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Research Article

Aligning organizational structures with digital transformation and industry 5.0 in construction: a Delphi study

Cristian C. Osorio-Gómez [1*], Rodrigo F. Herrera [2], Vicente A. González [3], Eugenio Pellicer [4]

1 Assistant Professor, School of Applied Sciences and Engineering, Universidad EAFIT, Medellín (Colombia); ccosoriog@eafit.edu.co
2 Associate Professor, School of Civil Engineering, Pontificia Universidad Católica de Valparaíso, Valparaíso (Chile); rodrigo.herrera@pucv.cl
3 Professor and Tier 1 Canada Research Chair in Digital Lean Construction, Infrastructure Human Tech Lab, Department of Civil and Environmental Engineering, Faculty of Engineering, University of Alberta, Edmonton (Canada); vagonzal@ualberta.ca
4 Professor, School of Civil Engineering, Universitat Politècnica de València, Valencia (Spain); pellicer@upv.es
*Correspondence: ccosoriog@eafit.edu.co

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Highlights:

- Implementing changes in OS can facilitate the adoption of technologies.
- More optimized OS would allow companies to maximize the benefits of DT.
- The Model serves as a tool for companies to identify weaknesses and strengths.
- The Model integrates organizational and DT variables due to synergistic effects.
- Construction 5.0 must integrate the organization into its framework.

Abstract: The digitalization of the AEC sector, while steadily progressing, has been largely driven by technological adoption rather than by a transformation of its organizational structures. Within construction 5.0, the AEC organizations have not been investigated in depth. For this reason, exploratory research is currently underway to examine the mutual impact between digital transformation and organizational structures, but it has not yet been fully developed. For this reason, this research examined a joint conceptual model between digital transformation and organizational structures. Based on a previous conceptual model, a panel of industry and academic experts will conduct an assessment. This assessment was conducted using the Delphi method, bringing together 40 academic experts and industry-leading professionals to provide a holistic view of digital transformation, both theoretical and practical. The experts' responses were analyzed using statistical methods, including Kendall's concordance, level of importance, consensus, and Mann-Whitney analysis. The main findings from this study show a consensus among the experts in the conceptual model, having as the most relevant variables Transformational Leadership, Data Integration and Analytics, Knowledge Management, and Integrated Organizational Innovation (IOI) are critical in a joint digital-organizational implementation, this conceptual model provides a vision to construction companies to improve their productivity and achieve their goals through digital transformation and organizational redesign in the context of construction 5.0.

Keywords: Digital transformation, organizational structure, organizational culture, construction 5.0, construction sector; integrated organizational innovation (IOI).

Abbreviation:

DT: Digital transformation

OS: Organizational structures

OC: Organizational culture

IE: Information exchange

IOI: Integrated organizational innovation

1. Introduction

Companies in the construction sector strive to achieve productivity targets that meet collective interests based on economic development, as well as interests of the individual's context (Hughes and Thorpe, 2014; Wierzbicki et al., 2011). However, in developing their activities, they face several difficulties, such as cost overruns, delays, reprocessing, and material waste, which make it time-consuming and unproductive to achieve the proposed results (González et al., 2014). Among the weaknesses identified in companies and projects that prevent them from achieving these objectives is the lack of control over what is planned, settling for the monitoring and compliance of completed activities, and neglecting the variables of time, progress, and quality (Pellicer et al., 2012; Tchidi et al., 2012). Often, these problems are caused by inefficiencies in the construction value chain (Maqsoom et al., 2021). Some of the most common sources of inefficiency are fragmentation of work teams, material waste, rework, poor design coordination, and unforeseen site conditions, among others (Herrera et al., 2021; Koolwijk et al., 2020; Panteli et al., 2018). These inefficiencies have led to comparatively lower productivity than other industries (Barbosa et al., 2017; Catlin et al., 2015). However, these conditions are often not directly related to construction procedures but to administrative support processes (Porter, 2001). These processes are directly associated with the configuration of the organizational structure, which defines the collaborators' norms, roles, responsibilities, and coordination (Ahmady et al., 2016; Zheng et al., 2010).

To increase the added value of the construction sector, technological methodologies that enhance its efficiency have been developed (Akintoye et al., 2012; Bygballe and Ingemansson, 2014). The case of Building Information Modeling (BIM) combines virtual construction, information flows, and stakeholder integration to make the construction sector more efficient (Azhar, 2011; Eastman et al., 2008; Succar, 2009). In addition, technologies such as IoT, drones, extended reality, and artificial intelligence, among others, have also been implemented (Alizadehsalehi and Hadavi, 2023; Karmakar and Delhi, 2021). These digital technologies can complement one another, adapting to each company's needs. The phenomenon associated with technological adoption in organizations is digital transformation (Ismail et al., 2017; Papadonikolaki et al., 2020; Schreckling and Steiger, 2017).

The digital transformation tries to exploit the opportunities caused by the massive digitization of information (Matarneh et al., 2019), material processes and extensive digital data collected from sensors, cameras, general contractors, and users related to construction objects and the built environment (Klinc and Turk, 2019). Nonetheless, the implementation of digital technologies signifies such initiating factors that demonstrate the ability to impact the conventional methods of structuring the architecture and engineering sector (Lavikka et al., 2018). Digital transformation (DT) involves adopting digital tools within a sector to make it more productive and transforming business models and customer relationships. On the other hand, organizational structures (OS) are defined as the organization's roles, responsibilities, and guidelines to meet its strategic objectives. For this reason, DT is a process of organizational change that requires an OS to execute it, and these OS have peculiarities in the construction sector (García de Soto et al., 2019; Shirazi et al., 1996); some of these characteristics in the construction sector are hierarchical structure, focus on projects, use of subcontractors, different work teams between phases (Liu et al., 2016). In this process of organizational redesign, a critical concept appears, such as Organizational Culture (OC), which is the set of values, norms, beliefs, and practices of the members of an organization; if the changes are not aligned with the OC, members will reject those changes, and the digital transformation is more likely to fail.

