Collinearity Statistics (VIF)

	Green Practices	Industry 4.0	Lean Culture	Lean Practices
Green Practices		2.37		
Industry 4.0				

	Green Practices	Industry 4.0	Lean Culture	Lean Practices
Lean Culture	1.352	1.67		
Lean Practices	1.352	1.96		

Figure 2

First-Order Reflective Conceptual Framework



Second-Order Reflective Measurement Model

As part of the measurement model validation, the second or higher-order constructs were also validated. Both the internal consistency and convergent validity of each one of these factors were examined. Sarstedt et al. (2019) proposed that a study should include the investigation of the discriminant validity of the higher-order constructs in comparison to lower-order constructs. Both the validity and reliability of higher-order constructs are shown in Table 7 below. The table demonstrates that to determine the reliability and convergent validity for any additional constructs, the reliability value must be higher than 0.70 and the AVE must be lower than 0.50. Discriminant validity of higher-order constructs along with lower-order constructs is also tested in addition to reliability and validity.

Table 7

Second-Order Reflective Measurement Model Outer Loadings, Composite Reliability, and AVE (Convergent Validity)

Construct	Items	Outer Loadings	Composite Reliability	Average Variance Extracted (AVE)
Green Practices	GD	0.837	0.924	0.709
	GIM			0.807
	GL			0.883
	GM			0.783
	GP			0.896

Discriminant validity with other lower-order constructs was established using the HTMT criterion, which is less than 0.90 (Henseler et al., 2015) in Table 8 below.

Table 8

Second-Order Reflective Measurement Model Discriminant Validity (HTMT Ratios)

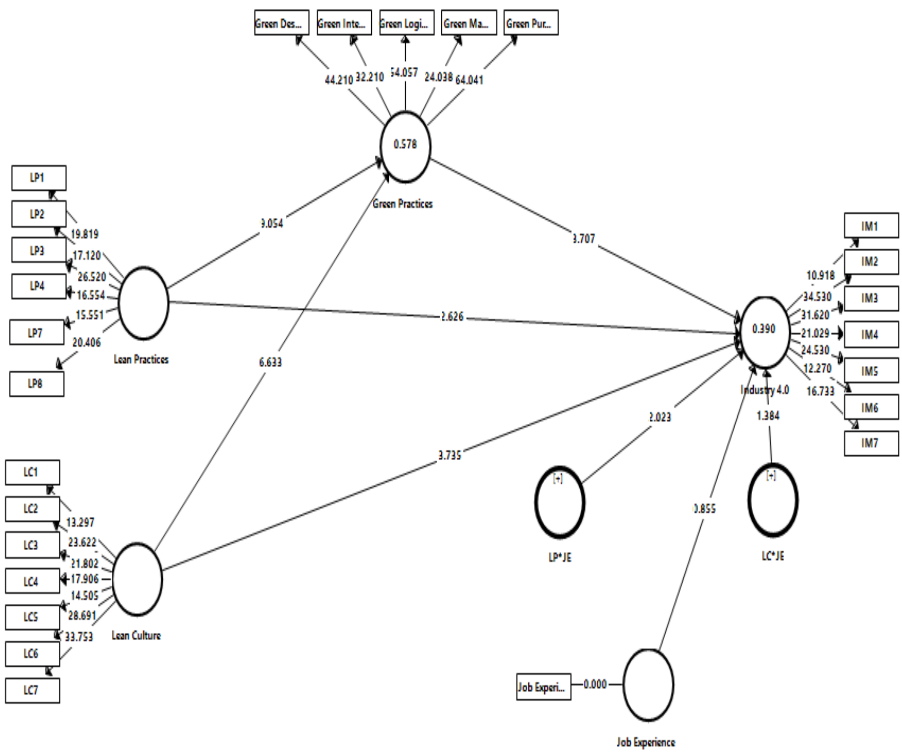
	Green Practices	Industry 4.0	Lean Culture	Lean Practices
Green Practices				
Industry 4.0	0.625			
Lean Culture	0.705	0.574		
Lean Practices	0.804	0.586	0.608	

Structural Model Measurement

The measuring model shown in (Figure 3) was evaluated before the structural model. Bootstrapping using 5000 subsamples was applied to test the model. This Structuring model measurement consisted of the structural path coefficient (beta) R^2, Q^2, and f^2 values. R^2 and Q^2 values were used to measure predictive ability and model fit. To determine whether or not the estimated SEM accurately represents the data, the coefficient of R^2 was applied to each endogenous variable in the model. According to Table 7, the R^2 value for dependent variables is 0.578 for green practices and 0.39 for Industry 4.0. Hence, the value of R^2 is greater than 0.2. This suggests that the model has sufficient capacity to describe the changes in the variables that are reliant on it (Hair, 2021). It is evident from Table 7 that lean practices, lean culture, and green practices explain 39% of the variance in Industry 4.0 implementation. This is a moderate percentage. Lean practices and lean culture explain 57.8% of the variation in green practices, which is strong enough.

