Digital Leadership and Lean Manufacturing: An Analysis Using an Importance-Performance Map

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Abstract

The success of lean manufacturing practices in Industry 4.0 is highly dependent on people and technology; therefore, an appropriate leadership style is essential when pursuing the implementation of lean manufacturing. This study explores whether digital leadership has direct and indirect effects on lean manufacturing practices via the mediation of the two dimensions of thriving at work; in parallel, the degree of its importance and respective performance is evaluated. The research design was quantitative, non-experimental, cross-sectional, and explanatory and was conducted in the Mexican border export manufacturing industry using a non-probabilistic sample of 1,123 people. The statistical techniques used were partial least squares structural equation modelling [PLS-SEM] and importance–performance mapping [IPMA]. The results reveal a direct effect of digital leadership on lean manufacturing practices and an indirect effect through the learning dimension of thriving at work; the vitality dimension has no significant effect on lean manufacturing practices. The importance–performance map highlights the significant effect of digital leadership on lean manufacturing; at the indicator level, it reveals that leaders need to improve their performance by seeking out and motivating employees to experience and use new technologies.

Key words

Industry 4.0, digital leadership, thriving at work, lean manufacturing, structural model, performance importance map.

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Introduction

Manufacturers must respond quickly to market demands and operate with high quality, productivity, and low costs; thus, lean manufacturing practices are useful (Lu et al., 2018). This productive scheme is essential for companies to thrive in competitive markets (Sekhar et al., 2023), even emerging as the only method that meets most of the objectives required by companies in the line of business, due to the multiple benefits associated with the application of its techniques (Kumar et al., 2022). However, lean practices designed for high volumes and low production variety face the challenge of adapting to new requirements: low volumes and high variety; shorter response times; greater customisation; and environmental concerns. For this, management approaches supported by digital technologies, particularly Industry 4.0 (I4.0), are useful (Sartal et al., 2022).

Manufacturing companies using lean production techniques should adapt to I4.0 (Qureshi et al., 2023). I4.0 helps improve manufacturing practices and operations by employing different emerging technologies (Rahardjo et al., 2023). Moreover, manufacturing companies have changed with the use of I4.0 technologies, including cloud computing, big data analytics, robotics, and the Internet of Things (IoT) (Rahardjo et al., 2023). Although a single definition of Industry 4.0 is lacking, some studies (Buer et al., 2018) have operationalised it with the use of smart products and processes, enabling autonomous data collection and analysis, and interaction between products, processes, suppliers, and customers via the Internet. Recent studies (Maware & Parsley, 2023) indicate that Industry 4.0 technologies have positive and significant effects on lean manufacturing.

People are important in both I4.0 and lean manufacturing. Industry 4.0 is based on the adoption of technologies, but it also demands considerable changes in organisational culture, which requires the consideration of workers (Bianco et al., 2021). In parallel, the integration of people into the process is a relevant factor (Veile et al., 2019) and success in the application of lean manufacturing essentially depends on people (Tortorella et al., 2021), since they and technology integrate in a fundamental binomial to maximise performance (Qureshi et al., 2023). It is important to mention that when a company seeks to produce under lean manufacturing schemes, appropriate leadership styles are indispensable (Benkarim & Imbeau, 2021; Kumar et al., 2022). In this regard, academic literature recognises the importance of leadership in addressing the challenges of digital transformation (Ratajczak, 2022; Zeike et al., 2019). It should be noted that lean manufacturing has evolved toward a culture rooted in values, principles, and behaviours that promote continuous improvement, and in this regard, leadership 4.0 plays a fundamental role (Gatell & Avella, 2024).

Furthermore, organisations face new opportunities and challenges in managing their human capital (Agustina et al., 2020; Bartsch et al., 2021). Among the consequences of thriving at work are self-improvement, talent development, sustainable performance, and competitive management (Brown et al., 2017; Goh et al., 2021; Porath et al., 2011). In recent decades, the 'thriving at work' variable has been the subject of increasing attention (Brown et al., 2017; Liu et al., 2021). Papers published in the last five years (Rego et al., 2021) highlight the importance of discovering its antecedents, among which different leadership styles are included (Liu et al., 2021). This research makes an important contribution to the literature. First, it adds knowledge regarding the integration of lean manufacturing and Industry 4.0, a topic of growing interest in the early stages of development (Bianco et al., 2021; Rahardjo et al., 2023). Moreover, the impact of leadership on lean manufacturing initiatives has been investigated, which is a topic of knowledge with few empirical studies (Tortorella et al., 2021). With regard to thriving at work, insights into its causes and consequences are added, and in doing so it is expected that the limited proposals for specific and reliable recommendations will be enhanced (Kleine et al., 2019). Furthermore, although several studies have assessed the influence of leadership styles, such as authentic (Xu et al., 2017), servant (Walumbwa et al., 2017), and transformational (Hildenbrand et al., 2018), on thriving at work, no studies were identified that examined digital leadership as a precursor to thriving at work. It is worth mentioning that recent studies have pointed out that studies on leadership in the context of I4.0 will take time to consolidate, as those published to date have focused on technological topics (Bianco et al., 2021). In the context of the export manufacturing industry of the northern border of Mexico, this study analysed whether digital leadership has direct and indirect effects on lean manufacturing practices through the mediation of thriving at work. In addition, it evaluates the degree of importance and performance of the latent variables and indicators. This document includes four sections: the theoretical framework of the study constructs; research methods; results; discussion and conclusions.