An unprepared organization is the main obstacle to digital transformation's failure or scant progress (Gupta, 2018). Digital technologies have the disruptive power to transform conventional OS due to these new technologies requiring new processes, information flows, and customer relationships (Porter and Heppelmann, 2014). It can be argued that adopting digital technologies creates a demand to manage organizations as relational ecosystems (Bonanomi et al., 2019). However, in the construction sector, barriers have been found in organizations that have prevented DT concerning organizational design. Some of these need to be more precise roles and responsibilities of employees, rigid and unadjusted organizational culture, and a lack of internal talent for digital projects (Kohnke, 2016). For example, in the construction sector, leadership styles vary frequently, leading to greater variability in team productivity (Giritli et al., 2013; Osorio-Gómez et al., 2022). In addition, the construction sector is characterized by low investment in innovation processes, skills training, and technological development (Dixit et al., 2017). To improve the construction sector's productivity, investments must be made in skills development and technology (Al-Hakim and Lu, 2017; Kane et al., 2015). Making a "digital shift" primarily requires a "culture shift" by adjusting leadership, communication, and collaboration models (Papadonikolaki et al., 2020).

Industry 5.0 is an evolution of Industry 4.0, with a more social and sustainable vision that prioritizes human needs while not neglecting sustainability (Leng et al., 2022). There is a need in Industry 5.0 to adapt organizations to employees' needs in the context of automation and robots (Leng et al., 2022; Xu et al., 2021). In Industry 5.0, there is a remarkable collaboration between humans and machines. Thus, human creativity will be combined with the precision and efficiency of machines to deliver effective, customized solutions (Tunji-Olayeni et al., 2024). On one hand, the framework proposed by Ikudayisi et al. (2023) has 3 main categories of implementation of Industry 5.0 in the AEC sector: 1) Human-centric; 2) resilient; 3) sustainable. In each of these categories, there are technologies and drivers to achieve a construction 5.0 (Ikudayisi et al., 2023). On the other hand, another investigation by Faraji et al. (2024) coincides with the fact that the four principal aspects of the Construction 5.0 are: 1) Resilience, 2) sustainable development, 3) human-centric, and 4) economic efficiency. However, none of the above research mentions organizations as an important factor in Industry 5.0, even though they are the vehicles that enable the development of construction projects. Within this context, this research aims to align changes in the OS of the construction sector with the processes of DT and Industry 5.0 through a validated conceptual model, agreed upon by academics and industry experts, that can be implemented in companies in the edification and infrastructure sectors. Finally, Section 2 presents the knowledge gap and research goals; Section 3 describes the research method; Section 4 presents the results; Section 5 discusses the conceptual model developed; and Section 6 describes the main conclusions and findings.

2. Knowledge gap and research goals

During the DT process in the construction sector, movements such as Construction 4.0 and Lean Construction 4.0 have emerged. Previous research highlights essential points of interaction between the implementation of Construction 4.0 methodologies and OS aspects that must be considered for such a transformation (Aghimien et al., 2022; Karmakar and Delhi, 2021; Nagy et al., 2021; Sawhney et al., 2020). Nevertheless, there is a central emphasis on the tools and methods to be implemented such as BIM (Hamidavi et al., 2020; Najjar et al., 2022), IoT (El Jazzar et al., 2021), Artificial Intelligence (Elghaish et al., 2020; Oprach et al., 2019), Drones (Amariles-López and Osorio-Gómez, 2023; Umar, 2021), and Robotics (Cai et al., 2020; Chung et al., 2019), among others.

There is still a research gap in understanding globally how changes in OS enhance/decrease DT processes in organizations in the construction sector could. For example, González et al. (2022) speak of three great circles of influence in their conceptualization of lean construction 4.0: processes, culture, and technology; however, technology primarily has a direct relationship with Industry 4.0. Therefore, in the research by Aghimien et al. (2022), variables such as lack of knowledge, communication problems, and lack of collaboration are noted, but only the relationship with DT variables is explicitly stated. In the framework proposed by Sawhney et al. (2020) for Construction 4.0, technological tools for DT are discussed without considering organizational changes. In the manufacturing industry 4.0 models, the concept of Cyber-Physical Systems (CPS) is highlighted due to it is integration of physical systems with digital ones through the network; this concept could be the core of industry 4.0 (Li, 2018; Sawhney et al., 2020). CPS must be supported by implementation factors, including leadership, management, and OS (Oesterreich and Teuteberg, 2016; Pozzi et al., 2023); nonetheless, these concepts are presented as factors without analyzing their causal relationships (Pozzi et al., 2023; Yagiz et al., 2017). In the current trends of Industry 5.0, concepts such as resilience, human-machine collaboration, and emphasis on worker well-being appear (Adel, 2022; Aslam et al., 2020; Pereira and dos Santos, 2023); although, most of the current research is focused on exogenous factors such as advances in robotics, artificial intelligence, and more resilient industrial systems (Yitmen et al., 2023).

After reviewing the literature on variables affecting organizations in terms of DT and OS, an initial model was developed that identified 14 primary relationships (Osorio-Gómez et al., 2023). Moreover, these variables already had a theoretical basis from the literature review. In this model, there are decision variables related to the company's internal processes and strategy, as well as outcome variables related to internal and external results (Osorio-Gómez et al., 2024). This model was taken as a basis, as it is the only one to consider the macro variables comprising the joint implementation process DT and OS, such as organizational climate (OC), information exchange (IE), and integrated organizational innovation (Osorio-Gómez et al., 2024). Integrated organizational innovation (IOI) is a concept in which innovation is not composed of isolated organizational elements; instead, it is transversal throughout the organization, drawing on areas such as procurement, contracts, finance, engineering, and human resources. Information exchange (IE) is an organizational outcome in which information flows between departments and projects are directly enhanced through the implementation of more structured technological tools and processes. Furthermore, organizational climate (OC) is a macro-variable with significant impact, as any change made by the DTandOS must be validated and implemented by the people in the organization.

