Journal of Infrastructure, Policy and Development 2024, 8(7), 4776.
https://doi.org/10.24294/jipd.v8i7.4776

Article

Digital transformation and agile methodologies: An innovative model for competitiveness in the manufacturing sector

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CITATION

Pacheco A, Mogrovejo D, Yupanqui R, et al. (2024). Digital transformation and agile methodologies: An innovative model for competitiveness in the manufacturing sector. Journal of Infrastructure, Policy and Development. 8(7): 4776. https://doi.org/10.24294/jipd.v8i7.4776

ARTICLE INFO

Received: 21 February 2024
Accepted: 20 March 2024
Available online: 26 July 2024

Abstract: Currently, numerous companies intend to adopt digital transformation, seeking agility in their methodologies to reinvent products and services with higher quality, reduced costs and in shorter times. In the Peruvian context, the implementation of this transformation represents a significant challenge due to scarcity of resources, lack of experience and resistance to change. The objective of this research is to propose a digital transformation model that incorporates agile methodologies in order to improve production and competitiveness in manufacturing organizations. In methodological terms, the hypothetical deductive method was used, with a non-experimental cross-sectional design and a quantitative, descriptive and correlational approach. A questionnaire was applied to 110 managers in the manufacturing sector, obtaining a Cronbach's alpha coefficient of 0.992. The results reveal that 65% of the participants consider that the level of innovation is regular, 88% think that the competition in their companies is of a regular level, and 76% perceive that the level of change is deficient. The findings highlight the importance of digital transformation in manufacturing companies, highlighting the adoption of agile methodologies as crucial to improving processes and productivity. In addition, innovation is essential to developing high-quality products and services, reducing costs and time. Digital transformation with agile methodologies redefines the value proposition, focusing on the customer and improving their digital experience, which differentiates companies in a competitive market.

Keywords: digital transformation; agile methodologies; change; quality

1. Introduction

Today, manufacturing companies face an extremely competitive and ever-changing business environment. This is due to the growing need to be more efficient in production, which means they can no longer rely exclusively on traditional approaches to analyze data and improve processes if they want to remain competitive in the market. In this context, digital transformation has emerged as a phenomenon of great relevance in the business field. This digital revolution spans various industries and sectors, driving profound changes in the way organizations operate and relate to their customers, partners and employees; improving aspects such as data analysis, automation and connectivity in a company's operations and processes (Schallmo et al., 2017). In this approach, digital transformation in manufacturing companies demands a profound cultural and operational reinvention. This includes the adoption of emerging technologies such as IoT, big data, AI and blockchain, essential to maintain competitiveness (Cuenca-Fontbona et al., 2020). Digital transformation in manufacturing companies will improve efficiency, develop innovations and optimize decision-making, making it a crucial tool for evolution and continued success in a competitive and digitalized market.

Globally, digital transformation has changed the way companies operate, highlighting the adoption of agile methodologies to increase competitiveness and business value. These methodologies vary in type and must be selected considering the nature of the company, the project and the characteristics of the collaborators, motivation and relationships between workers are key factors in the choice and success of the methodology (Molina Montero et al., 2018). Agile methodologies, which adjust to the level of maturity of the organization, stand out for their flexibility and ability to adapt. Some notable methodologies include SCRUM (Sprint, Certified, Releases, Unanimity & Meetings), which emphasizes collaboration and an efficient environment (Alruwaili et al., 2019); extreme programming (XP), which focuses on developing software in a flexible way (Tolfo and Wazlawick, 2008); lean, which seeks to maximize quality and value (Maldonado and Cadavid, 2014); and Kanban, which focuses on visualizing and controlling work progress (Ahmad et al., 2018). The choice depends on the specific needs of each company in a constantly changing business environment.