1. Literature review

1.1. Leadership

In the business context, a leadership style capable of managing people's talent is essential (Kaur et al., 2024; Sivathanu & Pillai, 2018). Leaders influence people's confidence, effectiveness, and commitment (Agustina et al., 2020), and by acting as role models and motivating with inspiring visions, they enhance the experience of collaborators, enabling them to feel fulfilled and vital in their tasks (Dvir et al., 2002; Koistinen & Vuori, 2024).

In the manufacturing context, the transition from mass production models to lean management systems demands significant technical and sociocultural changes, for which conducive leadership is required (Fujimoto et al., 2024; Tortorella et al., 2021). The industry 4.0 era demands the development of specific competencies in leaders (Bianco et al., 2021; Netland & Ferdows, 2016). Leadership 4.0, also known as digital leadership (Oberer & Erkollar, 2018), is essential in the era of digital transformation and technology, and is recognised as an important element for operational excellence, digital culture, and firm competitiveness (Chatterjee et al., 2023; Mihardjo et al., 2019a; Peng, 2021), given the need to optimise the use of digital technology to strengthen the firm's advantages (Sasmoko et al., 2019). In parallel, digital leadership is considered a benchmark in the knowledge society: its influence is achieved with the use of digital tools (Narbona, 2016). Its purpose is to lead the company toward digital transformation and strengthen its ability to adapt to rapid changes in the environment (Nagel, 2020). Moreover, in the I4.0 environment, the leader is oriented towards the customer, staff development, lean principles, and operational performance (Gatell & Avella, 2024). In addition, the digital leader manages the organization's dynamic capabilities to thrive in business scenarios with high and rapid rates of change (Tigre et al., 2023). This leadership style drives communication and transformation using digital media (Mihardjo et al., 2019b; Oberer & Erkollar, 2018) and has distinctive characteristics, such as creativity, deep knowledge, global vision and collaboration, and loyal participation through vision (Sasmoko et al., 2019; Zhu, 2015)

1.2. Thriving at work

Organizational interest in investigating thriving at work grew in response to its strong predictive ability on variables like work engagement, performance, satisfaction, and burnout (Goh et al., 2021). Thriving at work is a state of mind in which people learn and feel stronger in their job. (Spreitzer et al., 2005). Employees who thrive at work feel energized, empowered, and full of life because they feel a sense of personal growth and can apply their valuable knowledge and skills (Kleine et al., 2019; Niessen et al., 2011; Spreitzer et al., 2005). In parallel, thriving at work benefits workers in diverse aspects, such as health (Porath et al., 2011; Spreitzer et al., 2005; Walumbwa et al., 2017), performance, satisfaction, and well-being (Pfeffer, 2010; Porath et al., 2011; Spreitzer et al., 2012), and it decreases their propensity to feel worried, depressed, or disturbed (Keyes, 2002).

Spreitzer et al. (2005) developed the Socially Embedded Model of Thriving (SEMT), which makes two fundamental assumptions: most employees work in socially integrated contexts; and work environments in which trust, respect, and inclusive decision-making exist enhance self-determination and personal agency (Goh et al., 2021). According to this model, employees thrive at work through interaction, observation, and communication with supervisors and peers (Liu et al., 2021; Spreitzer et al., 2012).

Thriving at work is composed of two dimensions: a feeling of vitality; and a sense of learning or improving – the former represents a sense of energy and enthusiasm for work, and the latter involves the acquisition and application of knowledge and skills to build capacity and confidence. The two dimensions reflect the experience of personal growth, and it is necessary to maintain high levels across them both for employees to thrive (Goh et al., 2021; Porath et al., 2011). Then, thriving at work involves growth in expressions of vitality (hedonic) and learning (eudemonic) as characteristics of psychological development (Saleem et al., 2020).

People are more likely to thrive under favourable working conditions (Spreitzer et al., 2005). In this regard, leadership styles that empower, support, and inspire people are essential to creating environments where people thrive. According to various studies, leaders who focus on employee development foster and enable thriving at work (Chen and Kanfer, 2006; Lin et al., 2020; Shahid et al., 2020; Walumbwa et al., 2017). In parallel, when they show high levels of determination and can create favourable contexts (with social support and availability of emotional, motivational, informational, and relational resources), they can enhance employees' drive and courage, thereby increasing their perception of thriving at work (Rego et al., 2021). Digital leaders tend to increase subordinates' feelings of competence and promote vitality (Tummers et al., 2016). Therefore, it is proposed that:

H1a. Digital leadership positively and significantly influences the learning dimension of thriving at work.

H1b. Digital leadership positively and significantly influences the vitality dimension of thriving at work.