Additionally, this conceptual model, shown in Figure 1 (Osorio-Gómez et al., 2024), presents development at the variable level, where, for example, employee training and development have a positive synergistic effect on IOI, IE, and OC. Likewise, Services with other companies have positive effects on the IOI, as there is a transfer of know-how through the shared execution of projects (IOI) and the establishment of processes for a better flow of information (IE). Conversely, the variables presented in red in Figure 1 have a negative effect on the macro-variables and should be avoided. Thus, the changes resulting from the joint implementation of DT and OS will be reflected in more decentralized organizational structures and more efficient decision-making. Furthermore, this model by Osorio-Gómez et al. (2024) provides a solid conceptual basis for the joint implementation of DT and OS; methodologically, it was validated by professionals in the AEC sector; another validation by academics and industry experts would be advisable. In addition, there is no initial prioritization of the variables, leaving it to discretion which variable to implement first.

For these reasons, there is a knowledge gap since no research in construction goes in-depth to understand the relationships between these organizational variables and DT processes, and how these relationships align with the endogenous changes in organizations that must be facilitated to avoid problems in construction projects, such as low productivity, cost overruns, delays, waste, and quality issues. Therefore, the main question of the research is: What would the prioritization of variables be in a joint implementation between DT and OS? This research will examine a joint transformation conceptual model, focusing on a hierarchy of variables rather than solely on methods and technological tools. In summary, this research aims to achieve the following objectives: (1) to validate the variables of the initial model that relate DT to OS (Osorio-Gómez et al., 2023, 2024); and (2) to propose an improved conceptual model according to the panel of experts for DT and OS. The findings are expected to apply to organizations in the construction sector seeking to enhance DT and OS outcomes.

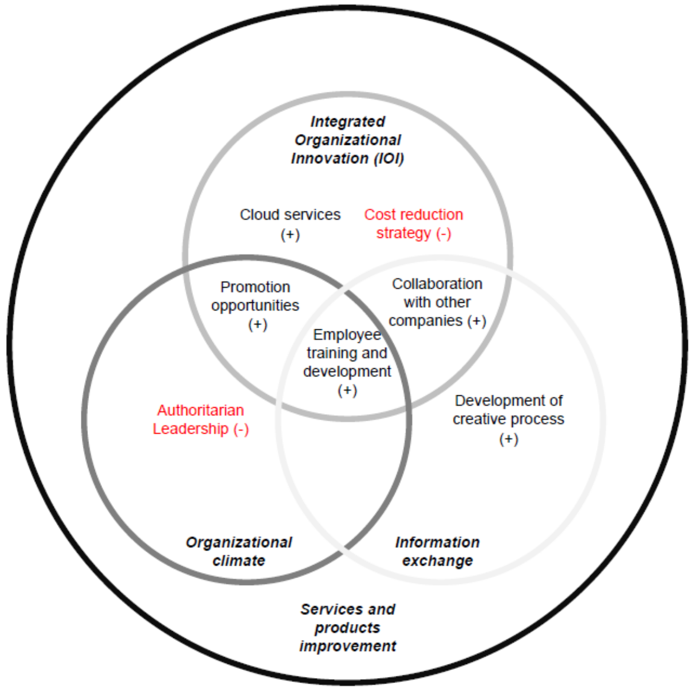

Figure 1. Conceptual model 1.0 digital transformation and organizational structures (Osorio-Gómez et al., 2024).

3. Research method

Considering the first (1) objective of the research, which is to validate the variables of the conceptual model of DT and OS (Osorio-Gómez et al., 2024). This research is exploratory in nature, as it builds upon an initial conceptual model that, prior to this study, lacked expert validation and feedback. A method was sought that could lead to a "collective agreement" between experts who combine evidence and expert judgment, rather than to statistically test pre-defined hypotheses with empirical data. One of the most plausible options was the Delphi method, an investigative technique for obtaining expert judgment on a specific topic (Sforzini et al., 2022; Valdés and Marín, 2013). Many previous studies have used the Delphi method to reach consensus and understand expert perspectives (Hallowell and Gambatese, 2010; Mansour et al., 2022; Naji et al., 2022). The Delphi method was chosen because the research problem is exploratory rather than confirmatory. Also, Delphi would allow for systematic evaluation and potential for improvement of initial components (variables). In contrast, another confirmatory method, such as structural equation modeling (SEM), requires more data, and obtaining this volume with experts is difficult (Westland, 2010). Consequently, to ensure compliance with the proper procedures, ethical approval was obtained from the Universitat Politecnica de Valencia. The overall research method is summarized in Figure 2 and explained in detail in the following subsections, including the expert selection criteria, the questionnaire structure, and the statistical analysis.

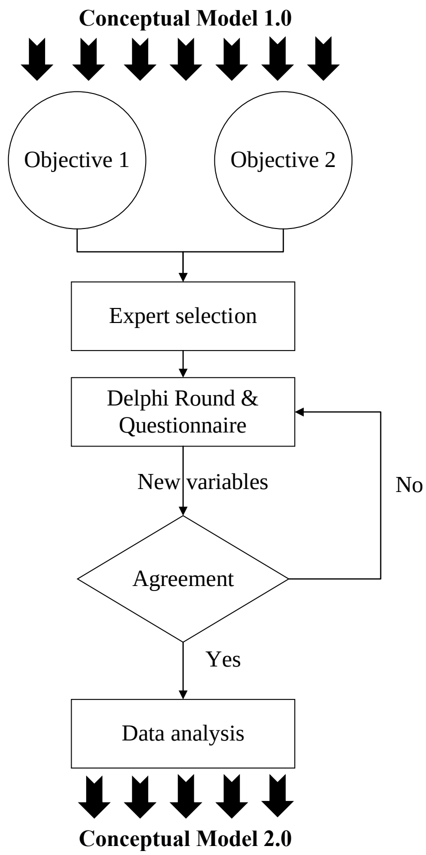

Figure 2. Overall research method.

3.1. *Expert selection criteria*

One of the study's success criteria depends on the selection of experts, as credibility and results will depend on the respondents' selection and expertise in the field of work (Balali et al., 2022; Cortés et al., 2012; Hallowell and Gambatese, 2009). Two main types of professional profiles were sought: (1) industry experts with considerable experience and leadership in the construction sector and (2) academic experts with research papers on DT issues in the construction sector. The expert panel was recruited via two primary channels: academic experts were identified and contacted via email based on their publications on digital transformation in recognized journals, while industry experts were recruited through LinkedIn.