Figure 3

Second-Order Reflective Measurement Model



Apart from the goodness-of-fit measurements, the effect size coefficients (f^2) were used to assess the adequacy of the derived model, as shown in Figure 3. According to Sarstedt et al. (2019), the f^2 values of 0.02 (small effect), 0.15 (medium effect), and 0.35 (large effect) for endogenous latent variables are indicated in Table 9. All f^2 values are above the 0.02 range, justifying acceptable impact size. In addition, the blindfolding approach was employed to evaluate the model's predicted accuracy (Akter et al., 2011). If the Q^2 value for a reflecting endogenous variable is greater than 0, the path model's predictive relevance is satisfied (Sarstedt et al., 2017). Table 9 shows that the predictive significance of the constructs to be more than 0, which falls within the allowed range for any endogenous construct.

Table 9

Total Effect Size (f^2), Coefficient of Determination (R^2), and Predictive Relevance (Q^2)

	Total effect size (f^2)		coefficient of determination (R^2)	Predictive relevance (Q^2)
	Green Practices	Industry 4.0		
Lean Practices	0.449	0.031	-	-
Lean Culture	0.233	0.058	-	-
Green Practices	-	0.053	0.578	0.403
Industry 4.0	-	-	0.39	0.185

The last phase is SEM. It involves analyzing the hypothesized connection to provide support (or lack thereof) for the suggested hypotheses.

Direct Effects

The inner model was examined using bootstrapping with 5000 subsamples, so that the hypotheses could be tested. Table 10 provides a summary of the hypothesized direct influence route coefficients, as well as t values, effect sizes, and decisions. H1 evaluates whether lean practices have a significant impact on Industry 4.0 implementation. The results revealed that lean practices have a significant effect on Industry 4.0 (β =0.197, t =2.626, p =0.002). Hence, H1 is supported. H2 evaluates whether lean culture has a significant impact on Industry 4.0 implementation. The results revealed that lean culture has a significant effect on Industry 4.0 (β =0.244, t =3.735, p =0.000). Hence, H2 is also supported. The exogenous variable's contribution to R^2 is represented by the effect size (f^2). In this regard, the value of 0.02 is considered as a small-size effect, 0.15 is considered as a medium-size effect, and 0.35 is considered as a large-size effect (Hair, 2021). The study's supported hypothesis has a large impact size in this model.

Table 10
Direct Effects

Relationships	Beta Coefficient	Std Error	*t*	Confidence Interval		*p*	Decision
				5.00%	95.00%		
LP -> Industry 4.0	0.197	0.075	2.626	0.076	0.324	0.002	Supported
LC -> Industry 4.0	0.244	0.065	3.735	0.135	0.345	0.000	Supported

Note. Direct relationships of independent variables with the dependent variable. LP, Lean Practices; LC, Lean Culture

Mediation (Indirect) Effects

The model suggested above has two simple mediation processes. The result shows that the indirect effects of the mediation were effective in their functioning. A mediation analysis was carried out to evaluate the function that green practices play as a mediator. It was found that the relationship between Industry 4.0 implementation and lean practices is mediated through green practices. The results (see Table 11) revealed significant ($p < 0.05$ and β =0.142) but partial mediating role of green practices. Green practices also mediate between lean culture and Industry 4.0 implementation. The results (see Table 11) again revealed a significant ($p < 0.05$ and β =0.102) but partial mediating role of green practices.

Table 11
Indirect Effects

Relationships	Beta Coefficient	Std Error	*t*	Confidence Interval		*p*	Decision
				5%	95%		
LP -> GP -> Industry 4.0	0.142	0.041	3.484	0.080	0.213	0.000	Supported
LC-> GP -> Industry 4.0	0.102	0.033	3.083	0.054	0.163	0.001	Supported

Note. LP and LC with simple mediation of GP. LP, Lean Practices; LC, Lean Culture; GP, Green Practices

Moderation Effects

The moderation results depicted in Table 12 confirm the hypothesis (H6) that job experience moderates the effect of lean practices ($p < 0.05$, β = 0.254) on Industry 4.0 implementation. However, job experience does not moderate the effect of lean culture ($p > 0.05$, β = -0.097) on Industry 4.0 implementation.