Companies are adopting agile transformation as part of their digital transformation process, seeking to gain speed and adaptability in their operations (Hobbs and Petit, 2017). Agile methodologies stand out for their focus on early customer engagement and continuous improvement, allowing them to respond effectively to changes in uncertain environments (Hadida and Troilo, 2020). These methodologies improve visibility, adaptability and value, while reducing risks in organizations.

In this section, research on the same topic is presented in order to make some points of comparison.

Previous studies such as the research of Argarwal (2020) highlight that digital transformation has led to an increase in productivity in manufacturing companies, along with improvements in social cohesion, workplace well-being, employee satisfaction and skills development. Likewise, Mergel et al. (2019) pointed out the changes generated by technological adaptation such as interaction with customers through social networks and the proliferation of smart products that allow monitoring and updating in real time. In the work of Schwarzmüller et al. (2018) categorize and describe that digital technologies can drive product innovations, alter existing processes, and open up new business models. In a similar context, Salvador Hernández et al. (2020) point out the impact of technology on public organizations in Cuba, while Agarwal (2020) highlights the challenges of digital transformation in the United States and the importance of preparing leaders. Finally, Iivari et al. (2020) emphasize the need to evaluate the predisposition to change in organizations in Spain, highlighting that the success of digital transformation depends on a genuine change in organizational culture and human evolution within the organization.

In this sense, these case studies have shown that the application of digital transformation has had a significant impact on manufacturing companies, increasing productivity in a range of 20% to 30%, improving work well-being, employee satisfaction, employees, the development of skills and the forms of interaction with customers through social networks, allowing the agile adaptation of products and services to the changing needs of the market, as well as the increase of intelligent products that allow monitoring and updating in real time (Mergel et al., 2019).

However, the specialized literature in the technology sector lacks solid, precise and updated evidence on how digital transformation and agile methodologies specifically impact small and medium-sized manufacturing companies in Peru, as noted by Fischer et al. (2020). There is a need for additional research that explores and validates the impact of digital transformation in the context of manufacturing companies and on organizational improvement.

The present work aims to fill this gap by analyzing the implementation of a digital transformation model with agile methodologies in manufacturing organizations, with a focus on building a digital transformation that delivers profitable products and solutions from the customer's perspective and the introduction of automated transformation (Ehmke, 2017; Holmström, 2022). Within this research, it is demonstrated that the implementation of digital transformation with agile methodologies has a positive impact on competitiveness, innovation, value proposition, customer satisfaction and adaptation to change in the industrial sector, by taking into account the workers, their motivation and mutual relationships within the organization. Therefore, the objective of this study is to propose a digital transformation model with agile methodologies that improves production and competitiveness in manufacturing organizations in Peru, contributing to a profitable digital transformation from the customer's perspective and the adoption of a new mentality within the organization. This research contributes to the field by recognizing the importance of considering workers, their motivation, and mutual relationships through agile methodologies when implementing a digital transformation model that manages the culture, strategies, and capabilities of organizations. Furthermore, he highlights how these strategies not only improve operational efficiency and competitiveness, but also redefine the value proposition of companies by focusing on the digital customer experience. It also highlights the need for continuous innovation to develop quality products and services in a dynamic and competitive business environment. Taken together, these findings offer valuable insights to guide organizations on their path to successful and sustainable digital transformation.

2. Method

Within the framework of this research, a non-experimental cross-sectional design was used, which allowed us to capture a representative panorama of the perceptions and attitudes of managers in the manufacturing sector in Peru regarding digital transformation and the adoption of agile methodologies.

The methodological approach was based on the hypothetico-deductive method, which involves the formulation of hypotheses and the deduction of conclusions from collected data. This approach provided a solid framework to evaluate the relationship between the implementation of digital transformation and its effects on the production and competitiveness of manufacturing organizations in the country.

The methodology adopted in this study was quantitative in nature. This choice allowed for the collection of numerical data and the application of statistical analysis to evaluate participants' perceptions in terms of innovation, competition, and change in their companies. We sought to establish quantitative relationships and trends within the data collected. The research hypothesizes that there is a positive and significant

relationship between the implementation of digital transformation and increased competitiveness in manufacturing companies.