The panel of experts will comprise leading academics and industry professionals to provide a holistic view of DT across theoretical and practical domains. Due to their diverse experiences, they may hold different opinions based on their expertise, country, and academic background. Experts must reach a minimum level of agreement to reach a consensus (Hallowell and Gambatese, 2010; Nasa et al., 2021). Table 1 presents the selection criteria for respondents from both industry and Academia, and it is essential to clarify that respondents had to meet at least (4) of the (5) criteria shown below to be considered experts (Grime and Wright, 2016; Hallowell and Gambatese, 2010).

Table 1. Selection criteria: experts from industry and academia, construction sector.

Criteria	Academia	Industry
Academic degree	Ph.D.	Postgraduate degree related to construction engineering or construction management
Industry experience	At least five years of professional experience in the AEC sector.	At least five years of professional experience in the AEC sector.
Expertise	Lead author on at least three journal articles	Currently linked to an organization in the construction sector
Experience digital transformation	Research/consulting project on digital transformation issues	Implementation of digital transformation in at least two projects
Organizational level	Faculty member or Researcher at an accredited institution	Professional registration, such as Professional Engineer or Licensed Architect

3.2. *Structure of the questionnaire*

International experts were invited to a two-round Delphi survey to evaluate 14 relationships with theoretical foundations in DT and OS (Osorio-Gómez et al., 2024). Subsequently, the questionnaire was developed with socio-demographic information, academic or industry experience, and DT expertise.The experts were asked to evaluate the relevance of each of these variables of the initial model on a 6-point Likert scale (Chomeya, 2010), ranging from 1= "Strongly Disagree"; 2= "Disagree"; 3= "Partially Disagree"; 4= "Partially Agree"; 5= "Agree"; 6= "Strongly Agree." Meanwhile, the experts were invited to choose from a conglomerate of additional variables found in the literature review to evaluate their relevance for inclusion in the conceptual model; these new variables could be included or not according to the expert's judgment. If the new variables were chosen by half plus one of the expert panel, they were re-evaluated in the second round of the Delphi with the rest of the initial model's variables. Later, after each round, an anonymous report with the principal results was sent to guarantee anonymity (Ma et al., 2022) and correct feedback to the experts to consider all options again (Bhandari and Hallowell, 2021; Hallowell and Gambatese, 2010). Consensus can be achieved in 2-3 rounds with a minimum of 7 participants (Grime & Wright, 2016; Keeney et al., 2011).

3.3. *Data analysis*

The experts' responses were analyzed using statistical methods: Cronbach's alpha, concordance test, descriptive statistics, Kendall's concordance Level of importance, Consensus, and Mann-Whitney analysis. Cronbach's alpha is a widely used reliability indicator that measures internal consistency within a construct; its values range from 0 to 1. Values above 0.6 are considered acceptable for further analysis (Bland and Altman, 1997). In addition, a normality test was performed to evaluate whether the data followed a normal distribution; the Shapiro-Wilk test assessed normality (Yap and Sim, 2011). The Kendall coefficient is a nonparametric test used to measure the level of agreement within a group of experts and the consistency across rounds of the Delphi method. Kendall's W values range from 0 ("strongly disagree") to 1 ("strongly agree"); however, values above 0.2, even when there are many experts, can indicate agreement (Olawumi and Chan, 2018). Additionally, if there is a low Kendall W, it could use $\chi 2$ as an indicator of agreement (Hon et al., 2012; Naji et al., 2022).

In the meantime, the consensus formula proposed by Tastle and Wierman (2007) has been used to validate the agreement between expert groups, and it is a variation of the Shannon entropy equation. This consensus equation is used to measure the strength of consensus of each factor evaluated in the second round of the Delphi. There is a proposed scale for assessing the consensus (Keeney et al., 2011; Rodríguez-Mañas et al., 2013): 0.00-0.49 "Null agreement"; 0.50-0.69 "Low agreement"; 0.70-0.79 "Moderate agreement"; 0.8-1.00 "Strong agreement." Eq. 1 presents the Consensus's formula for validating the agreement of each variable.

$$Cns\ (X) = 1 + \sum_{i=1}^{n} p_i \, log_2 \left(1 - \frac{|X_i - \mu_x|}{d_x}\right) \quad (1)$$

Finally, the Mann-Whitney test is a non-parametric test that is very useful for measuring significant differences between medians in the same factor of two groups (Mcknight and Najab, 2010). When the level of significance (p) is less than 0.05, the null hypothesis (H0) is rejected; the null hypothesis refers to "there are no significant differences between the medians in the same factor between the academics and industry practitioners." Subsequently, the results obtained from the two rounds of Delphi will be analyzed with descriptive and inferential statistics

4. Results

This research had the initial participation of forty-four (44) experts from both industry and Academia; however, in the second round, there was a response from forty (40) experts who satisfactorily completed the two rounds. Additionally, respondents noted that they had implemented DT processes in their organizations, including BIM, Drones, Lean Construction, and Automation, as Construction Project Managers (7), Senior Consultant (4), BIM Champion (3), Lean Managers (3), among others (Appendix A). The academics also researched BIM, Lean Construction, Automation, and Construction 4.0, among other topics.

Forty (40) experts from twelve (12) different countries were present during the two rounds of Delphi, of which (20) were from Academia and others (20) from industry. It was considered to define the country by where they worked, not by their country of origin. Respondents reported strong experience: 20 experts have more than 21 years of experience in the AEC sector, and 5 have more than 15 years. Additionally, twenty-seven (27) experts had Ph.D. degrees, and twelve (12) had master's degrees.

Table 2. Nationality and expertise of the panel members.

Country	Experts	Academics	Industry
Colombia	13	5	8
Chile	7	5	2
Spain	6	5	1
Venezuela	3	1	2
United States	2	1	1
Germany	2	0	2
Peru	2	0	2
Denmark	1	1	0
United Kingdom	1	1	0
Ecuador	1	1	0
Mexico	1	1	0
Switzerland	1	0	1

The two rounds of Delphi lasted approximately four months, and a consensus was guaranteed to be reached. Descriptive and inferential statistics were used to analyze the Delphi results. The results sections were: (1) reliability, normality, and overall ranking; (2) agreement of respondents; (3) level of importance and validation of experts; and (4) agreement between expert groups.