Both dimensions of thriving at work can contribute to personal growth and development, but the perception of thriving largely depends upon the extent to which they are combined and mutually beneficial (Porath et al., 2011). Employees may be enthusiastic about their work, but over time, this enthusiasm can fade if there are no opportunities for learning and growth (Paterson et al., 2014). In addition, people do not feel fulfilled if they experience low energy levels, even if they have acquired new skills in their work (Abid et al., 2020). Therefore, it is postulated that:

H2. The learning dimension of thriving at work has a positive and significant impact on the vitality dimension of thriving at work.

1.3. Lean manufacturing (LM)

Lean manufacturing is a management philosophy focused on organizational efficiency, with a continuous search for perfection (Salvadorinho et al., 2024; Tayaksi et al., 2020). The lean philosophy emerged in Japan in the 1950s and is used to manage and optimize production processes; it emphasizes eliminating waste, improving production efficiency and effectiveness, increasing product quality, customer satisfaction, and eliminating variability in processes, which involves focusing on activities that add value to the customer and suppressing all waste in the production process (Medyński et al., 2023; Qureshi et al., 2023; Schonberger, 2007; Shah & Goldstein, 2006; Vinodh & Joy, 2012). Globally, this thinking is adopted as a strategy to promote flexibility, reliability, and productivity (Kumar et al., 2022).

Lean thinking prioritizes people as an essential factor for maintaining and strengthening continuous improvement in processes (Pagliosa et al., 2019). Within lean environment, soft practices are fundamental if the purpose is to foster long-term and continuous improvement (Qureshi et al., 2023). Note that employees can facilitate or limit the use of lean manufacturing techniques, especially when performing implementation tasks (Benkarim & Imbeau, 2022; Tortorella & Fogliatto, 2014; Wong et al., 2009).

Leadership became critically significant once it was understood that Lean goes beyond the concept of a toolbox and is best understood as a philosophy based on changing human behaviour (Bianco et al., 2021). Moreover, leadership is regarded as an indispensable driver of lean success because it contributes to creating conditions for continuous improvement and waste elimination (Gatell & Avella, 2024). Digital leadership enables the successful implementation of lean manufacturing (Aripin et al., 2023; Walker & Qian, 2020). In a case study conducted with a European automobile manufacturer, it was found such leadership enabled the successful implementation of lean manufacturing practices, since employees were involved and committed to the company (Aripin et al., 2023). Thus, it is postulated that:

H3. Digital leadership directly, positively, and significantly impacts the use of lean manufacturing practices.

The workplace is an essential environment where people can achieve a positive identity, whether for reasons of self-admiration or to give meaning to their lives (Saleem et al., 2020). Thriving can be seen as a reaction to challenges, not only in overcoming work pressure, but also in responding to challenging situations (Bartram et al., 2023; Saleem et al., 2020; Subramanian & Suresh, 2024). Thus, vitality and energy are key resources in demanding work environments (Bartram et al., 2023). On the other hand, employee learning plays an important role in improving performance (Muhammad et al., 2022; Qureshi et al., 2023). This means that people who learn at work are more likely to be competent and acquire knowledge that helps improve the functioning of the organization (Saleem et al., 2020). Therefore, in the implementation of lean manufacturing initiatives, it is important to create positive work environments that consider not only the needs of the firm but also depart from the requirements of the people; this will involve determining how to ensure that employees are self-sufficient, have a sense of purpose, and are committed (Hines et al., 2022). Therefore, it is postulated that:

H4a. Thriving at work, through its learning dimension, positively and significantly influences the use of lean manufacturing practices.

H4b. Thriving at work through the vitality dimension positively and significantly affects the use of lean manufacturing practices.

2. Methodology

This research is quantitative, non-experimental, cross-sectional, and explanatory. The participants were employees from productive (operational) and management areas working in manufacturing companies of the maquiladora export industry in Ciudad Juarez, Chihuahua. The sample was non probabilistic and was conducted as a convenience sampling, applying the snowball technique. A survey was used as the data collection technique; an online questionnaire was submitted through an electronic link, and the fieldwork was carried out in October and November 2023. Eligible individuals to receive the electronic link were active employees in the export manufacturing industry. A total of 1,123 employees participated, and of them 50.7% were men and 48.3% were women. Regarding age, 53.6% of them were between 20 and 25 years old, and 63.2% had been with the organization for less than 2 years. Regarding education, 29.5% of the participants completed high school, followed by 22.7% with a bachelor's degree. In terms of position, 27.5% of the employees were operators, 17.6% were technicians, 10.4% were group leaders, 19.1% were engineers, 6.3% were supervisors, 2.3% were managers, and 16.8% were assistants, administrative or forklift workers. Lastly, 39.8% of participants worked in companies manufacturing parts for the automotive sector, 17.3% for the medical sector, 17.1% for the electronics sector, 3.7% for the metallurgical sector, 2% for the aerospace sector, and 20.2% for other sectors.

The scales available in the literature were adapted for each construct (Table 1).

Table 1. Operationalization of study variables.