2.1. Sample and selection procedure

The sample of participants consisted of 110 workers from companies in the manufacturing sector. The selection of participants was carried out through simple random sampling, ensuring representativeness and diversity in terms of experiences and work responsibilities in the organizational field. To be included in the study, participants had to meet the following inclusion criteria: (a) be between 30 and 55 years old, (b) provide informed consent to participate in the research, and (c) be permanent employees with at least 6 months of work experience in a manufacturing company. Incomplete questionnaires and cases where participants expressed a lack of willingness to continue their participation were excluded.

2.2. Data collection instrument

The data collection technique used was the survey, implemented through a structured questionnaire. Each eligible employee was provided the opportunity to participate in the survey via an emailed link, which redirected to the online questionnaire hosted on Google Forms, allowing participants to complete the survey conveniently and confidentially. The questionnaire included two opinion scales based on the Likert methodology, validated by expert judgment with a Cronbach's alpha coefficient of 0.992. The first scale measured the opinion on the independent variable digital transformation with the dimensions innovation, competition and value with a total of 12 questions. The second scale evaluated the dependent variable agile methodologies with the dimensions customers and change with 6 questions. The scale comprises values from 1 to 3 representing good, fair and poor respectively.

2.3. Validation of the measurement tool

The Likert scale used in the questionnaire was subjected to a validation process by expert judgment to ensure its suitability and relevance. A panel of experts in the field of digital transformation and agile methodologies evaluated the clarity, relevance and consistency of the statements on the scale. Adjustments were made based on comments and suggestions from experts to improve the understanding and applicability of the scale.

2.4. Analysis of data

The data collected were subjected to descriptive statistical analysis, including measures of central tendency and dispersion for each dimension of the independent and dependent variables. Furthermore, correlation tests were carried out to explore possible relationships between the different dimensions and the participants' opinions. To carry out these analyses, statistical software tools such as SPSS were used.

2.5. Ethical considerations

The research was conducted in strict compliance with ethical research principles. Participants provided informed consent before inclusion in the study, ensuring their

voluntariness and confidentiality. All personal information and responses provided were handled confidentially and used exclusively for research purposes.

3. Results

The questionnaire was applied to 110 workers from manufacturing companies, based on which the following results were obtained:

The findings obtained in **Figure 1** revealed that 65% of the workers consider that the level of innovation in the company is poor. This could suggest that significant efforts are required to foster a more innovative and creative environment in the organization. Furthermore, 88% maintain that competition in the market is regular. The high percentage that rates the competition in the market as "fair" could indicate that the company may need to improve its strategy to stand out in a competitive market. Finally, 79% of them consider the company's value to be bad. Such a high percentage of employees rating the company's value as "bad" suggests a negative perception regarding the organization's value proposition. This could indicate that the company faces challenges in creating and communicating its value proposition, which may affect its reputation and competitiveness in the market.

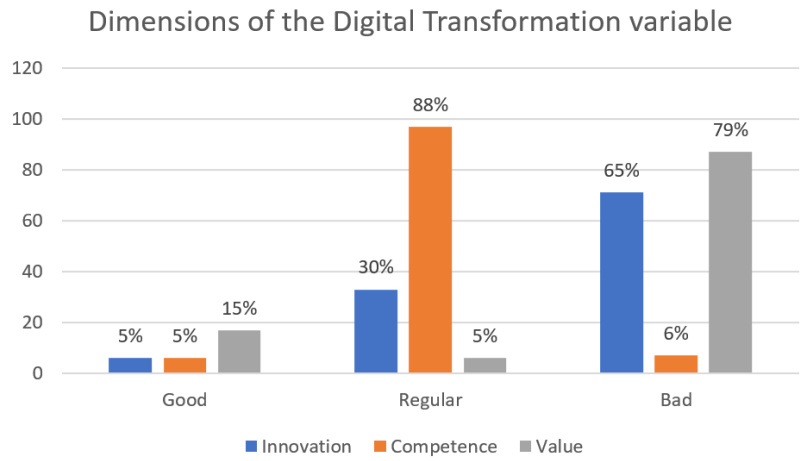

Figure 1. Status of the digital transformation variable.

