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THE DIGITAL ORGANIZATION TRANSFORMATION (DOT) MODEL: BRIDGING DIGITAL TRANSFORMATION AND ORGANIZATIONAL STRUCTURES IN CONSTRUCTION FIRMS

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Abstract. Digital transformation is a pathway to improve productivity in the construction sector, but organizational structures still need more adaptation. There are no fully developed models at the level of factors and evidence between organizational structures and digital transformation. This paper analyzes the impact of digital transformation on organizational structures within the construction sector, utilizing a semi-structured interview and field inspection methodology to validate key organizational factors and evidence influencing this process. The research focuses on Colombia's medium and large construction companies and aims to validate an integrated conceptual model of digital transformation and organizational structures. Results indicate that while technological tools have been adopted, the full potential of digital transformation still needs to be explored. The study highlights the factors and evidence that affect the variables of digital transformation and organizational structures. While technological tools are essential, they are unlikely to create a long-term competitive advantage. This research advances the understanding that the integrated implementation of digital transformation and organizational structures, grounded in validated factors and evidence, can drive enhanced decision-making, reduce inefficiencies, and improve productivity within the construction industry.

Keywords: digital transformation, organizational structure, organizational culture, construction sector, conceptual model, construction firms.

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1. Introduction

There is a growing trend toward digitalizing processes in various industries (Yamamoto, 2020); this phenomenon is known as Digital Transformation (DT). However, there are still significant gaps in terms of productivity, as DT has been different in all industries (Al-Hakim & Lu, 2017). In the case of the construction sector, there have historically been lower productivity rates (Olanipekun & Sutrisna, 2021); this situation is due to a craft-based industry (Crawford & Vogl, 2006), with low innovation (Pellicer et al., 2012), stakeholder fragmentation (Succar, 2009; Samuelson & Stehn, 2022), and re-processes (Li et al., 2013). These characteristics of the construction industry commonly cause delays, cost overruns, waste of materials, variable quality, and high accident rates (Balali et al., 2022; Wong et al., 2023).

New methodologies and technologies have been developed to address the problems of the construction sector (Forcael et al., 2020), focusing on increasing productivity and reducing construction errors (Hughes & Thorpe, 2014). For instance, BIM is a project management methodology that is based on digital models for the management of assets throughout the life cycle of projects through the collaboration of stakeholders (Succar & Poirier, 2020); among its advantages are the reduction of errors, reduction of cost overruns, deadlines adjusted to the schedule, reduction of waste, among others (Hao et al., 2020). Recently, Construction 4.0 appears as a trend, considering the adoption of these new technologies in the construction sector (Pantazis et al., 2022; Koc et al., 2020); it includes a very relevant concept such as Cyber-Physical

Systems (CPS) that aims to integrate the digital and the built environments (El Jazzar et al., 2021). Furthermore, the concept of Construction 5.0 is being developed (Yitmen et al., 2023), which seeks to take advantage of technological benefits while considering sustainability, stakeholders' well-being, and buildings' resilience (Ikudayisi et al., 2023; Marinelli, 2023).

Moreover, these DT processes have been implemented in the value chain of the construction sector (Tortorella et al., 2023), focused mainly on technological methodologies and software available today (Baduge et al., 2022); nonetheless, there have not yet been significant changes in organizations to adapt to DT (García de Soto et al., 2019) due to limited attention to Organizational Structures (OS) and organizational culture. Organizational Structures (OS) are companies' frameworks that establish the rules, positions, responsibilities, strategy, and relationships to meet the organization's objectives (Bonanomi et al., 2019). Likewise, the OS will directly relate to the organizational culture (Janićijević, 2013). If the OS is not aligned with the culture, it can lead to adverse work climates and a lack of stakeholder commitment (Hazana Abdullah et al., 2015). Digital Transformation must be aligned with OS as well as with organizational culture (García de Soto et al., 2019).

Digital transformation and OS determine how organizations function. Digital Transformation is directly related to the transformation of the business model (Ismail et al., 2017), which includes changes in the relationship with internal and external customers, incentives, improvement of products and services, and an organizational climate (Morakanyane et al., 2017). For example, if there is an advanced level of DT, a common data environment is used to exchange information with the stakeholders (Succar & Poirier, 2020). At the same time, if, for example, OS is flatter and encourages more collaborative decision-making, better job satisfaction rates can be obtained among its employees (Bonanomi et al., 2019).

Some DT models consider leadership, training, and incentives (González et al., 2022; Pantazis et al., 2022). Digital Transformation models used in the manufacturing industry highlight the importance of organizational changes (Elia et al., 2024); variables such as organizational vision, cultural change, training of people, and collaboration between companies are estimated (Elia et al., 2024). A BIM implementation model in emerging countries highlights the need for people training and knowledge management, but organizational changes are mentioned tangentially (Rinchen et al., 2024).

Various frameworks and models have been proposed for the DT of the construction industry. For instance, Vararean-Cochisa and Crisan (2025) used the context-intervention-mechanism-output (CIMO) framework to review 15 cases presenting the DT process of construction companies. They distinguished major drivers of DT, such as top management support, organizational culture, and customer requirements. Naji et al. (2024) proposed the Digital Transformation Level of Readiness Framework (DTRLF) based on 70 factors that contribute to the DT of the construction industry, grouped into five categories, i.e., management, design, technology, policy, and infrastructure. Zhu et al. (2024) evaluated DT maturity within construction companies, proposing an evaluation model based on the Analytic Hierarchy Process (AHP) and Decision-Making Trial and Evaluation Laboratory (DEMATEL) methods. In their model, the authors emphasized factors, such as digital strategy, digital business applications, digital technology capabilities. Nyqvist et al. (2025) applied a multiple case study methodology and a systemic framework to distinguish DT barriers and drivers in construction industry. The three key drivers identified are shift to data-driven industry, targeted technological solutions, and standardization and process modification. However, these models and frameworks do not fully develop the interaction between DT and OS variables and their relationship with macrovariables that ensure interconnection within the organization.

On the other hand, the model introduced by Osorio-Gómez et al. (2024) shows the interaction of synergistic processes between DT and OS. This model groups variables into three sets: Organizational Climate (OC), Integrated Organizational Innovation (IOI), and Information Exchange (IE). It is chosen as the foundation of this research because it illustrates the relationship between DT and OS variables, specifically in the construction sector; nonetheless, it has not yet been developed practically for organizational implementation. A deeper pragmatic understanding will contribute to designing more effective strategies for the integrated implementation of DT aligned with OS in construction companies. For this reason, the goals of this research are: (1) to improve the DT and OS model proposed by Osorio-Gómez et al. (2024) and (2) to validate the applicability of improved model in construction companies. The model of reference is explained in detail in Section 2. Section 3 describes research methodology, while Section 4 provides results and discussion. Section 5 concludes the research.