Thriving at work			
Learning dimension		Vitality dimension	
I consider that in my work: TWL1. I am always learning. TWL2. Even as time goes by, I am still learning	TWL3. I feel that I am getting better every day. TWL4. I am always moving forward. TWL5. I have developed a lot as a person.	TWV1. I feel alive. TWV2. I am encouraged and energized. TWV3. I feel very active.	TWV4. I feel alert and awake. TWV5. I look forward to each new day.
Digital leadership		**Lean manufacturing**	
In the company where I work, leaders/supervisors use digital media (such as e-mail, WhatsApp, intranet) to: Lid1. Share the information	Lid6. Encourage employees to be more open and adopt new technologies (NT) for work Lid7. Can select the technologies that help the company the most. Lid8. Build environments where employees use new technologies (NT).	At the company where I work LM1. Employees from different areas (such as production, quality,	LM5. Employees are able to reduce the time to change from model to production. LM6. More than one

Digital leadership		Lean manufacturing	
that you need on the job. Lid2. Share the information needed to learn and/or contribute new ideas. In parallel, leaders/supervisors: Lid3. Listen to their employees. Lid4. Build collaboration, trust, and participation agreements between employees. Lid5. Provide an environment that encourages decision-making among employees.	Lid9. Select communication platforms (such as WhatsApp, e-mail) that are more favourable to the company. Also, leaders/supervisors: Lid10. Encourage employees to explore new technologies so that they can bring new ideas into the workplace. Lid11. Seek to involve employees in a variety of activities Lid12. Know how to prepare employees to work with new technologies (NT). Lid13. Know what it takes to have more participatory and collaborative environments.	maintenance) can perform different types of activities. LM2. The layout of the workstations can be easily changed (e.g. the location or order of operations in an area). LM3. There are warning systems for moving material (e.g. cones, cards, empty shelves). LM4. Only the necessary quantities are produced, not more and not less.	model is produced in a work shift. LM7. Different techniques are used to improve product quality (e.g. control charts). LM8. There are systems to know when the machine is failing (such as sounds, coloured lights) LM9. Material arrives when needed (minimum inventory/just in time).

Source: Self-elaboration.

Thriving at work with 10 items from the scale of Porath et al. (2011), including two dimensions: 1) Learning (TWL) and 2) Vitality (TWV); Digital leadership was assessed with 13 items from the proposal by García-Vázquez et al. (2023); and Lean manufacturing practices with 9 items from the scale of Nawanir et al. (2015). In all cases, a Likert-type scale with 5 response options ranging from "strongly disagree" to "strongly agree" was used. Partial least squares structural equation modelling (PLS-SEM) and an importance-performance matrix (IPMA) were used for inferential analysis.

3. Research results

Since only a theoretical proposal was available to measure digital leadership, the first step was to perform a test to validate its theoretical dimensions. For this purpose, an exploratory factor analysis (EFA) was used. In the EFA, a varimax rotation was employed, and the number of factors was set to three, in accordance with the factors proposed in the original scale and a Kaiser–Meyer–Olkin (KMO) index of 0.957 was obtained, reflecting a good factorial fit (Hair Jr, et al., 1999). Also, the EFA showed a chi-square value of 13,711.316 with 78 degrees of freedom, and a significance of 0.000 in Barlett's test of sphericity, evidencing its validity (Lévy Magin & Varela Mallou, 2008). The three dimensions of digital leadership were grouped into the following factors: Information (Lid1 and Lid2); Technological empowerment (Lid3, Lid4, Lid5, Lid6, Lid7, Lid8 and Lid9); and Participation and experimentation (Lid10, Lid11, Lid12 and Lid13).

Subsequently, the measurement model was assessed. The factor loadings, reliability, and convergent validity were verified. In the first criterion, it is recommended that the items exhibit loadings equal to or greater than 0.708 (Hair Jr et al., 2020). In this regard, from the original model of 32 items, six were eliminated: one from digital leadership (Lid7); four from thriving at work (TWL2, TWL3, TWV2, TWV3); and one from lean manufacturing (LM2). Table 2 shows the loadings of the remaining 26 items in the measurement model. The factor loadings are greater than 0.708 and statistically significant. Regarding convergent validity, Cronbach's alpha values, rho_a and rho_c show values between 0.700 and 0.950, and the average variance extracted (AVE) scores exceed the 0.500 threshold, as they are between 0.638 and 0.859 (Hair Jr et al., 2020).

Table 2. Measurement indicators and convergent validity.

Construct	Items	Charges	Cronbach's alpha	Composite reliability rho_a	Composite reliability rho_c	Average variance extracted (AVE)
Digital leadership-information	Lid1	0.950	0.897	0.898	0.951	0.906
	Lid2	0.954				
Digital leadership-technological empowerment	Lid3	0.855	0.936	0.936	0.949	0.758
	Lid4	0.892				
	Lid5	0.886				
	Lid6	0.890				
	Lid8	0.876				

Construct	Items	Charges	Cronbach's alpha	Composite reliability rho_a	Composite reliability rho_c	Average variance extracted (AVE)
Digital leadership-participation and experimentation	Lid9	0.821	0.917	0.917	0.942	0.801
	Lid10	0.883				
	Lid11	0.888				
	Lid12	0.902				
	Lid13	0.907				
Thriving at work - learning	Prosp1	0.919	0.918	0.918	0.948	0.859
	Prosp4	0.934				
	Prosp5	0.928				
Thriving at work- Vitality	PTV1	0.919	0.901	0.910	0.938	0.835
	PTV4	0.925				
	PTV5	0.896				
Lean manufacturing	LM1	0.739	0.919	0.921	0.934	0.638
	LM3	0.822				
	LM4	0.745				
	LM5	0.768				
	LM6	0.810				
	LM7	0.856				
	LM8	0.843				
	LM9	0.799				

Source: Own calculations.