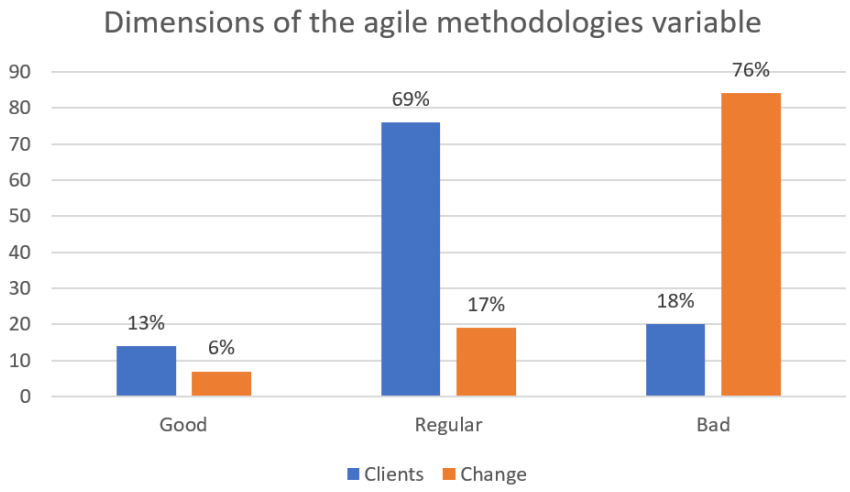

Figure 2. Status of the agile methodologies variable.

The results of the research obtained in **Figure 2** show that a significant part of the workers, specifically 69%, perceive that customer service in the company is of "fair" quality. This could suggest that there is room to improve customer satisfaction and strengthen customer service-related practices through agile methodologies. Furthermore, 76% of employees believe that the dimension of change in the organization is in a poor state, which points to challenges in managing change and adapting to new circumstances within the company. This data underscores the importance of considering measures to improve both customer service and the company's ability to manage and adapt to change effectively.

Correlation coefficient

As can be seen in **Table 1**, Pearson correlation results have been obtained that provide information on the relationships between the different dimensions analyzed in this study. A statistically significant positive correlation was found between the innovation and customers dimensions ($r = 0.733$, $p < 0.001$). This indicates that as innovation levels improve, a better relationship with customers was evident. Likewise, a strong positive correlation was found between the innovation and change dimensions ($r = 0.931$, $p < 0.001$), as well as the competition and change dimensions ($r = 0.938$, $p < 0.001$). Similarly, it was evident that there is a moderate positive correlation between the dimensions of competition and clients ($r = 0.608$, $p < 0.001$). This indicates that as competition levels increase, workers reported a greater number of customers.

Table 1. Interrelationships between digital transformation dimensions and agile methodologies dimensions.

	***M* (*DE*)**	**1**	**2**	**3**	**4**	**5**
1) Innovation	2.05 (0.63)	1	0.881**	0.931**	0.733**	0.931**
2) Competence	2.18 (0.76)	0.881**	1	0.938**	0.608**	0.938**
3) Value	2.11 (0.67)	0.931**	0.938**	1	0.663**	10.000**
4) Clients	2.16 (0.61)	0.733**	0.608**	0.663**	1	0.663**
5) Change	2.11 (0.67)	0.931**	0.938**	10.000**	0.663**	1

Note: ***P* < 0.01.

4. Proposal

The proposal of this research shows a digital transformation model with agile SCRUM methodology for manufacturing companies, using innovation, competition, customers, value and change to achieve an ideal state in manufacturing organizations, implementing digital technologies; making changes and improving marketing strategies in the organization.