2. Model of Digital Transformation and Organizational Structures

The model of DT and OS (Osorio-Gómez et al., 2024) aims to improve products and services in the construction sector by implementing DT in operational processes and redesigning OS within construction companies; this model will be referred to as the Original Model henceforth (see Figure 1). Three key macro-variables influence this process: Organizational Climate (OC), Integrated Organizational Innovation (IOI), and Information Exchange (IE). These macro-variables collectively impact improvement of products and services in the construction sector.

Each macro-variable comprises a series of variables identified through a literature review. Organizational Climate (OC) primarily relates to the perception of the company's work environment, which directly impacts employ-

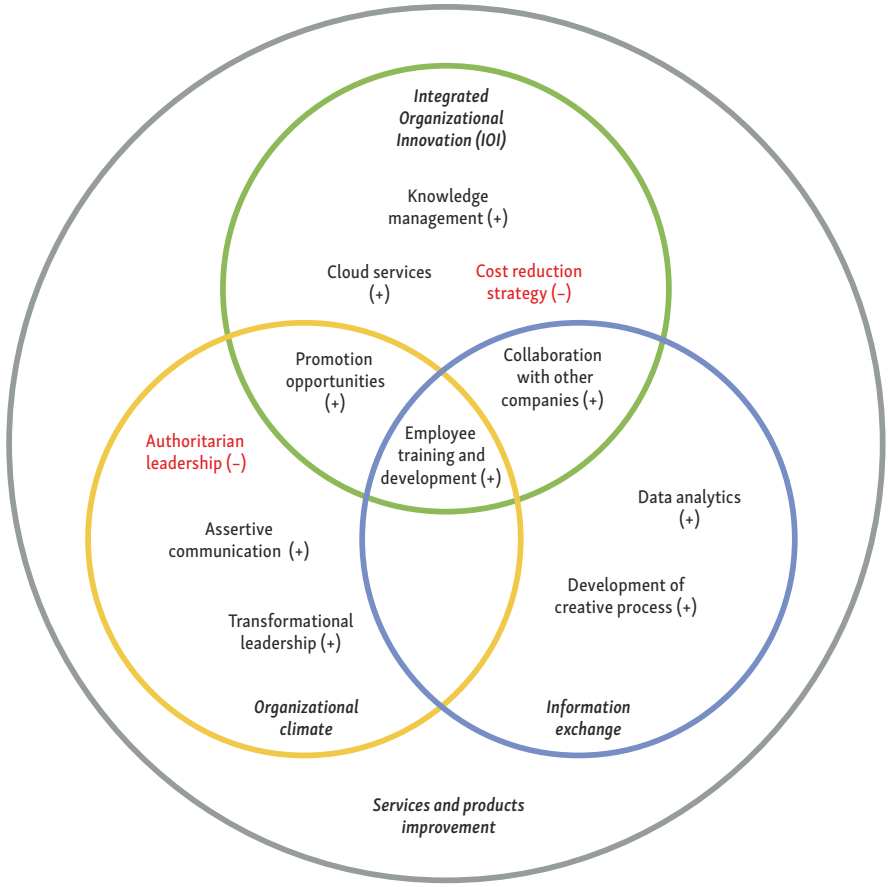

Figure 1. Original Model of Digital Transformation and Organizational Structures (adapted from Osorio-Gómez et al., 2024)

ee motivation. Similarly, OC is shaped by leadership styles and assertive communication. Another key macro-variable is the IOI, which refers to systematic innovation within the organization; this concept is not confined to a specific area but is implemented across the organization. IOI is influenced by knowledge management, cloud services, the avoidance of cost-reduction-focused organizational strategies, and collaboration with other companies; furthermore, promotion opportunities and employee training and development are shared with OC, too.

Finally, IE refers to transferring information within an organization to enhance decision-making and foster collaboration. Digital Transformation significantly influences IE, as technologies streamline the processes of information collection, analysis, and communication. The key variables that impact IE include data analytics, the development of creative processes, collaboration with other companies, and employee training and development (these last two are in common with OC).

3. Research method

The nature of this research is exploratory for validation purposes (Nilsen et al., 2020) to confirm the Original Model of DT and OS developed by Osorio-Gómez et al. (2024). First, a literature review was focused on the factors and evidence influencing each variable. The literature review was conducted by analyzing scientific articles from databases, such as Web of Science and Scopus, to identify key factors and evidence for each variable in the Original Model. Only factors and evidence with a minimum frequency of three occurrences in scientific articles were included. Subsequently, these factors and evidence were categorized within each variable, illustrating their relationship with the macro-variables, resulting in what is referred from now on as the Improved Model.

Next, organizations in the construction sector in Colombia were selected to validate the Improved Model; the selection process is explained below. The chosen validation method was semi-structured interviews, which were used to assess the organizational factors and evidence influencing DT processes and OS in the construction sector. Additionally, a field inspection of the Improved Model's factors was carried out to cross-check the interview results; this inspection consisted of an in-situ visits to the organizations to check visually that the evidence was in place or being in use. Finally, after the interviews and field inspection, the Digital-Organization Transformation (DOT) was presented. The research process is summarized in Figure 2. The criteria for sample selection were defined as follows: (1) the companies included in the study were required to be classified as medium or large construction firms based on their

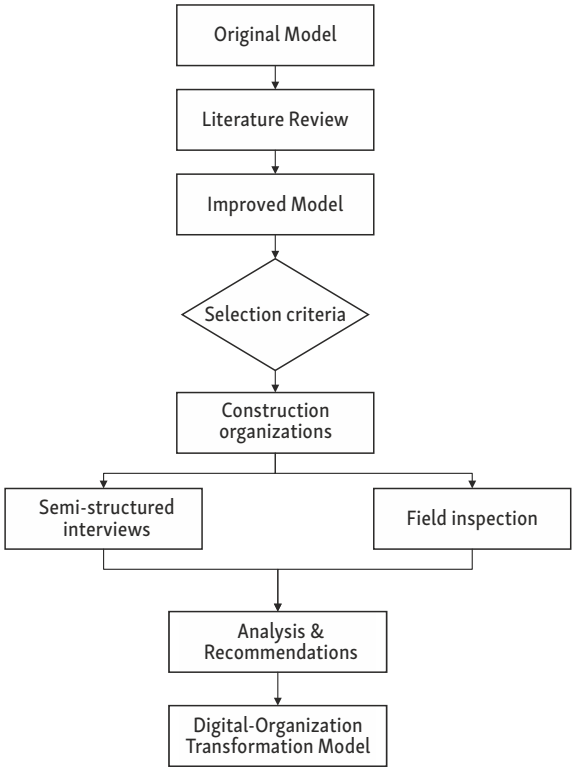

Figure 2. Research process

annual revenue (Superintendencia de Sociedades, 2024); (2) they must have over ten years of industry experience and be actively engaged in DT processes, regardless of their current maturity level; and (3) they could encompass building construction firms as well as companies specializing in infrastructure design and supervision, thereby offering a more holistic representation of the value chain within the construction sector.