4.1. Reliability, normality, and overall ranking

The value of Cronbach's alpha for the first round was 0.733, and the value for the second round was 0.843; both were higher than 0.6. In addition, a normality test was performed to evaluate whether the data followed a normal distribution. The Shapiro-Wilk test assessed normality (Yap and Sim, 2011). The (p) value obtained for the 15 variables was less than 0.05, meaning the data have a non-normal distribution. For this reason, non-parametric methods are used for the following analyses.

According to the 14 initial relationships that had an impact on the macro-variables of the initial model (Osorio-Gómez et al., 2024), measures of central tendency such as mean (M), median (Me), and standard deviation (SD) were considered. Table 3 shows the results of the first round of Delphi. In addition, the panel of experts was asked about a set of new relationships that it would consider including in the initial model. The criterion was that the additional variable with more than half plus one of the experts would be included as part of the model in the second round and scored the same as the others. Variables such as "Promotion opportunities in organizational climate" (M=5.45, SD=0.68), "employee training and development in organizational climate" (M=5.20, SD=0.56), "Authoritarian leadership in organizational climate" (M=5.05, SD=1.06) had an average above 5 for the Organizational Climate, respectively also "Development of Creative Processes in Information Exchange" (M=5.08, SD=0.80) and "Integrated organizational innovation in service and products improvement" (M=5.58, SD=0.59).

Consequently, the second round of Delphi was carried out after having consolidated the results of the first round, which were sent to the experts in an anonymous report. Table 3 shows the results of the second round of the Delphi, among which we can see an increase in the means of some relationships such as "Promotion opportunities in organizational climate" (M=5.66, SD=0.48), "Authoritarian leadership in organizational climate" (M=5.39, SD=1.00) and the three macro-variables also had an increase "Organizational climate" (M=5.46, SD=0.71), "Information exchange (M=5.4, SD=0.71), and IOI (M=5.63, SD=0.62).

Table 3. First and second Delphi round – relationship between digital transformation and organizational structures in construction.

Variables	Round 1			Round 2		
	Mean	Median	SD	Mean	Median	SD
Promotion opportunities have a positive impact on the organizational climate	5.45	6	0.68	5.66	6	0.48
Employee training and development has a positive impact on the organizational climate	5.20	5	0.56	5.10	5	0.77
Authoritarian leadership style negatively impacts the organizational climate	5.05	5	1.06	5.39	6	1.00
Assertive communication has a positive impact on the organizational climate	*	*	*	5.59	6	0.55
Transformational leadership has a positive impact on the organizational climate	*	*	*	5.68	6	0.69
Employee training and development positively impact information exchange	4.90	5	0.71	5.12	5	0.68
Services with other companies positively impact the information exchange	4.40	4.50	0.96	4.44	5	1.07
Development of creative processes positively impact the information exchange	5.08	5	0.8	4.90	5	0.77
Data integration and analytics positively impact information exchange	*	*	*	5.37	5	0.66
Promotion opportunities positively impact integrated organizational innovation	4.98	5	0.92	5.05	5	0.95
Employee training and development positively impact integrated organizational innovation	5.38	5	0.59	5.37	6	0.83
Cloud services positively impact integrated organizational innovation	4.53	5	1.04	4.56	5	0.95
Services with other companies positively impact integrated organizational innovation	4.55	5	0.81	4.54	5	1.07
Excessive business focus on cost reduction negatively impacts integrated organizational innovation	4.75	5	1.15	5.02	5	1.25
Knowledge management positively impacts integrated organizational innovation	*	*	*	5.49	6	0.68
The organizational climate has a positive impact on the services and product improvement	5.38	5.50	0.7	5.46	6	0.71
The information exchange positively impacts the services and product improvement	5.35	5	0.58	5.41	6	0.71
Integrated organizational innovation positively impacts the services and product improvement	5.58	6	0.59	5.63	6	0.62

*= Variables were included in the 2nd round of Delphi.

4.2. Agreement of respondents within the expert groups

The result of Kendall's W in the first round was 0.213 with a significance of 0.000 and a $\chi2$=110.6. In the second round, the W value improved to 0.236, with a significance of 0.000 and a $\chi2$ of 160.4; thus, it can be evidenced that there was greater agreement among the experts during the second round. This Kendall coefficient indicates low agreement; however, increasing the number of experts consulted only yields a lower Kendall coefficient (Gisev et al., 2013; Raadt et al., 2021). Additionally, the value of χ 2 went from 110.6 in the first round to a value of 160.4 in the second round, which in turn is also much higher than the critical values of $\chi2$ for df=17 with a value of 27.58 (p=0.05), and 33.41 (p=0.01) in the table of degrees of freedom. In this way, the significance of the consensus reached in the second round of the Delphi can be demonstrated.

4.3. Level of importance and validation experts.

The 14 relationships between variables will be ranked by mean after the second round of the Delphi. In this way, the results are shown in Table 4. In the second round, only one relationship with a value below 0.7 was classified as "low agreement": excessive cost reduction. Most variables are in the "strong agreement" range, as evidenced by their scores. In addition, six variables with “moderate agreement," such as authoritarian leadership in organizational climate, services with other companies in information exchange, promotion opportunities, employee training and development, cloud processes, and services with other companies in IOI. In this way, we can observe that most relationships are strong or moderate agreement, indicating high consensus among the variables of the proposed model. The results of the second round of Delphi are consolidated to provide a summary of the level of importance and consensus for each macro-variable, as shown in Table 4. The variables were organized in descending order, with the first variable being the one with the highest degree of significance within the macro variable.

Transformational leadership has the greatest significance in the organizational climate, data analysis, and information exchange, and in knowledge management in IOI. Finally, IOI has the highest degree of significance in services and product improvement.

Table 4. Summary of the model variables in terms of level of importance and consensus.