Figure 3 highlights the digital transformation in manufacturing companies through the use of agile methodologies. This visual representation shows three fundamental aspects that converge to promote positive change in these organizations. First of all, the direct connection between the adoption of digital technologies in the production process and the ability to innovate in the design and development of new and improved products is highlighted. The implementation of agile methodologies facilitates agile adaptation to changes in market requirements, accelerating the time to

market of innovative products.

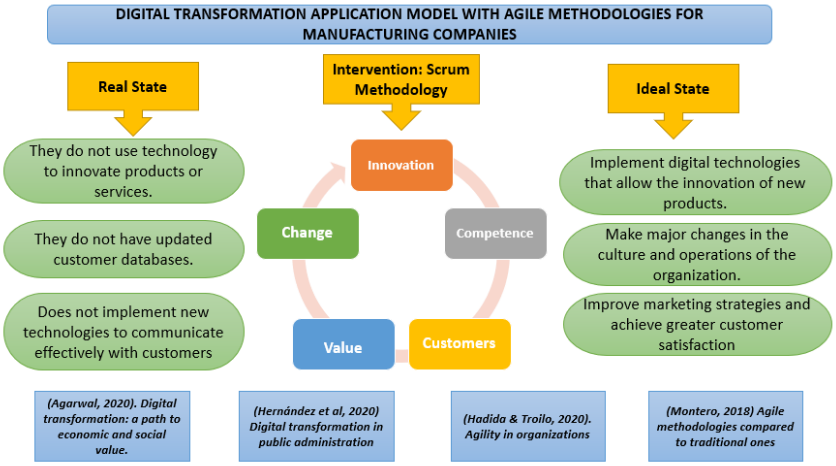

Figure 3. Proposal for digital transformation with agile methodologies in manufacturing companies.

Furthermore, the figure highlights the cultural and operational change that accompanies digital transformation. It is not just about incorporating new technologies, but about promoting a change in organizational mentality. Agile methodologies emerge as key enablers by promoting collaboration, flexibility and transparent communication between teams, contributing to a cultural shift towards agility and innovation. At an operational level, process automation and the implementation of digital systems improve efficiency, reduce production times and increase product quality.

Finally, the figure effectively illustrates how digital transformation positively impacts the marketing strategies of manufacturing companies. Digitizing operations provides valuable information to understand customer needs, personalize marketing strategies, and improve user experience. Decision-making agility, driven by agile methodologies, allows companies to quickly adjust their marketing strategies in response to market trends. Taken together, this convergence of elements represents an essential boost for competitiveness in a dynamic and highly technological business environment.

5. Discussion

In **Figure 1**, it is observed that 65% of the participants indicate that the level of innovation in their companies is classified as bad. This finding suggests the imperative need for managers of manufacturing companies to implement concrete strategies, provide adequate training, and disseminate organizational objectives to all levels of the workforce. These actions are essential to encourage the development of higher levels of innovation in the organization. This result finds support in the existing literature, where studies such as Schwarzmüller et al. (2018) and Hidalgo (2019), have indicated that digital technologies have the potential to constitute disruptive innovations in the field of products, displace processes and open up completely new business models. The convergence of this evidence underscores the critical importance

of manufacturing companies moving toward the adoption of digital technologies and innovative strategies to remain competitive in a constantly evolving business environment. The results of our research largely coincide with the trends identified in the literature, reinforcing the idea that effective innovation management in the context of digital transformation is essential to ensure the long-term viability and competitive success of companies. manufacturing organizations.