Discriminant validity was assessed with the heterotrait–monotrait (HTMT) ratio, in which a maximum cut-off point of 0.85 (for dissimilar constructs) or 0.90 (for similar constructs) is recommended (Henseler et al., 2015). As shown in Table 3, the model has discriminant validity, given that the HTMT ratios are below the suggested cut-off points.

Table 3. Discriminant validity.

Construct	Digital leadership - technological empowerment	Digital leadership - information	Digital leadership -participation experimentation	Thriving at work - learning	Thriving at work - vitality	Lean manufacturing practices
Digital leadership – technological empowerment						
Digital leadership – information	0.786					
Digital leadership – participation and experimentation.	0.894	0.750				
Thriving at work – learning	0.780	0.747	0.786			
Thriving at work – vitality	0.777	0.672	0.755	0.813		
Lean manufacturing practices	0.769	0.765	0.752	0.770	0.652	

Source: Own calculations.

Subsequently, the structural model was reviewed and the variance inflation factor (VIF) indicators of the constructs, the size and significance of the path coefficients, and the values of f^2, R^2, and Q^2 were assessed. In the first case, it is recommended that the VIF values be equal to or less than 3.0 (Hair Jr et al., 2020). The results indicate that the possibility of multicollinearity is low since the VIF values are below the recommended threshold of 3.0. Specifically, the VIF value between Digital leadership and Thriving at work – learning is 1.000, between Digital leadership and Thriving at work – vitality is 2.470, and between Digital leadership and Lean manufacturing practices is 2.932. In addition, the VIF between Thriving at work – learning and Thriving at work - vitality is 2.470, between Thriving at work - learning and Lean manufacturing practices is 2.949, and between Thriving at work – vitality and Lean manufacturing practices is 2.667. The size and significance of the path coefficients are shown in Table 4. Of the six hypotheses posed, only one is rejected (H4b. Thriving at work, through the vitality dimension, positively and significantly impacts the use of lean manufacturing practices, path = 0.050, t = 1.566). The remaining five hypotheses are validated.

Table 4. Hypothesis testing.

Hypothesis	Path	Values t	Result
H1a. Digital leadership positively and significantly influences the learning dimension of thriving at work.	0.771	46.667***	Validated
H1b. Digital leadership positively and significantly influences the vitality dimension of thriving at work.	0.416	11.200***	Validated
H2. The learning dimension of thriving at work has a positive and significant impact on the vitality dimension of thriving at work.	0.424	11.421***	Validated
H3. Digital leadership directly, positively, and significantly impacts the use of lean manufacturing practices.	0.552	14.900***	Validated
H4a. Thriving at work, through its learning dimension, positively and significantly influences the use of lean manufacturing practices.	0.544	14.608***	Validated
H4b. Thriving at work, through its vitality dimension, positively and significantly affects the use of lean manufacturing practices.	-0.050	1,566ns	Not validated

Notes: *** significant with an Alpha of 0.001, if t >3.291, for a two-tailed test.
Source: Own calculations.

The effect size f^2 estimates the predictive ability of the model constructs: values between 0.02 and 0.14 indicate small effects; between 0.15 and 0.35, medium effects; and above 0.35, large effects (Cohen, 1988; Hair Jr et al., 2020). In this study, no significant effect was identified for Thriving at work – vitality – Lean manufacturing practices (0.002), but a small effect was identified for Thriving at work – learning – Lean manufacturing practices (0.094); medium effects of Digital leadership – Thriving at work -vitality (0.187), Thriving at work –learning – Thriving at work – vitality (0.194) and Digital leadership – Lean manufacturing practices (0.261); and a large effect of Digital leadership – Thriving at work – learning (1.470).

The R^2 coefficient is a measure of prediction and determines the extent to which it explains the model data (Seidel & Back, 2009). An R^2 equal to or greater than 0.670 is considered substantial, an R^2 of 0.350 moderate and 0.190 or less is considered weak (Henseler et al., 2009). The results show three R^2 between moderate and substantial: Thriving at work – learning (0.595), Thriving at work – vitality (0.625), and lean manufacturing practices (0.615). Moreover, with the Stone–Geisser's Q2 coefficient, the relevance and predictive quality of the model was reviewed. It is stated that there is predictive relevance when this indicator is greater than zero, values of Q2 = 0.25 reveal medium relevance, and when Q2 = 0.50 there is large relevance (Hair Jr et al., 2020). The results showed large significance in the three endogenous variables: thriving at work (learning) (0.594); thriving at work (vitality) (0.552); and lean manufacturing practices (0.539). We also evaluated the mediating role of thriving at work in its two dimensions – vitality and learning – on the relationship between digital leadership and lean manufacturing practices, identifying that this variable performed a complementary mediation (direct β 0.544, t=14.608; indirect β = 0.215, t= 6.934; total β=0.759, t= 40.738) (Cepeda-Carrión et al., 2017). The final model is shown in Figure 1.