Macrovariable	Variables	Significance	Consensus (value)	Consensus
Organizational climate	Transformational leadership has a positive impact	5.68	0.84	strong
	Promotion opportunities have a positive impact	5.66	0.86	strong
	Assertive communication has a positive impact	5.59	0.85	strong
	Authoritarian leadership style impacts negatively	5.39	0.72	moderate
	Employee training and development have a positive impact	5.10	0.82	strong
Information exchange	Data integration and analytics have a positive impact	5.37	0.82	strong
	Employee training and development have a positive impact	5.12	0.83	strong
	Development of creative processes have a positive impact	4.90	0.81	strong
	Services with other companies have a positive impact	4.44	0.70	moderate
Integrated organizational innovation	Knowledge management has a positive impact	5.49	0.81	strong
	Employee training and development has a positive impact	5.37	0.77	moderate
	Promotion opportunities have a positive impact	5.05	0.77	moderate
	Excessive business focus on cost reduction impacts negatively	5.02	0.66	low
	Cloud services have a positive impact	4.56	0.74	moderate
	Services with other companies have a positive impact	4.54	0.70	moderate
Services and products improvement	Integrated organizational innovation has a positive impact	5.63	0.84	strong
	Organizational climate has a positive impact	5.46	0.80	strong
	Information exchange has a positive impact	5.41	0.80	strong

4.4. Agreement of the respondents between the expert groups

The Mann-Whitney test was conducted to measure whether there were significant differences between the answers given by academics and those in industry. In all variables and macro-variable, the significance was more than 0.05 (i.e., $p>0.05$). For this reason, the null hypothesis cannot be rejected, indicating that there was no significant difference between the medians of the two groups. In this way, these results confirm that the agreement between academics and industry is similar across the variables presented in the model.

5. Discussion and conceptual model

DT is a process that has developed over the last few years, and the construction sector has not been immune to it. However, it has lower digitalization rates than other sectors. An essential part of research on DT has focused on tools and technologies that improve project efficiency. However, more extensive research is needed to generate organizational changes that increase value along the value chain (Osorio-Gómez et al., 2020). This study provides empirical support for a holistic organizational vision, in which specific organizational variables act as critical catalysts or barriers in this joint process (DT and OS).

According to the conceptual model shown in Figure 3, leadership is fundamental to achieving this internal outcome in the Organizational Climate. Authoritarian Leadership should be avoided, and Transformational Leadership should be promoted (Hazana Abdullah et al., 2015). However, stakeholders in the construction sector say that male leadership is more likely to be seen as authoritarian (Osorio-Gómez et al., 2022). Additionally, the conceptual model identifies Transformational Leadership (M=5.68) and Promotion Opportunities (M=5.66) as predictors of a good organizational climate, among the most relevant variables; this affirmation is supported by other authors, who find that transformational leadership can improve the Organizational Climate and organizational learning (Kim and Park, 2020).

Additionally, leadership on current teams is not only face-to-face; due to current trends, but virtual leadership is also used. In industry 5.0, the digital leader must be able to link knowledge, skills, and resources to teams, control processes, execute tasks together with teams, and distribute tasks based on the team's competency (Klein, 2020; Oberer and Erkollar, 2018). Assertive communication is one of the pillars of an excellent organizational climate, as it ensures a smooth flow of communication among stakeholders (Brubaker et al., 2014; Omura et al., 2016). Employee Training and Development (M=5.10) emerges as a catalyst for many improvements in organizations (Brown and Sitzmann, 2010), as it is a tool for transmitting knowledge, best practices, and trends (Caniëls and Baaten, 2019). However, employee training and development have high associated costs to keep personnel trained and updated (Mehale et al., 2021); these derived costs can be one of the biggest barriers that prevent them from being done constantly (Osorio-Gómez et al., 2025), and Employee Training depends exclusively on them, which indicates a divergence between the most recommended (literature) vs. a real financial situation (practice). Finally, this variable has a synergistic impact as it also impacts IOI and IE.

IOI is an integrative concept of organizational improvements. Knowledge Management is highlighted (M=5.49); this variable can transfer the findings at the project level to the organization (Pellicer et al., 2014). However, according to Osorio-Gómez et al. (2025), this process of knowledge transfer is more complex to keep up to date and fed back into the construction field. Moreover, it is recommended to identify alternative mechanisms and channels for knowledge sharing, as suggested by other investigations that knowledge can be more easily imparted through training and creative processes (Nda and Fard, 2013; Rodriguez and Walters, 2017). Likewise, an investment budget must be allocated to carry out these organizational innovation processes, which would be at odds with an excessive focus on cost reduction (Ariss and Deilami, 2012; Bygballe and Ingemansson, 2014). However, in the construction sector, there is a focus on high efficiency, which often requires clarification through low investment in technology and research (M=5.02); this approach can increase the profitability of projects and organizations in the short term, but it could lead to a loss of competitive advantage in the long term (Ortner et al., 2025). Hence, investment in technology and research should be promoted, as such developments can lead to greater efficiency and directly impact one of the principal aspects of Industry 5.0: economic efficiency. In the same way, to keep staff motivated to implement the innovations the organization needs, win-win schemes must be in place so that employees also feel part of that success (Osorio-Gómez et al., 2025). Furthermore, promotion opportunities (M=5.05) are necessary to maintain collaborators' motivation in an innovation environment (Kosteas, 2011), this variable also has synergistic effects with OC (Figure 3). Finally, Cloud Services (M=4.56) are also a key element in maintaining innovation in the organization, as they have an impact on both the internal and external customers (Sun et al., 2014), and it is one of the points at which DT processes are most positively fed back with changes in the organization (Adel, 2022). However, difficulties may arise with Cloud Services, for example, in underground construction activities such as tunnels and excavations, which must be connected to new internet stations to guarantee Internet coverage (Kjellmark et al., 2026).