Figure 1 highlights that a significant 88% of the managers surveyed perceive that the level of competition in their respective companies is classified as regular. This result highlights the prevailing need to improve marketing strategies in the manufacturing organizations studied. Additionally, the importance of achieving greater customer satisfaction is highlighted, a crucial element for competitive success in today's market. This finding is aligned with the existing literature, where research such as those by Hadida and Troilo (2020) and Mergel et al. (2019) highlight the centrality of customers in achieving continuous improvement. These studies highlight that the implementation of agile methodologies is essential to respond effectively to changes, thus guaranteeing the ability to adapt to unforeseen situations in the business environment. Compared to these literature findings, our results reinforce the idea that the adoption of agile methodologies in competition and customer satisfaction management is presented as a crucial strategy for manufacturing organizations. The convergence of this evidence supports the premise that digital transformation, accompanied by agile practices, can be a key factor to improve competitiveness in the market and strengthen customer relationships.

Figure 1 highlights that a significant 79% of participants perceive that the value of their respective companies is classified as poor. This result suggests that manufacturing organizations face significant challenges regarding the value proposition of their products or services, indicating a critical need to review and improve their strategic approaches. This finding finds support in the existing literature, where studies such as those by Ahmad et al. (2018) and Argarwal (2020), emphasize the importance of organizations creating value quickly and at low cost. These investigations propose the adoption of a new way of thinking, which promotes the transition from the known to the unknown in the search for innovative strategies for the creation of value. When comparing these results with the trends identified in the literature, a convergence is observed in the importance of rethinking and transforming business models and strategies to provide solid and differentiated value.

Figure 2 highlights that 69% of the participants indicate that the level of customer satisfaction is classified as regular. This finding points to the need to improve various aspects in manufacturing organizations, including production processes, product innovation, and marketing strategies, among others. This result finds support in the existing literature, where research such as those by Alruwaili et al. (2019) and Dikert et al. (2016), highlight the importance of efficiently managing the changes generated by digital transformation in organizations. These studies specifically highlight the need to adopt new forms of direct interaction with customers through social media. Direct interaction allows products and services to be adapted according to changing customer needs, which is essential to maintain high levels of satisfaction. Comparing these results with the literature, consistency is evident in the importance of digital transformation not only to improve internal processes but also to strengthen the

relationship with customers. Agile adaptation to changing customer needs, through channels such as social media, emerges as an essential component to optimize customer satisfaction and maintain a competitive advantage in today's market.

Figure 2 highlights that a considerable 76% of participants indicate that the level of change in their organizations is classified as poor. This finding underscores the pressing need to shift mindsets, culture and processes in manufacturing companies to address the challenges associated with digital transformation. This result aligns with the existing literature, where research such as those by Cuenca-Fontbona et al. (2020) and Salvador Hernández et al. (2020), emphasize that the beginning of the digital transformation implies a fundamental reconfiguration in the way of thinking of the organization. This change, in turn, requires substantial transformations in culture, operations and organizational structure. However, it is observed that many companies still face resistance to digital change, underscoring the importance of addressing cultural barriers when initiating transformation processes. When comparing these results with the trends identified in the literature, consistency in the need for a cultural transformation to facilitate the adoption of digital transformation is evident. Resistance to persistent digital change, as noted by literary sources, highlights the importance of initiatives that encourage agile conversion in organizations.

Relationship between digital transformation and agile methodologies for manufacturing companies

The relationship between digital transformation and agile methodologies, such as scrum, is fundamental to understanding how manufacturing companies can effectively adapt to a constantly changing business environment. Flexibility and adaptability are key elements in this relationship (AlNuaimi et al., 2022; Castilla et al., 2023). Digital transformation introduces disruptive technologies and changes in business processes, while agile methodologies offer a flexible framework that allows companies to quickly adjust to these changes (Frau et al., 2022). The survey conducted in our study shows that companies that combine digital transformation with agile methodologies are better able to respond nimbly to market and customer demands, giving them a significant competitive advantage.

Another crucial aspect of this relationship is continuous iteration and incremental improvement. Both digital transformation and agile methodologies promote continuous improvement in the company's processes and products. The survey revealed that companies that apply agile methodologies within their digital transformation are more agile in identifying and correcting problems, resulting in constant improvement in the quality and efficiency of their operations.