The information was collected through in-depth interviews with key organizational stakeholders; these interviewees had to be able to access the evidence of best practices from these organizations, too. The sample size was determined by saturation (van Rijnsoever, 2016); if there is homogeneity and richness in the sample, saturation can be obtained between the eighth and twelfth interview (Guest et al., 2006). When saturation is reached, more interviews provide very little information to the findings (Oviedo-Haito et al., 2014). This research achieved saturation after nine iterations. These nine interviewees and their corresponding organizations are described in Table 1. Organizations are described based on years of experience in the market, annual revenue (USD), number of direct employees, and position of the interviewees in that organization. It can be observed that the interviewees represented companies in the building and infrastructure construction sectors, with 15 to 65 years of experience and annual revenues ranging from USD 15 to 300 million. All companies are classified as medium or large-sized.

The protocol for this study, as well as the forms used, were approved by the Ethics Committee at the Universitat Politècnica de València. To ensure the impartiality of the research, the results obtained were anonymized. The interview, based on Woodside (2010), consisted of a semi-structured questionnaire divided into four sections: (1) characterization of the interviewee and company, as indicated in Table 1; (2) an in-depth discussion of the organizational performance targeting the macro-variable OC; (3) a similar approach applied to the macro-variable IOI; and finally, (4) the organizational performance of the macro-variable IE was discussed similarly. For the last three sections, during the interview, each stakeholder was asked to explore the processes being implemented by each firm in relation to its variables, factors, and evidence, as well as the challenges of implementation, along with stakeholder insights and recommendations for further refining and enhancing the Improved Model.

Following the interviews, a field inspection was conducted, where the organizations' information was validated through tangible evidence obtained in situ, supporting the factors and findings previously identified in the literature review. This tangible evidence was verified based on organizational procedures, projects, databases, and other relevant data sources. The collected data was cross-checked with the information gathered during the semi-structured interviews.

The data were transcribed, analyzed, organized, and conceptualized following Charmaz (2006). The concepts

Table 1. Characterization of the interviewees and organizations

Interviewee	Main Activity	Company's Experience (Years)	Annual Income (USD Million)	Number of employees	Interviewee's Position
E1	Building & Infrastructure Construction	40	300	1200	Engineering Leader
E2	Building Construction	32	70	305	BIM Project Manager
E3	Building & Infrastructure Construction	65	45	157	BIM Project Manager
E4	Building Construction	31	170	700	BIM Project Manager
E5	Building Construction	15	15	30	General Manager
E6	Design and supervision of infrastructure projects	15	50	200	Digital Transformation Manager
E7	Building Construction	30	30	60	BIM Project Manager
E8	Building & Infrastructure Construction	25	60	260	IT Leader
E9	Building Construction	31	80	300	BIM Project Manager

identified during the interviews are presented in the next section to determine whether they represent isolated viewpoints or reflect a broader consensus among other organizations (Charmaz, 2006; Woodside, 2010). Subsequently, a descriptive statistical analysis of the variables from field inspection was performed in each of the nine organizations. This approach enhanced the robustness of the study, facilitated the collection of new perspectives, and provided external validation for the findings. Finally, the analysis, recommendations, and implications of the Digital-Organization Transformation Model (DOT Model) were presented.

4. Results and discussion

The main goal of this research is to propose a Digital-Organization Transformation (DOT) Model that relates DT and OS in a way that can be applied to companies in the construction sector. To fulfil this goal, the first step is to generate an Improved Model through an in-depth literature review (Sub-section 4.1). Next, the semi-structured interviews and the field inspection (Sub-sections 4.2 and 4.3) are carried out. Finally, the DOT Model is presented (Subsection 4.4).

4.1. Improved model proposal: Literature review

Based on the scientific articles identified in Web of Science and Scopus, factors influencing the variables of the original model were sought (Osorio-Gómez et al., 2024). These factors have a theoretical influence on the variables. However, conducting a field validation of the factors could be challenging, as they are intrinsic elements of the organization that determine its functioning but are challenging to measure. For this reason, tangible evidence was also sought in literature reviews, including specific proofs, indicators, or data that demonstrate the existence of the factors within the organization. It was found that 13 factors influenced OC, 12 impacted IOI, and 10 affected IE. Furthermore, at least one piece of evidence was identified for each factor. This information was subsequently analyzed and summarized in Tables 2, 3 and 4. These tables are structured hierarchically in the following way (from left to right): variables; associated factors and their evidence; and, lastly, the scientific sources. Based on each macrovariable, the variables, identified factors, and evidence are further analyzed, discussed, and categorized in the following subsections.

Table 2. Relationship between OC, variables, factors, and evidence

Variables	Factors & Evidence	Sources
Authoritarian leadership (–) (AL)	■ Decentralized decision → Decision-making protocol → Leadership assessment ■ Efficient communication → Communications management plan → Corporate manual ■ Job recognition → Career plan → Monetary and non-monetary incentives	Aghimien et al. (2023), Alkan and Tunç (2019), Kim and Park (2020), Pizzolitto et al. (2023), Zulu et al. (2024)
Promotion opportunities* (PO)	■ Organization chart → Roles and responsibilities by position → Organigram ■ Staff turnover → KPI's staff turnover → Staff performance metrics ■ Employee perception → Surveys on promotion opportunities ■ Promotion policies → Promotion and dismissal convention	Ahmady et al. (2016), Frenkel and Bednall (2016), Mykytas et al. (2018), Xie and Yang (2021)
Transformational leadership (TL)	■ Collaborative Decisions → Decision-making protocol ■ Corporate values → Organizational communication record ■ Organization vision → Graphic pieces (Wallpapers, posters)	Jensen et al. (2018), Klein (2020), Oberer and Erkollar (2018), Smuttrasen and Heo (2020)
Assertive communication (AC)	■ Culture of dissent → Coaching on assertive communication ■ Conflict resolution → Conflict resolution protocol ■ Identification of communication problems → Collaborative dialogue platform	Brubaker et al. (2014), Filipeanu and Cananău (2015), Gultekin et al. (2018)

Note: * – variables shared with IOI and IE.