Table 12

Moderation Effects

Relationships	Beta Coefficient	Std Error	*t*	Confidence Interval		*p*	Decision
				5%	95%		
LP*JE	-0.097	0.070	1.384	-0.211	0.019	0.083	Not Supported
LC*JE	0.254	0.055	4.661	0.029	0.240	0.000	Supported

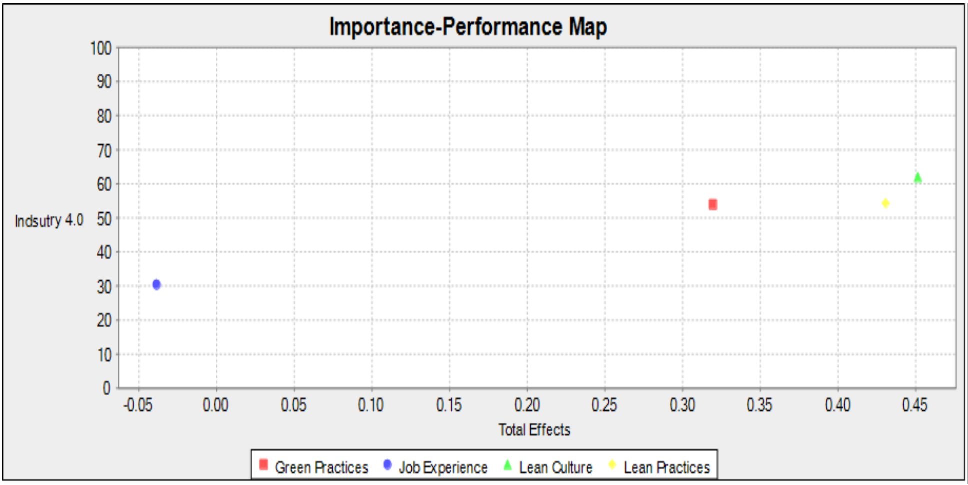
Note: LP and LC with the moderating effect of GP. LP, Lean Practices; LC, Lean Culture; JE, Job Experience

Importance Performance Map Analysis (IPMA)

Smart PLS (version 3) was used to report PLS-SEM findings using importance-performance map analysis. It is often used to evaluate key elements behind a company's success. The y-axis displays the 'performance' of business success drivers on a scale of 0 to 100, while the x-axis shows their 'importance' (total impact). Researchers may then select earlier constructs with a substantial overall impact (high relevance) but low average latent variable scores (poor performance) for operational improvement (Hair et al., 2018). As demonstrated in Figure 4, lean culture has a high total effect (importance) and also shows high performance in the Industry 4.0 implementation process. This is an area that the managers should not overlook. Lean practices also have a high total effect and performance after lean culture. Green practices are marginally higher in performance than lean practices but have a lower importance than lean practices. Further, job experience has very low importance and performance as compared to other variables in this model.

Figure 4

Importance of Performance Map Analysis



PLS-Predict

When it comes to predicting model parameters for new observations, explanatory modeling is not very reliable (Hair & Sarstedt, 2021). On the other hand, explanatory accuracy describes a model's capacity to provide accurate forecasts about the future (Shmueli & Koppius, 2011). The model was tested to see if it could have predictive relevance. As shown in Table 13, for all dependent variables, the PLS-SEM Q^2 prediction is bigger than 0. All of the PLS-SEM indicators have a lower RMSE (prediction error statistic) than the linear model. As a result, the model's strongest predictive potential was determined (Shmueli et al., 2019) through this analysis.

Table 13

PLS Predict

Item	PLS-SEM		LM	PLS-SEM - LM
	RMSE	$Q^2_{predict}$	RMSE	RMSE
GD	0.771	0.41	0.793	-0.022
GIM	0.768	0.415	0.789	-0.021
GL	0.778	0.401	0.797	-0.019
GM	0.832	0.315	0.859	-0.027
GP	0.744	0.452	0.748	-0.004
IM6	1.257	0.073	1.258	-0.001

Item	PLS-SEM		LM	PLS-SEM - LM
	RMSE	$Q^2_{predict}$	RMSE	RMSE
IM3	1.139	0.217	1.166	-0.027
IM2	1.022	0.266	1.04	-0.018
IM5	1.166	0.145	1.176	-0.01
IM1	1.113	0.189	1.129	-0.016
IM4	1.3	0.075	1.334	-0.034
IM7	1.283	0.15	1.313	-0.03