The results of the structural model are complemented with an importance-performance map. This map compares the effects of exogenous constructs (identified with the PLS-SEM) on an endogenous construct of interest, and performance is added as an additional dimension (Hair Jr et al., 2024; Streukens et al., 2017). The variable of interest in this study was lean manufacturing practices. The importance and performance values of the latent variables are presented in Table 5.

Table 5. Effects and performance of the latent variables.

Latent variables	Importance	Performance
Thriving at work: learning	0.306	66.285
Thriving at work: vitality	-0.050 n.s.	56.484
Digital leadership	0.759	59.792

Source: Own calculations.

The results revealed that digital leadership has the highest importance (0.759), and the lowest relevance is in thriving at work (vitality) (-0.050, with no statistically significant effect). In terms of performance, the highest level is in thriving at work the learning dimension (66.285) and the lowest in thriving at work in vitality dimension (56.484). These results show that digital leadership is the latent variable that most influences lean manufacturing practices. It should be noted that lean manufacturing practices have a performance level of 62.196.

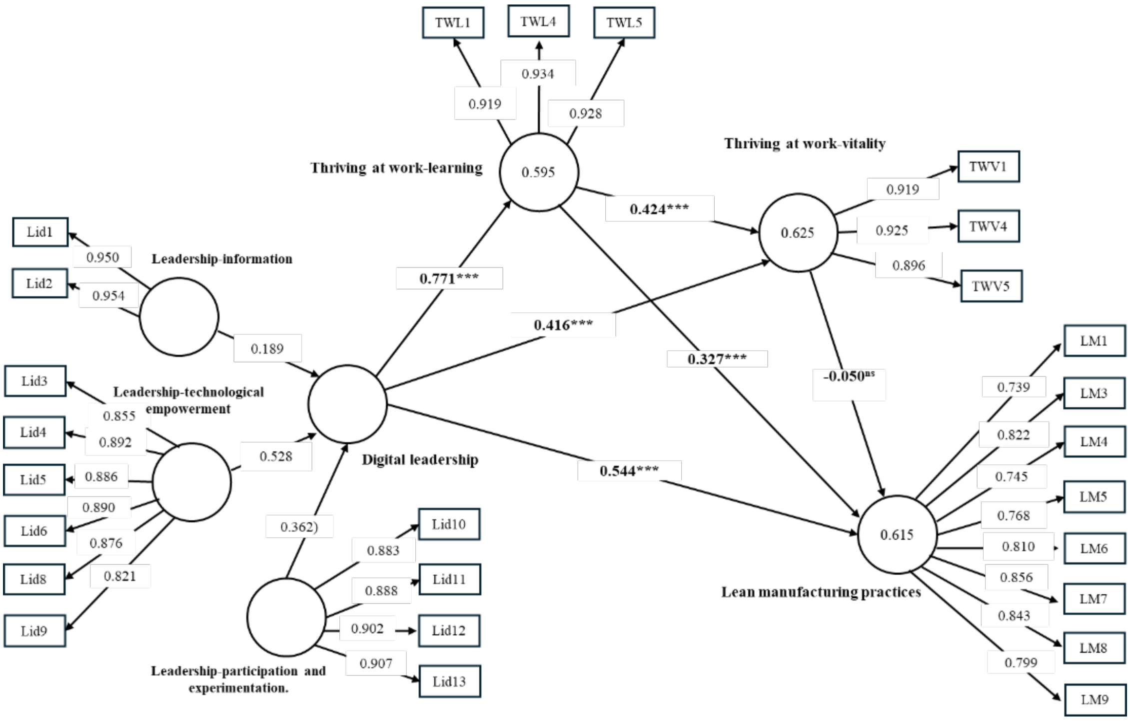

Figure 1. Final model.
Notes: *** significant with an alpha of 0.001, if t >3.291, for a two-tailed test.
Source: Own calculations.

With this information, the importance-performance map was created (Figure 2). In the lower-right quadrant is located digital leadership (importance=0.759, performance=59.792), which implies that it has a high level of importance but a low level of performance. The upper-right quadrant is empty, implying that there are no predictors with both high importance and performance. The lower-left quadrant contains latent variables with low importance and performance. In this quadrant is located the thriving at work - vitality variable (with no statistically significant effect), and finally, in the upper-left quadrant is located thriving at work - learning, with a low level of importance, but a high level of performance (Figure 2).