4.1.1. Organizational Climate (OC)

Organizational Climate is based on the environment that employees perceive, directly influencing employees' motivation (Schneider et al., 2013); the variables, factors, and evidence that influence OC are summarized in Table 2. Employees feel greater motivation when they feel an essential part of organizations when they are part of decisions and are recognized at work (Hooi et al., 2013). This is directly related to the organizational strategy encouraging the development of new capabilities of its employees (Xie & Yang, 2021). Within the vision of the organization, it must promote a focus on the well-being of its stakeholders (Ingólfsson, 2019); its corporate values must be aligned with permanent actions toward the transformation to a more humane and transformational leadership style (Ernstsen et al., 2021). In addition, transformational leadership must be communicated assertively (Filipeanu & Cananău, 2015) since innovative cultures are more prone to dissent and respectful dialogue among their employees (Omura et al., 2016).

4.1.2. Integrated Organizational Innovation (IOI)

Technology adoption today is not a competitive advantage as it was a few years ago (Porter, 2001). It is currently a necessity for the survival of companies in a highly competitive and globalized market (Akintoye et al., 2012). However, innovation should not be an isolated element within the organization but a systematic process that cuts across the entire organization (Osorio-Gómez et al., 2024) and allows all its collaborators to be part of innovation processes (Jackson, 2019). Table 3 provides a detailed representation of the relationship between IOI, its associated variables, factors, and evidence. Additionally, there must be a budget from the organizational strategy for investment in technology and the development of new products and services because an excessive focus on cost reduction limits the growth of innovations (Ozorhon et al., 2016). Innovative ideas must follow a selection and development process to ensure good use of resources (Chen et al., 2020). Subsequently, when ideas are developed, there must be a way to manage knowledge within the organization (Omotayo, 2015). Hence, an effective transfer of knowledge allows for improving the flexibility of processes and the training of employees (Smuttrasen & Heo, 2020). This knowledge transfer must occur agilely in the cloud to be permanently accessible (Redmond et al., 2012). Correspondingly, cloud processes allow the real-time management of digital twins to take advantage of information in the life cycle of construction projects (Ding & Xu, 2014). In the same way, these processes in the cloud facilitate processes such as the design and coordination of projects (Adel, 2022). To avoid the loss of competitiveness, new business models must emerge in the construction sector that facilitate cooperation between organizations; for example, there are digital platforms to enable collaboration between organizations based on IPD (Integrated Project Delivery) for construction projects (Ma et al., 2018).

Table 3. Relationship between IOI, variables, factors, and evidence

Variables	Factors & Evidence	Sources
Cloud services (CS)	▪ Cloud projects → BIM models in CDE → Tracking and control of versions ▪ Designs and coordination in the cloud → Clash detection & resolution → Accessible digital logs ▪ Information backup → Information backup protocol → Data center or server room	Hu et al. (2019), Koeleman et al. (2019), Sawhney and Odeh (2020), Shelden et al. (2020)
Cost reduction strategy (–) (CRS)	▪ Investment in technology → Technology investment plan ▪ Investment in innovative products/services → Innovation investment plan ▪ Financial indicators → KPI's (ROI, NPV, Payback period)	Agustia et al. (2020), Koeleman et al. (2019), Liu and Kong (2021), Schreckling and Steiger (2017)
Collaboration with other companies* (COC)	▪ Collaboration registration → Partnership record ▪ Joint performance evaluation → KPI's shared project ▪ Cost-benefit analysis → Shared project cost/benefit	Bouguerra et al. (2023), Faris et al. (2022), Gino (2019), Oraee et al. (2017)
Knowledge Management (KM)	▪ Benchmarking → Benchmarking periodic report ▪ Good practices and lessons learned → Record of lessons learned (Documents or videos) ▪ Reference framework & Intranet → K.M platform (ERP) → Best practices guide	Aghimien et al. (2023), Garcia and Mollaoglu (2020), Smuttrasen and Heo (2020)

Note: * – variables shared with OC and IE.

4.1.3. Information Exchange (IE)

Table 4 shows the relationship between EI, variables, factors, and evidence. IE is one of the direct results of BIM implementation (Matarneh et al., 2019), Augmented Reality (Chung et al., 2019), Artificial Intelligence (Baduge et al., 2022; Qu et al., 2025), Big Data (McAfee & Brynjolfsson, 2012). Furthermore, the accessibility of real-time information from BIM allows organizations to improve decision-making in the design, construction, and operation phases (Najjar et al., 2022); in the same way, data allows prediction and optimization models to be generated to improve organizational performance (Barton & Court, 2012). Data analytics enables organizations to respond quickly to competitors and the market (Dallemule & Davenport, 2017); however, threats to organizations' data must be protected (Mantha & de Soto, 2019). Creative processes empower the implementation of new technologies and processes (Weisberg, 2012); it is necessary to generate spaces to transfer ideas and creativity (Fisher & Barrett, 2019). An open and comfortable architecture in the organization's infrastructure is required to facilitate communication and cognitive diversity (Corritore et al., 2020). Employee training and development are essential for transferring knowledge between employees; new technologies only have the expected impact if employees adopt them in their processes (Rodriguez & Walters, 2017). Finally, organizational redesign and DT will be constantly improved if employees are proactive in their implementation (Caniëls & Baaten, 2019).

4.2. Improved model through semi-structured interviews

The Improved Model, obtained in the previous subsection, is evaluated in construction sector organizations using semi-structured interviews and field inspection. To validate the Improved Model, nine organizations were sampled, representing various key activities within the sector's value chain, including the design and supervision of infrastructure projects as well as building construction. These organizations have an average of over 30 years of experience, reflecting a strong foundation in traditional methods of managing and executing construction projects. Simultaneously, they are actively engaged in adapting to contemporary DT processes. Given their extensive experience, the improved model of DT and OS will be assessed through semi-structured interviews with key organizational stakeholders. The essential findings from these interviews are outlined in the subsequent subsections.