Collaboration and teamwork are also prominent aspects of this relationship. Both digital transformation and agile methodologies foster collaboration between different departments and teams within an organization. The survey highlighted that manufacturing companies that adopt scrum or other agile methodologies experience a significant improvement in internal communication and collaboration. This collaboration facilitates the successful implementation of digital transformation initiatives, as employees work together toward common goals and share knowledge and resources more effectively.

Finally, the relationship between digital transformation and agile methodologies focuses on meeting customer needs and expectations. Both promote a customer-centric approach, resulting in a better understanding of customer demands and the ability to adapt quickly to meet them (Castilla et al., 2020; Wiechmann et al., 2022). The survey revealed that companies that integrate digital transformation with agile approaches have a greater ability to adapt to changing market needs and deliver products and services that generate higher customer satisfaction. Taken together, this symbiotic relationship drives agility, innovation and competitiveness for manufacturing companies in an increasingly digitized and dynamic business environment.

6. Limitations and future research

Despite the encouraging results obtained in this research, it is crucial to recognize some limitations that could affect the generalizability of the findings. First, the sample was limited to 110 managers from the manufacturing sector in the Peruvian context, which may not be fully representative of the diversity of companies in the region. Furthermore, the quantitative approach used may not fully capture the richness of perspectives and experiences that could emerge in a more in-depth qualitative study. Likewise, the scarcity of resources and resistance to change identified as challenges in the Peruvian context could vary in other regions or sectors, suggesting the need to consider local particularities in future research.

In terms of future research, it would be valuable to explore the specific impact of resistance to change on the implementation of digital transformation in manufacturing companies. Furthermore, the inclusion of a more detailed qualitative analysis could provide a deeper understanding of the cultural and organizational factors that influence the adoption of agile methodologies. Furthermore, extending the research through longitudinal monitoring would allow evaluating the long-term sustainability of the proposed digital transformation and its impact on competitiveness. Finally, the comparison of results between different sectors and regions could enrich the understanding of the dynamics of digital transformation in diverse business environments.

7. Implications of the study

The findings of this study have several practical implications for manufacturing companies in Peru and beyond. First, they highlight the importance of focusing on specific areas such as innovation, competency, and change management to drive digital transformation and adopt agile methodologies effectively. Companies can use these results to identify areas for improvement and develop specific strategies to address them.

In addition, this study underscores the need to promote an organizational culture that fosters innovation and adaptability to change. Companies can implement training and talent development programs to equip their employees with the skills needed to meet the challenges of digital transformation and adopt agile methodologies successfully.

In summary, this study provides a solid foundation for manufacturing companies in Peru and other contexts to take full advantage of digital transformation and agile

methodologies, boosting their competitiveness and their ability to innovate in an ever-changing business environment.

8. Conclusion

In conclusion, the findings of this research provide a comprehensive vision of the reality of manufacturing companies in the context of digital transformation. The adoption of agile methodologies in the digital transformation process is revealed as an essential strategy to improve various key aspects in these organizations.

To conclude, digital transformation and agile methodologies are significantly related in organizations, allowing them to implement changes in all areas of the organization, improving their processes and productivity. Likewise, high levels of innovation must be developed to develop high-quality products and services with low costs and shorter times. These changes satisfy customers, develop and increase competitiveness in manufacturing companies.

On the other hand, implementing digital transformation with agile methodologies redefines the value proposition, aligns the customer-centric vision and improves the digital customer experience, differentiating the company from its competitors.

Author contributions: Conceptualization, JG; methodology, YUH; formal analysis, DM; investigation, RY; resources, JG; data curation, YUH; writing—original draft preparation, DM; writing—review and editing, AP; project administration, AP; funding acquisition, AP. All authors have read and agreed to the published version of the manuscript.

Conflict of interest: The authors declare no conflict of interest.

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