As a final step, the same procedure was applied to build the importance-performance map (Figure 3). In the lower-right quadrant are located eight leadership items, which have high importance but exhibit low levels of performance. The items belong to the dimensions of technological empowerment (L3, L4, L5, L6, L8) and participation and experimentation (L10, L12 and L13). Within that quadrant, according to their importance and low performance, the items with the greatest opportunity for improvement are: Lid10 "Encourage employees to explore new technologies so that they can bring new ideas into the workplace (importance=0.076, performance=56.122); Lid12 "Know how to prepare employees to work with new technologies (importance=0.076, performance=57.146); Lid5 "Provide an environment that encourages decision-making among employees" (importance=0.077, performance=57.191); Lid 13 "They know what it takes to have more participatory and collaborative environments" (importance=0.078, performance=57.703); Lid6 "Encourage employees to be more open and adopt new technologies for work (NT)" (importance=0.077, performance=58.393); Lid3 "Listen to their employees" (importance=0.074, performance=58.482); Lid8 “Build environments where employees use new technologies (NT)" (importance=0.078, performance=58.660); and Lid4 "Build collaboration, trust, and participation agreements between employees" (importance=0.077, performance=59.216).

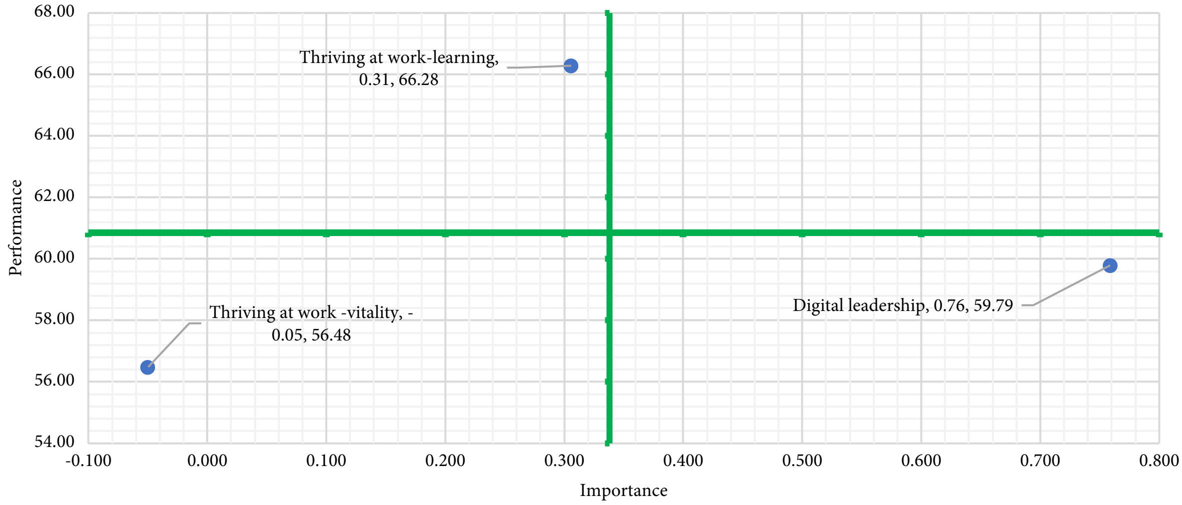

Figure 2. Adjusted importance-performance map of the constructs.
Source: Own calculations.

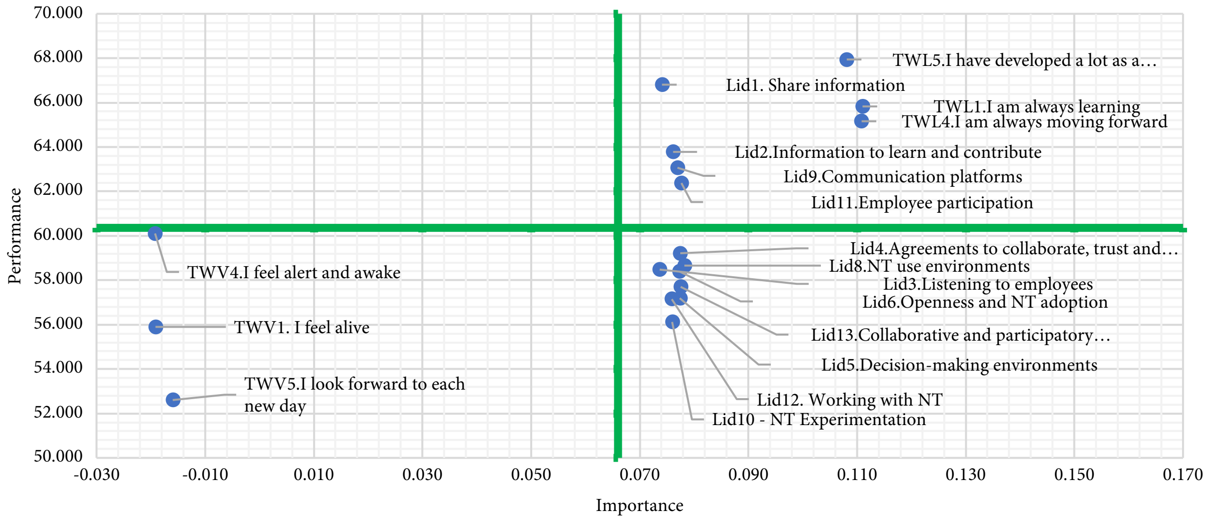

Figure 3. Adjusted importance-performance map of the items.
Note: NT new technology.
Source: Own calculations.