4.2.1. Organizational climate

Authoritarian leadership (AL)

Most organizations consulted operate with a hierarchical decision-making structure (Ahmady et al., 2016), primarily by top-level management, often without a collaborative environment. Authoritarian leadership is often prevalent in environments where control and dominance are centralized in the leader (Pizzolitto et al., 2023). This leadership style is closely associated with excessive centralization of authority, characterized by a hierarchical structure where decisions are predominantly made at the top, often relying solely on the leader's discernment: "*There is a very hierarchical structure, and decisions are made at the 'top', basically based on experience*" (E1). Furthermore, Interviewee E3 explained that the organization lacks a formal decision-making protocol, relying instead on a strategic committee to make decisions for the entire company. Other interviewees described centralized decision-making as the prevailing norm. Interviewee E6 reinforced this by mentioning that most decisions are centralized despite the

Table 4. Relationship between IE, variables, factors, and evidence

Variables	Factors & Evidence	Sources
Development of creative process (DCP)	■ Creation workshops → Workshop registration ■ Indicators and registration of new ideas → Innovation selection protocol ■ Architecture → Collaborative workspaces	Botella et al. (2019), Fisher and Barrett (2019), Sokół and Figurska (2021)
Data analytics (DA)	■ Data quality → Data Quality Audit Framework ■ Data visualization → Dashboards ■ Decision-making → Data-driven decision protocol	Dallemule and Davenport (2017), Rialti et al. (2019), Shelden et al. (2020)
Employee training and development* (ET&D)	■ Training needs → Training request registration ■ Training record → Training registration ■ Performance assessment → Results of post-training performance surveys ■ Satisfaction evaluation → Satisfaction surveys	Mehale et al. (2021), Rodriguez and Walters (2017), Urbancová et al. (2021)

Note: * – variables shared with OC and IOI.

presence of decision-making bands aligned with roles and responsibilities. Work teams with authoritarian leadership performed worse than their peers (Pizzolitto et al., 2023). In contrast, Interviewee E4 highlighted a more collaborative approach within their organization, where managers and tactical personnel work together effectively (Alkan & Tunç, 2019), supported by a communication culture that uses tools to track commitments.

Promotion opportunities (PO)

The promotion of opportunities depended mainly on the size of the organizations; larger organizations had a greater predisposition to promotion opportunities, while smaller organizations had fewer opportunities for promotion (Frenkel & Bednall, 2016). Interviewee E2 highlighted that their company follows a protocol where new vacancies are initially published on the intranet to prioritize internal candidates; the vacancy is opened to external applicants if no suitable internal profile is found. According to Interviewee E4, while administrative areas have clearer pathways for promotion, opportunities within construction sites are more limited, resulting in higher job turnover (Ayodele et al., 2020): "*There is a higher turnover in construction sites*" (E2). Interviewee E5 observed that implementing new processes driven by DT has led to significant changes in roles and responsibilities, necessitating the re-engineering of key functions (García de Soto et al., 2019): "*The semi-annual evaluation has helped to standardize the profiles of each position, with the new roles and responsibilities*" (E3).

Transformational leadership (TL)

Most organizations prominently display corporate values across offices, computers, and meetings (Ingólfsson, 2019). Interviewee E4 states that the company's vision is evidenced by the website and wallpapers, which are printed in various areas of the offices. Face-to-face communication of vision significantly impacts work teams (Jensen et al., 2018). Interviewee E7 highlighted that corporate values are consistently communicated through electronic media and reinforced during meetings. However, a disconnect between these values and their practical application can arise when face-to-face activities are not conducted adequately within organizations. Similarly, Interviewee E5 aligned with the observations of Jensen et al. (2018), stating: "*People generally don't know the company's vision*". In contrast, more personalized initiatives can favor more transformational leadership (Kim & Park, 2020). Interviewee E3 highlighted the initiative "Outdoor Day", where employees gather to strengthen their leadership skills while sharing and reinforcing the organization's corporate values. A shift towards a more collaborative organizational culture was described by Interviewee E6, who mentioned adopting a hybrid work model following the COVID-19 pandemic; however, there are still great challenges in terms of leadership, as interviewee E5 would affirm: "*There are still great challenges of leadership in construction*".

Assertive communication (AC)

Most organizations have established procedures for conflict resolution, typically involving a committee that addresses labor issues. However, decisions remain primarily hierarchical, with most outcomes determined by direct supervisors within each area (Filipeanu & Cananău, 2015): "*There is resistance to change due to managers who are not so open to new ideas and technologies*" (E9). Some organizations have implemented initiatives to address these challenges and improve communication and leadership. For example, Interviewee E2 highlighted the existence of a "leadership academy" where sessions on assertive communication are conducted. Similarly, Interviewee E3 acknowledged efforts by the organization to provide coaching sessions to enhance these skills. A primary goal of assertive communication coaching is to identify unrealistic thoughts that prevent members from an assertive attitude (Gultekin et al., 2018): "*There is a culture of not creating a 'fire' where there is none*" (E3). Assertive communication is directly related to immediate collaborators and clients (Brubaker et al., 2014). Interviewee E6 discussed the development of an anti-corruption policy to guide interactions with clients and subcontractors to prevent bribery and misunderstandings.

4.2.2. Integrated Organizational Innovation (IOI)

Cloud services (CS)

Depending on the level of implementation of DT in each organization, cloud services are used more than others. Organizations with more advanced digital transformation initiatives already utilize cloud-based platforms for design and coordination, while others are still transitioning (Begić & Galić, 2021): "*DT is mainly focused on BIM*" (E9). Different approaches to data management were observed across organizations. Interviewee E6 mentioned that 30% of their organization's projects are managed using Autodesk Construction Cloud (ACC) and Trimble. This perspective was further supported by Interviewee E4: "*Autodesk Construction Cloud (ACC) is a fundamental tool for fostering collaboration*". Other data management strategies are employed, with some firms maintaining proprietary on-site physical backup systems, including liquid cooling technologies in specific offices. In contrast, others depend exclusively on cloud-based storage solutions. Three organizations reported that 30–40% of their projects are in the cloud. At the same time, the rest still follow more traditional workflows (Teo et al., 2022): "*4D BIM is not used (for cost-benefit reasons), and 5D is already implemented*" (E2).

Cost reduction strategy (CRS)

The economic allocation for innovation and technology investment in the organizations consulted remains relatively low, resulting in a more gradual adoption of new technologies (Oladimeji et al., 2023). Despite this, companies acknowledge the importance of investing in technology and allocate an annual budget: "*The organization seeks efficien-*

cy, not necessarily in costs or times; there is also a focus on investment in innovation" (E1). Interviewee E4 mentioned that there is no predefined budget for technology investments, but requests can be submitted to the organization's directives for approval. Firms with a strong emphasis on production often strategically deprioritize innovation-focused initiatives (Pellicer et al., 2012): "*Companies are not used to investing in innovation, and a greater incentive must be created*" (E3). However, approaches to budgeting and incentivizing innovation vary. Interviewee E5 acknowledged that no formal incentive scheme exists, but efforts are underway to develop one alongside DT processes. Non-monetary incentives can improve job satisfaction and performance (Hooi et al., 2013): "*Sometimes there is a lack of resources for innovation and more recognition for people*" (E6). Moreover, Interviewee E1 mentioned that their company has implemented an incentive scheme to promote innovation, though these incentives are tied to individual performance KPIs.