Information Exchange is a macro-variable process that entails structuring organizational information. Data Integration and Analytics (M=5.37) could facilitate the analysis of millions of data points on economic and sustainability issues of organizations and projects (Koseleva and Ropaite, 2017). Additionally, there have been significant improvements in Information Exchange between the construction site, company, suppliers, and cyber-digital plants (Turner et al., 2021). According to Kjellmark et al. (2026), in an implementation of AI in road construction in Norway, there was widespread skepticism of the use of technologies by workers (Industry 5.0), which presents a challenge of implementation at the workforce level. Conversely, at managerial levels, according to Lutfi et al. (2022), a robust analysis of information can facilitate strategic decision-making. Nonetheless, to reach these levels of digitalization, it is necessary to have a training and learning program to transfer knowledge from strategic levels to the workforce (Gao et al., 2019; García de Soto et al., 2019). Additionally, Services with other Companies (M=4.44) can improve the structuring of internal information to carry out joint projects (Bouguerra et al., 2023; Gino, 2019). On the one hand, Services with other Companies are still a matter of discussion, since some experts consulted considered it better to preserve the company's know-how internally and to maintain a minimum number of alliances with other companies. On the other hand, other experts stated that to achieve greater levels of digitalization, it was necessary to open collaboration between companies to mutually improve their IT processes (Eondinelli and London, 2023). Likewise, it facilitates and promotes information exchange through the IT strategy (Kaplan et al., 2010). It is critical that management understands the competing demands in each perspective but appropriately takes a holistic approach to implementing DT (Loonam et al., 2018).

Considering this joint vision, changes necessary for DT also affect OS. In this way, the changes generated in the OS can be an appropriate implementation framework for the technology to add value. Likewise, there are statistically significant relationships and interconnections among IOI, IE, and OC, which are mutually reinforcing and contribute, respectively, to improving the organization's products and services. The final implication is strategic: without aligning the Business Strategy with organizational changes and a clear vision of DT, there is a risk of implementing only tools that will not generate long-term competitive advantage (Koeleman et al., 2019; Kotarba, 2018). In addition, articulation between the private and public sectors is important, as shared benefits, such as reduced carbon footprints from greater effectiveness in organizations and projects, could lead to economic compensation, as proposed by the Norwegian government (Kjellmark et al., 2026). Finally, each of the macro-variables also generates an impact on the Services and Products Improvement, which should be one of the ultimate goals of improvement in the construction sector, since part of the additional added value must go to the external client, carrying out projects with higher quality, in less time, and without cost overruns.

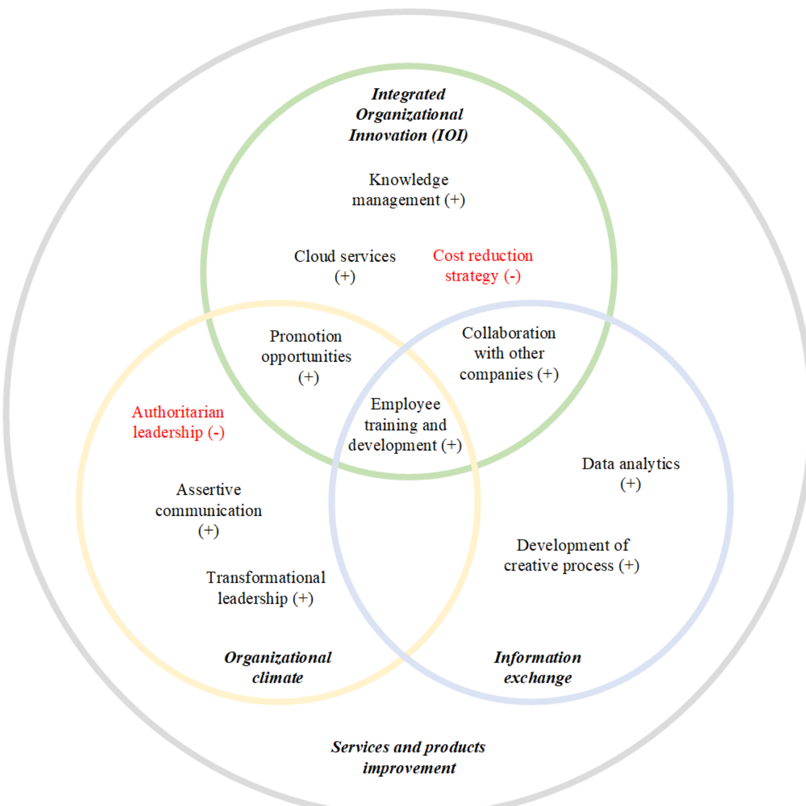

Figure 3. Conceptual model 2.0 digital transformation and organizational structures.

6. Conclusions

The construction sector has recently been developing and implementing technologies to increase its efficiency and added value. Much of this DT's focus has been on tools and technologies. However, in many cases, these technologies have been implemented in isolation without generating fundamental changes in the company's OS. For this reason, this research explored the relationship between DT and OS. In addition, it generated a prioritization of variables based on their levels of significance and agreement. The Delphi method was selected to involve 40 experts from 12 countries who were invited to participate in this research and were present during two rounds of the Delphi. The panel of experts reached consensus, and there were no significant differences between academics and industry, indicating a shared vision of DT. In the second round of the Delphi, better values were obtained for both the Kendall coefficient and the Chi-square; additionally, in terms of significance and level of agreement, a significant number of variables improved, some remained the same, and a few were reduced in the ranking. It was evident that some variables are often not considered necessary in DT models; for example, Assertive Communication and leadership styles are rarely included. However, these variables also impact that process. Finally, in the context of Construction 5.0, it is a contribution to give greater prominence to organizations that must also adapt to new changes to make a more fluid digitalization between people, processes, and projects.

6.1. Theoretical contributions

The conceptual model proposes a holistic vision of the implementation, considering organizational and DT variables. Finally, variables such as data integration and analytics, knowledge management, and transformational leadership were added considering expert consensus. The implementation of the variables must take place in parallel since some variables have synergistic effects, such as employee training and development, which influence all macro-variables and the Services and Products Improvement. Cost reduction is a controversial variable: high-efficiency approaches tend to yield cost savings, achieved through low investment in technologies and innovation, which can be beneficial for profits in the short term but detrimental in the long term, as competitive advantage is lost.

The theoretical contributions provide evidence of another crucial aspect of the DT as an OS in the construction sector, as it has historically been analyzed more at the project than at the organizational level. Furthermore, the model integrates the main variables of DT and OS and is focused on the AEC sector, drawing on the expertise of academics and industry experts. In addition, this joint vision represents a move towards an optimized organizational structure, a better work environment, and greater collaboration to achieve greater efficiency in construction projects. Moreover, the conceptual model shows that there are digital gaps in organizations in the AEC sector, where relevant organizational variables are considered less important, and there is a focus only on technologies.