Note. RMSE of the endogenous item of the PLS sample model and the linear model. Abbreviations: LM, Linear Model; PLS, Partial Least Square; RMSE, Root Mean Square Error. GD, Green Design; GIM, Green Internal Management; GL, Green Logistics; GM, Green Manufacturing; GP, Green Purchasing; IM, Industry 4.0 Implementation

Discussion

The results showed that lean culture and lean practices may be successfully used to implement Industry 4.0 technology. According to the findings, lean practices do have a positive and substantial influence on the Industry 4.0 implementation process (H1). In the same manner, the results of the previous studies highlighted the importance of lean practices as a prerequisite to implementing Industry 4.0 (Buer et al., 2018; Ciano et al., 2021; Shahin et al., 2020). Lean culture also has a positive and significant impact on the Industry 4.0 implementation process (H2), which complies with the results of previous studies (Iranmanesh et al., 2019; Taherimashhadi & Ribas, 2018). Furthermore, green practices positively and significantly mediate the relationship between lean practices and the Industry 4.0 implementation process (H3). Previous studies showed that lean practices have a positive impact on green practices (Agrawal & Bellos, 2017; Hao et al., 2021). Green practices positively and significantly mediate the relationship between lean culture and Industry 4.0 implementation (H4). Previous studies showed that lean practices have a positive impact on green practices (Campbell et al., 2013; Post & Altman, 2017). This study revealed that job experience as a moderator does not moderate the effect of lean culture on Industry 4.0 implementation (H5). This moderating relationship was not tested in previous studies; however, job experience does moderate the effect of lean practices on Industry 4.0 implementation (H6). In this research, Smart PLS was used. Besides testing the measurement model and the structural model, some advanced data analysis techniques including Importance-Performance Map Analysis (IPMA) and PLS prediction were also used. This is a novel contribution to research in this domain.

Managers who are directly involved in the Industry 4.0 implementation process, in particular, should have a thorough awareness of the current organizational practices and shifting patterns in order to adapt to the new technology and build an innovative environment and culture (Kamalahmadi & Parast, 2016). Based on the analysis of data collected from managers in various departments of Pakistan's manufacturing industry via structured questionnaires, it was determined that lean practices and lean culture, as independent variables, have a significant effect on the Industry 4.0 implementation process. Moreover, green practices serve as a significant mediating variable between the two. On the contrary, experience on the job has no bearing on the relationship between lean culture and Industry 4.0 implementation, although it does affect the relationship between lean practices and Industry 4.0 implementation. The findings show that lean culture is the key framework and backbone for the implementation of the Fourth Industrial Revolution. Based on both theory and results, it is recommended that manufacturing companies should first focus on building a lean culture by implementing awareness programs, provide effective training regarding the importance of new technology advancement and its effect on firm performance, and adopt the relevant rules, procedures, and practices including lean and green practices.

Conclusion

The manufacturing industry is currently in a state of instability. Indeed, it is becoming increasingly susceptible to growing pressure and mounting difficulties as a result of challenges faced on several fronts. One of the challenges is the implementation of new technology in order to compete successfully in the uncertain business environment. This study discussed how lean culture, lean practices, green practices, and job experience affect the Industry 4.0 implementation process. From a resource-based view and an institutional theoretical perspective, it was discussed in detail how these practices contribute to the successful implementation of new technology using present organizational processes in a dynamic business environment. The major research construct in this study was lean practices, which were developed using a conceptual framework based on the current literature. Due to the small sample size, this model was statistically validated using

PLS-SEM. The findings imply that lean culture is the primary driver of lean practices. Furthermore, the successful implementation of new technology is mostly determined by the previously adopted practices chatacterizing an innovative organizational culture. This is being driven by techniques, including lean and green practices, in a lean culture where employment experience has no such significance in the process of implementing new technologies. The findings are useful for the manufacturing industry stakeholders in terms of managing local and global risks due to the slow advancement of technology in the country.

Limitations and Future Directions

The focus of the research was limited to the manufacturing industry of Pakistan. Other sectors and industries should also be explored. On the other hand, the same model can be validated by employing a large sample size from a specific sector or industry. In addition, the same research can be conducted while targeting small and medium-sized firms. Moreover, scholars can use other related variables, mediators, and moderators to test this model, to investigate it further, and validate its significance. Researchers can also use other data collection approaches and analysis procedures and techniques to obtain more refined findings and generate broader perspectives regarding the relationships between the selected constructs.

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