Collaboration with other companies (COC)

The organizations primarily work in isolation; each one oversees its design and execution of construction projects; however, there are some specific cases where there are collaborations between companies, but that depends more on the need of the project than on it being something cultural in the organization (Al-Hakim & Lu, 2017): "*The organization seeks companies that complement its know-how, especially in public projects*" (E6). Inevitable protectionism towards sharing data and know-how with other companies is present in organizations since they are seen more as "competition" than as "allies" (Gino, 2019): "*There are collaborative projects with other companies, but they are not in BIM*" (E9). Interviewee E2 noted that collaboration within their organization is limited to outsourcing specific activities, such as design and supervision. Furthermore, the significance of measurement through indicators in these partnerships was emphasized. As Interviewee E1 stated: "*What is not measured does not exist*", underscoring the importance of defining measurable outcomes to ensure the effectiveness of these collaborations. In other ways, Interviewee E6 described a more innovative approach, explaining that their company has a spin-off dedicated to developing proprietary software and commercializing these solutions with other companies, fostering external collaboration through technological innovation.

Knowledge management (KM)

Knowledge management is essential in organizations (Sokół & Figurska, 2021), and it can be found on the intranet or in an ERP (Enterprise Resource Planning). The information collected is mainly written documents on how to carry out construction projects; nevertheless, organizations recognize that it is difficult to update this information (Omotayo, 2015): "*It is not easy to change standards; they are in PDF formats with photos, but they are not so dynamic*" (E7). Most organizations concentrate their benchmarking efforts on sales, with only a partial focus on other strategic areas, also, challenges arise in preserving the best practices in the construction field: "*It is more difficult for engineers in the field to preserve the best practices*" (E1). Interviewee E3 mentioned that their procedures and formats are verified through external audits to ensure continuous improvement, which helps maintain up-to-date documentation. An organization's ability to leverage acquired knowledge is fundamentally rooted in the individual capabilities of its employees (Garcia & Mollaoglu, 2020). Interviewee E8 shared that their organization uses video formats, with recordings limited to 15 minutes, to make best practices more accessible and easier to understand. Organizations efforts to share knowledge and promote DT vary (Yagiz et al., 2017). For example, Interviewee E6 highlighted using a company podcast on Spotify, which broadcasts weekly episodes addressing topics related to DT.

4.2.3. Information exchange

Development of creative process (DCP)

Most organizations recognize that they are still at a very incipient level of creative processes; most come out of isolated exercises, but not from forming groups or recurrent meetings that allow their sustainability in the organizational culture (Botella et al., 2019). Many offices lack areas dedicated to fostering creativity, and holding such meetings on construction sites is even more challenging: "*Innovation is focused on construction procedures*" (E5). Interviewee E6 explained that although creative meetings are infrequent, their organization uses a "digital log" to document project progress and provide feedback, focusing on construction site innovations to enhance project outcomes. Some organizations have initiatives to promote creativity; nevertheless, they recognize that their spaces and architectural designs do not facilitate creative processes (Fisher & Barrett, 2019). For instance, Interviewee E3 mentioned a "Design Picnic" hosted by their company outside the offices, where renowned speakers are invited to discuss topics of interest. However, these events primarily target management levels and do not extend to operational staff: "*There are creative process meetings, but they are isolated and do not permeate the rest of the organization*" (E4).

Data analytics (DA)

The importance of data analytics in the current context of DT for improving decision-making in organizations is recognized (Rialti et al., 2019); regardless, a significant part of the organizations consulted are only in the implementation process. Data began to be used to control data, especially in sales, credits, and work progress. However, it still needs to be articulated well throughout the value chain: "*One of the biggest difficulties has been the unification of language between areas*" (E2). Advanced organizations undergoing transformation also implement data protection and cybersecurity protocols to regulate access to sensitive information (Sonkor & García de Soto, 2021). Interviewee E2 suggested that integrating data analytics with Artificial

Intelligence (AI) could significantly enhance the development of tools to improve organizational productivity. This perspective was supported by Interviewee E8, who stated: "*Dynamic dashboards have been built for management to encourage data-driven decision-making*", highlighting the practical application of these technologies in fostering informed decision-making processes. However, Interviewee E3 highlights a key challenge: data analytics is often conducted in isolated areas, and there is a need for its transversal integration across the organization.

Employee training and development (ET&D)

In general, organizations focus on training, but it depends on budget availability and the topics of interest to management (Rodriguez & Walters, 2017): "*The training focuses on the company's tools and the specific role of each employee*" (E9). Training on BIM, Artificial Intelligence, and soft skills are the most common topics in the firms. On the other hand, Interviewee E1 mentioned that their organization offers an internal training platform complemented by partnerships with platforms like Coursera. In addition, Interviewee E6 noted that their organization collaborates with a MOOC course platform and creates short videos for training on various topics, such as BIM. Practical application-based training has better results in evaluations (Urbancová et al., 2021): "*Training is done through pilot projects, allowing employees to learn and apply knowledge in real-world scenarios*" (E6). Interviewee E3 explained that their organization allocates an annual budget for employee training, hiring external companies to provide training on relevant topics.

4.3. Field-based inspection approach for the improved model

Subsequently, a field inspection was conducted, and each organization was requested to provide tangible evidence for each factor of the improved model. This evidence was assessed using a 3-point Likert scale based on the level of implementation, indicating: 0 – "Not implemented", 0.5 – "Partially implemented", and 1 – "Fully implemented". This evaluation comprehensively assessed each variable and macro-variable within the Improved Model. In addition, some evidence of the macro-variables will be discussed. The main results are presented in Table 5, which includes the mean (M) values for each macro-variable across the organizations. Additionally, the table provides the overall mean and standard deviation (SD) for all the organizations evaluated.

Based on the field inspection, evidence was identified for each macro-variable related to OC. For instance, Organization 3 received a national award for its exemplary organizational culture, which was recognized for fostering high levels of employee satisfaction. Furthermore, Organization 4 demonstrated a structured decision-making protocol tailored to the organization's roles. Similarly, Organization 7 maintained comprehensive records of the training programs conducted by its human resources department. Likewise, Organization 9 offered a training portal managed by an external provider, complemented by evaluations conducted at the end of each program. Finally, the documentation from Organization 5 revealed an ongoing restructuring process within its human management department, highlighting efforts to improve organizational efficiency.