In the upper-right quadrant are seven indicators with high importance and high performance: three of thriving at work (learning dimension) "I have developed a lot as a person" (TWL5, importance=0.108, performance=67.943), "I am always learning" (TWL1, importance=0.111, performance=65.828), "I am always moving forward" (TWL4, importance=0.107, performance=65.160); two digital leadership – information, leaders/supervisors use digital media to "share the information that you need on the job" (Lid1, importance=0.074, performance=66.808), and "share the information needed to learn and/or contribute new ideas" (Lid2, importance=0.076, performance=63.780), one digital leadership – technology empowerment "Select communication platforms (such as WhatsApp, e-mail) that are more favourable to the company" (Lid9, importance=0.077, performance=63.068 and one of digital leadership – participation and experimentation "Seek to involve employees in a variety of activities " (Lid11, importance=0.078, performance=62.378). The lower-left quadrant shows the indicators with low importance and low performance and includes the three thriving at work - vitality items. Finally, in the upper-left quadrant are located the indicators with low importance and high performance: in this study the quadrant is empty.

4. Discussion

Industry 4.0 has benefits in social sustainability, as it gives employees the opportunity to master emerging technologies, which in turn fosters their motivation, satisfaction, and dynamism (Maware & Parsley, 2023). However, this context also poses new challenges for leaders and management of organisations (Bianco et al., 2021). Furthermore, in the case of lean manufacturing, the principles of value and process improvement cause tension, especially when they are realized at the expense of employees' working conditions (Al-Hakim & Sevdalis, 2021).

Previous studies have pointed out that research on the impact of leadership in lean manufacturing initiatives is scarce (Tortorella et al., 2021). It is also argued that more research is needed regarding the antecedents and consequences of thriving at work (Kleine et al., 2019). Thus, in the context of the export manufacturing industry, located in Ciudad Juarez, this research had two objectives: to analyse whether digital leadership has direct and indirect effects on lean manufacturing practices, through the mediation of thriving at work, and to evaluate the importance and comparative performance of constructs and indicators on lean manufacturing practices, as a construct of interest.

The results reveal that digital leadership directly and indirectly influences lean manufacturing practices through its effect on the learning dimension of thriving at work. These findings are in agreement with previous studies (Aripin et al., 2023; Pagliosa et al., 2019; Qureshi et al., 2023; Walker & Qian, 2020) that point out that digital leaders promote lean manufacturing practices when they are able to foster and facilitate the development of people, a primary factor for continuous improvement (Chen & Kanfer, 2006; Lin et al., 2020; Rego et al., 2021; Shahid et al., 2020; Walumbwa et al., 2017). Note that in this work, no influence of the vitality dimension of thriving at work on the use of lean manufacturing practices was identified.

To deepen the results of the effect of digital leadership and thriving at work on lean manufacturing practices, an analysis was conducted employing an importance and performance map. The results show that thriving at work (learning dimension) stands out for its importance and performance. In the case of lean manufacturing, the most important aspects are related to the employee's perception of personal development, learning, and continuous advancement. In addition, with regard to digital leadership, eight indicators were identified as highly important and underperforming: employees experimenting with new technologies, so that they contribute new ideas; preparing employees to work with new technologies; ensuring environments that encourage employees to make decisions; having the knowledge to build more participatory and collaborative environments; promoting the openness and adoption of new technologies; listening to employees; creating environments where new technologies are used; and fostering collaboration, trust, and participation.

Conclusions

This study demonstrates that digital leadership has a decisive role in strengthening lean manufacturing practices, particularly when leaders actively promote employee experimentation with new technologies and foster participatory and collaborative work environments. These leadership behaviours directly support the implementation of lean practices by enabling employees to contribute ideas and engage in continuous improvement activities.

The findings also confirm that lean manufacturing practices are reinforced when leaders encourage decision-making autonomy, openness to technological adoption, and trust-based relationships within the organization. Such conditions are especially relevant in export-oriented manufacturing contexts, where employees are expected not only to comply with standardized processes but also to adapt to ongoing technological changes associated with Industry 4.0.

In addition, the results highlight a critical managerial priority: leaders must prepare employees to work effectively with new technologies and actively encourage experimentation. This preparation enables employees to develop the competencies required to participate meaningfully in digitalized and lean-oriented work environments. Overall, the conclusions establish that the effective integration of lean manufacturing practices within an Industry 4.0 context depends on digital leadership behaviours that consistently promote learning, participation, and employee capability development.

This study has several limitations that should be considered when interpreting the results. First, a non-probabilistic sample and a cross-sectional research design were employed. Consequently, future studies should adopt longitudinal designs with probabilistic samples to strengthen causal inferences and improve the generalizability of the findings.

Second, the research sample was treated as homogeneous. Future research should examine potential differences based on employee position or organizational role, which may provide a more nuanced understanding of how digital leadership and thriving at work influence lean manufacturing practices. In addition, replicating this study in different organizational and industrial contexts would allow for greater external validity. Future studies may also incorporate additional predictors of lean manufacturing practices to extend the explanatory power of the model.

further research is required to examine both the antecedents and consequences of thriving at work. Variables such as proactive personality, innovative behaviour, perceived organizational support, and leadership styles including authentic and ethical leadership represent relevant avenues for advancing this line of research.

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