Finally, this research aligns with Industry 5.0, as it places greater emphasis on endogenous factors within organizations, the well-being of their workers, business sustainability, and human-machine collaboration. This study points directly to a gap in Industry 5.0, specifically in Construction 5.0, since most of the literature focuses on technological tools that support organizational change, prepared to assume those technological changes for a more fluid process. Moreover, in the literature on Construction 5.0, this is a conceptual model that positions organizations as vehicles for integrating technologies and good practices that satisfy its principles. Joint implementation of DT and OS could significantly transform organizations in the AEC sector, as historical characteristics such as fragmented work teams, unclear leadership styles, and misalignment with strategy can be addressed simultaneously through methodologies such as BIM, Artificial Intelligence, and Big Data.

6.2. Practical and managerial contributions

The conceptual model has practical implications for companies in the construction sector, as it can serve as input for strategic review of the most latent variables in the organization and for proposing an action plan to address the weakest variables. Additionally, the conceptual model can be a tool for a Project Manager, IT Leader, Digital Transformation Manager, or BIM Champion to conduct analysis or implement changes to support their organization's digital transformation. However, it can be used not only for the entire organization but also for a department or area, thereby focusing efforts on a particular macro-variable or variable. It also generates a conceptual basis for preparing the DT from people to technologies, where soft skills are crucial. In this way, it changes the logic of Industry 4.0, from the technologies to apply to how to adapt the organization to take advantage of its full potential, considering Industry 5.0's principles. Finally, this model can be implemented in 3 main phases: 1) An organizational diagnosis to show the strengths and weaknesses for the joint DT and OS process; 2) Development of Creative processes with stakeholders in which the new processes focused on DT are built, plus the organizational changes that must be supported by the top management, and 3) monitoring and follow-up for a few months to evaluate whether the changes have had an effect within the organization.

6.3. Limitations

This research has limitations: many experts are from Latin America, so there may be differences in the criteria compared with experts from other latitudes. Additionally, there is no particular emphasis on the technological methodologies that are part of the DT process; for example, BIM, drones, IoT, and AI were considered transversal to the organization's processes. However, a more detailed analysis would be necessary to understand the contribution of each methodology and technology to the macro variables of the conceptual model. Therefore, it must be recommended with other research for a complete implementation of the processes. Also, the research focused on developing a conceptual model, but an on-site check with stakeholders would be advisable to triangulate the theory with the experts and the real organizations in the AEC sector. The conceptual model presents synergies within the organization that could intuitively reduce reprocesses and waste; these expected effects have not been measured. Lastly, the roles and responsibilities of stakeholders are mentioned tangentially, but this research is not a methodological guide on roles.

6.4. Future research

Future research proposes implementing the conceptual model in real case studies and monitoring and following up on it during the implementation phase to highlight synergies and barriers. Additionally, obtaining final confirmation through an external evaluation by sector professionals, using a method such as SEM, would provide new insights into the model. Likewise, conducting on-site measurements of the organizational climate, information flows, and innovation outcomes would be a highly valuable practical complement to research. In addition, the proposed variables lead to radical changes at the organizational level when it comes to managing the organization; for this reason, it is also proposed better to delimit the roles and responsibilities within this conceptual model so that it is more apparent to organizations how best to take advantage of an organizational change within a DT process. The conceptual model provides a first outline of a digital organization in the AEC sector in the context of Construction 5.0, but it is necessary to delve deeper into more detailed levels for each type of residential, infrastructure, public, or private AEC organization. Finally, this conceptual model primarily focuses on the company's internal perspective. Nevertheless, it can be expanded to include the relationship with customers and the context (exogenous factors) within which the environment appears as one of the variables to be considered alongside the problems posed by the current climate crisis.

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Appendix 1. Roles and countries of the experts.

Expert	Type of organization	Role (expertise)	Country
1	Academia	Professor (BIM and IA)	United Kingdom
2	Academia	Professor (Lean Construction and Digitalization)	Chile
3	Industry	Senior Consultant	Chile
4	Industry	Senior Consultant	Venezuela
5	Academia	Professor (Lean Construction and Construction 4.0)	Chile
6	Academia	Professor (Quality Management and BIM)	Mexico
7	Industry	Construction Project Manager	Colombia
8	Academia	Professor (Construction 4.0)	Denmark
9	Academia	Professor (Last Planner System and BIM)	Chile
10	Industry	Construction Project Manager	Colombia
11	Industry	Senior Consultant	Venezuela
12	Academia	Professor (BIM and Extended Reality)	Chile
13	Academia	Professor (BIM and Sustainability)	Spain
14	Academia	Professor (Last Planner System and Project Management)	Ecuador
15	Academia	Professor (BIM and Target Value Design)	Venezuela
16	Academia	Professor (Lean Project Delivery and BIM)	Colombia
17	Academia	Professor (BIM and Scheduling)	Colombia
18	Academia	Professor (BIM and Lean Construction)	Colombia
19	Academia	Professor (Construction 4.0)	Chile
20	Industry	Construction Project Manager	Peru
21	Industry	Construction Project Manager	Peru
22	Academia	Professor (Machine Learning and Sustainability)	Spain

23	Academia	Professor (BIM and Automation)	Spain
24	Industry	Construction Project Manager	Colombia
25	Industry	BIM Champion	Colombia
26	Industry	Construction Project Manager	Colombia
27	Industry	Quality Leader	United States
28	Industry	Head of Data Science	Germany
29	Industry	Lean Manager	Germany
30	Industry	Lean Manager	Switzerland
31	Academia	Professor (Lean Construction and BIM)	Colombia
32	Academia	Professor (Construction Management and BIM)	Spain
33	Industry	Construction Project Manager	Spain
34	Academic	Professor (Construction 4.0)	Colombia
35	Industry	IT Leader	Chile
36	Industry	Lean Manager	Spain
37	Industry	BIM Champion	Colombia
38	Academic	Professor (Automation and Machine Learning)	United States
39	Industry	BIM Champion	Colombia
40	Industry	Senior Consultant	Colombia