Regarding IOI, Organization 1 has implemented an incentive scheme with clearly defined conditions for each employee. Similarly, Organization 2 offers performance-based bonuses linked to compliance with established performance indicators. Regarding physical infrastructure, Organization 3 provides amenities such as ping-pong tables and organizes recreational workshops using LEGO to foster employee creativity. Moreover, Company 6 has structured its creative processes around the SCRUM framework, designating a leader with responsibilities akin to a product owner.

Regarding IE, Organization 6 is collecting information using drones and an IoT assistant; nonetheless, it has not yet implemented more robust data analysis methods for processing the captured information. For instance, Organization 1 developed its own BIM-integrated API to monitor project site tracking; however, not all projects are currently integrated into this system. Similarly, Organization 3 has transitioned 70% of its projects to Autodesk BIM Collaborate Pro, enabling cloud-based design management. Additionally, Organization 4 has developed a proprietary classification system specifically designed for information management. Furthermore, Organization 8 utilizes a centralized system that integrates feedback from project sites and can be accessed conveniently from any smartphone. In contrast, Organization 7 is still in the early stages of BIM implementation, as it is conducting its first pilot projects but has yet to establish standardized processes.

Based on the principal results, the OC emerged as the macro-variable with the highest overall score among the organizations (M = 0.76). This was followed by IOI with a mean of M = 0.65, while IE had the lowest average (M = 0.59). For instance, Organization 3 achieved a high mean score in OC (M = 0.94); in contrast, Organization 5 had the lowest mean in this variable (M = 0.39). Regarding IOI, Organization 2 obtained the highest score (M = 0.89), whereas Organization 5 recorded the lowest result (M = 0.19). Furthermore, Organization 6 demonstrated a strong performance in IE with a mean of M = 0.87, while Organization 7 reported a low mean (M = 0.27) in the same variable. Additionally, the Improved Model evaluation revealed that no organization had any macro-variable classified as "fully implemented", highlighting the significant challenges associated with implementing digital transformation in organizations. Some of the organizations with smaller sizes, such as the 5 and 7, have lower values than the average of the rest of the organizations; the size and organizational strategy could directly influence the resources invested in improving the processes in each of the macro-variables (Oladimeji et al., 2023).

Table 5. General qualification of macro-variables in organizations

Interviewee	Organizational Climate (OC)	Integrated Organizational Innovation (IOI)	Information Exchange (IE)
E1	0.66	0.73	0.87
E2	0.94	0.89	0.73
E3	0.94	0.84	0.90
E4	0.88	0.76	0.56
E5	0.39	0.19	0.06
E6	0.82	0.74	0.87
E7	0.73	0.35	0.27
E8	0.62	0.48	0.34
E9	0.87	0.87	0.69
Mean (M)	0.76	0.65	0.59
Standard Deviation (SD)	0.18	0.25	0.30

Table 6 presents the specific results for each variable across the nine organizations in the sample. The Mean (M) and Standard Deviation (SD) for all organizations are displayed on the right side of the table. Among the variables, Collaboration with Other Companies (COC) exhibits the lowest mean M = 0.35 and a high standard deviation SD = 0.38, indicating a limited openness to collaboration within construction companies and an over-protectionism of business know-how. Similarly, the Development of Creative Processes (DCP) also shows low results (M = 0.47), reflecting a minimal focus on fostering creativity within organizations in the construction sector. Likewise, the Cost Reduction Strategy (CRS) exhibits a low mean (M = 0.59) and a high standard deviation (SD = 0.39), indicating a wide dispersion in the results. This can be attributed to the historical focus of construction firms on efficiency, which has traditionally prioritized cost-reduction strategies over investments in innovation. Conversely, Transformational Leadership (TL) achieves a notably high mean M = 0.83 and SD = 0.15, underscoring its critical importance for organizations in the construction sector. Nonetheless, significant challenges remain in effectively implementing leadership-driven actions within construction teams. Finally, Data Analytics (DA), a variable that reflects the implementation of DT processes, presents highly dispersed results, demonstrating the digital gaps between different organizations (SD = 0.39).

4.4. Digital-organization transformation (DOT) model contributions

This study presents a Digital-Organization Transformation (DOT) Model for the integrated implementation of DT and OS in Figure 3. Although the contributions mainly focus on the construction sector, some variables could also be an input for other DT models in various industries. Furthermore, the presented DOT Model has practical implications for its implementation in organizations in the construction sector, both for building construction and for supervision, design, and construction of infrastructure. The productivity problem in organizations may be unraveled by focusing more on the organizational issue, which has been left aside by the more common concentration on the technological tools available for DT.

Building upon the Original Model, which established macro-variables and variables, the DOT Model offers a more practical framework for implementation at the process level, incorporating organizational factors and tangible evidence. Moreover, it is a diagnostic tool for assessing DT and OS within the construction sector. The DOT Model highlights significant digital gaps among companies in the construction industry, along with latent needs for innovation, workforce development, greater openness to collaboration, and incentive schemes to achieve synergetic outcomes. This research has contributed to understanding the relationship between evidence, factors, variables, and macro-variables in DT and OS, as it can be observed in Figure 3. This approach is expected to carry out organizational redesign processes and make the most of the potential of DT, allowing construction sector organizations to improve their productivity levels.

Table 6. Results of field inspection based on factors and evidence

Macro-variables	Variables	Construction Firms									M	SD
		1	2	3	4	5	6	7	8	9		
Organizational Climate	(AL) (–)	0.33	0.83	0.83	0.83	0.50	0.83	0.83	0.33	0.67	0.66	0.22
	(PO)*	0.75	0.88	1.00	0.75	0.50	0.88	0.38	0.75	1.00	0.77	0.21
	(TL)	0.66	1.00	1.00	0.83	0.66	0.83	1.00	0.66	0.83	0.83	0.15
	(AC)	0.66	1.00	1.00	1.00	0.17	0.83	0.83	1.00	1.00	0.83	0.28
Integrated Organizational Innovation (IOI)	(CS)	0.83	1.00	1.00	1.00	0.50	1.00	0.33	0.33	1.00	0.78	0.30
	(CRS) (–)	1.00	1.00	0.66	0.83	0.00	0.33	0.00	0.66	0.83	0.59	0.39
	(COC)*	0.33	0.50	0.66	0.00	0.00	1.00	0.00	0.00	0.66	0.35	0.38
	(KM)	0.50	1.00	0.88	1.00	0.00	0.50	0.75	0.75	0.88	0.70	0.32
Information Exchange (IE)	(DCP)	1.00	0.25	0.75	0.75	0.13	1.00	0.00	0.00	0.38	0.47	0.41
	(DA)	1.00	1.00	1.00	0.50	0.00	0.75	0.13	1.00	0.50	0.65	0.39
	(ET&D)*	0.88	1.00	0.88	1.00	0.13	0.75	0.63	0.38	0.88	0.73	0.30

Note: * – variables shared between macro-variables.

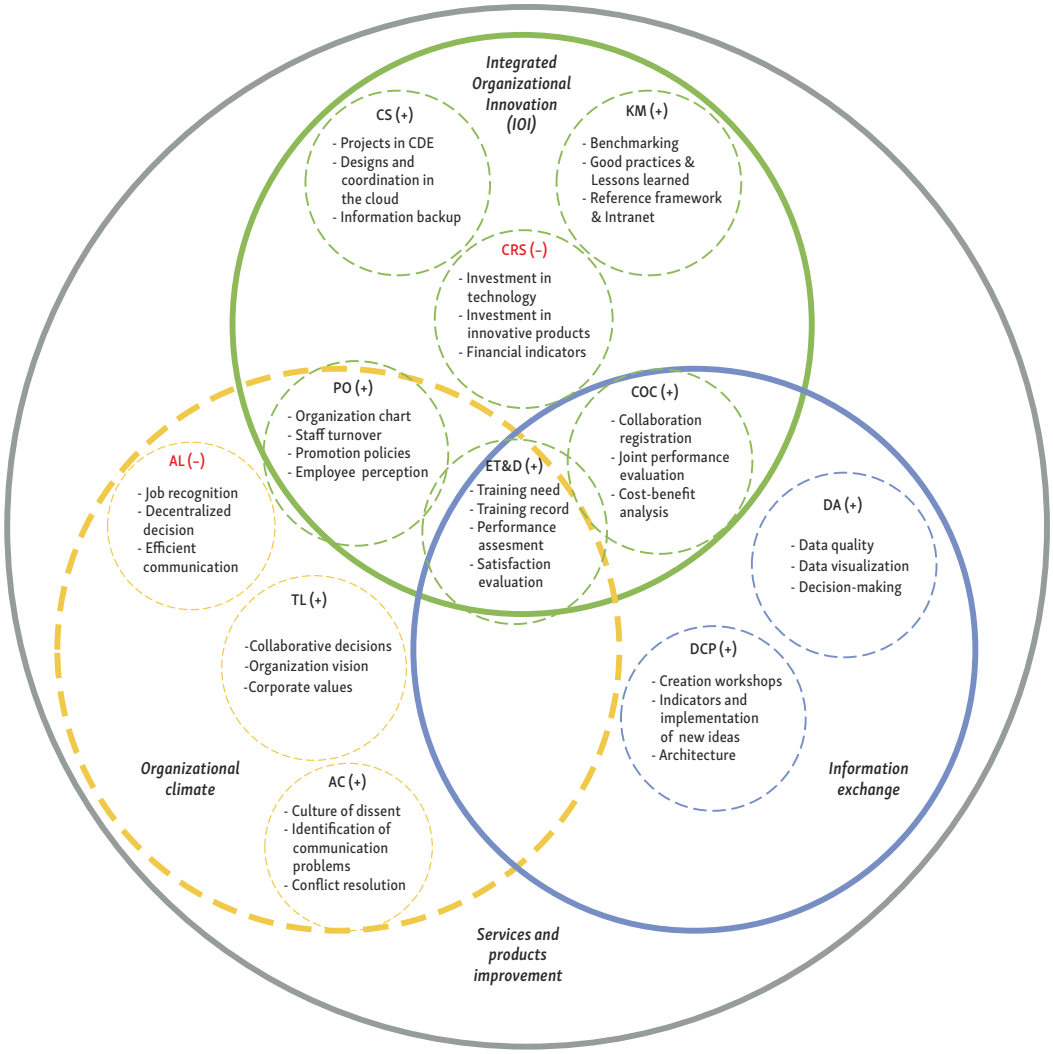

Figure 3. Digital-organization transformation (DOT) model

The most successful organizations in the long term will need to put more effort into effectively implementing organizational changes, rather than just relying on technological tools. As a result, technological tools will be consolidated in the medium term and will not be a competitive advantage due to their widespread use in the market. Likewise, IOI must be a systemic process of the organization and not just isolated efforts of areas of the organization; this is to permeate the vast majority of the organization and take advantage of the creative potential of the stakeholders to improve processes. Additionally, staff development is crucial to maintaining updated knowledge so that the employees themselves develop more organic improvement processes.

Finally, the DOT Model considers the internal aspects of organizations to improve products and services, which must be oriented from the organizational strategy, changing the processes considering the integrated process of DT and OS. However, organizations must keep abreast of external changes so as not to lose their competitive advantages. Furthermore, organizations need continuous feedback on the perception of their customers from the products and services. At last, new technology must be constantly incorporated into administrative and construction processes to increase productivity.

5. Conclusions

Implementing new technologies in the construction sector has been mainly focused on technological tools. However, the full potential of DT for the industry has yet to be reached. In this way, it is crucial to adapt organizations to carry out DT with changes in OS to enhance their synergies.

The main findings show there is still a potential for improvement in all the organizations sampled. IE and IOI are macro-variables still developing as DT processes and organizational maturity levels advance. The interviews and field inspection support the literature review findings on the factors and evidence of each variable, making the DOT Model a tool applicable to any organization in the construction sector that seeks to improve its productivity.

Nevertheless, the DOT Model has some limitations. The importance of each variable will depend on the context and each organization. Likewise, new relationships between variables and factors may exist as more scientific literature becomes available. Similarly, the results presented were from nine Colombian organizations in a similar context. It is recommended that similar research be done in other countries and contexts based on this model to compare implementation and organizational design levels. Additionally, the DOT Model considers technological tools and methodologies transversally to the organization, but some organizations have isolated implementations.

This research has generated an overview of the construction sector's DT and OS; nevertheless, the sample of organizations could be increased. It is expected that this study will be the beginning of more research on this aspect of DT, and the development of a maturity model is proposed, considering the variables of this model; there is also the possibility of analyzing the changes in roles/responsibilities of construction stakeholders considering organizational changes. Moreover, the external client could play a crucial role in future developments, as it helps to understand from an external perspective what aspects need to be improved in organizations. Finally, this DOT Model can also be adaptable to sustainability parameters in projects and organizations since the changes presented here can lead to improvements in decision-making, a decrease in re-processes, increased profitability, less waste, and an overall improvement in organizational and sectoral productivity.

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Author contributions

CCO, RFH, and EP conceived the study and were responsible for the design and development of the data analysis. CCO and LT were responsible for data collection and analysis. RFH and EP were responsible for data interpretation. CCO wrote the first draft of the article. RFH and EP revised the original draft. LT was responsible for the final editing.

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