Digital twins' impact on organizational control: perspectives on formal vs social control

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Abstract

Purpose – This study examines the connection between different digital-twin characteristics and organizational control. Specifically, the study aims to examine whether the digital-twin characteristics exploration, guidance and gamification will affect formal and social control.

Design/methodology/approach – The study is based on an analysis of survey results from 139 respondents comprising applied university students who use digital twins.

Findings – The results offer an interesting contribution to the literature. The authors consider the digital-twin characteristics exploration, guidance and gamification and investigate their contribution to two types of organizational controls: formal and social. The results show that two characteristics, exploration and gamification, affect the extent to which digital twins can be utilized for social control. Exploration and guidance's role is significant concerning the extent to which digital twins can be utilized for formal control.

Originality/value – This study contributes to literature by considering multiple digital-twin characteristics and their contribution to two different control outcomes. First, it diverges from previous technical-oriented research by investigating digital twins in a human context. Second, the study is the first to examine digital twins' effects from an organizational control perspective systematically.

Keywords Digital-twin, Social control, Formal control, Organizational control

Paper type Research paper

1. Introduction

Digital transformation through novel digital technologies currently affects all aspects of business and consequently will cause significant changes in organizational control – intentional or not. This will have profound effects on management research and practice as technologies generate data and reshape organizational procedures (Bhimani, 2020). An example of the influence of digital technologies on organizational control is the increase in predictability. Digital twin decreases the uncertainty of organizational processes by improving the organization's interactions with its customers and suppliers (Parmar *et al.*, 2020). Parmar *et al.* (2020) consider Uber as an example of this, because the app shows the position of the vehicle as it arrives to eliminate the uncertainty of the arrival time. Thus, digital twins certainly are one of the technologies affecting digital transformation. Thus, studying what kinds of organizational control tools are most efficient is crucial.

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From this perspective, this study focuses on the impact of digital twins on organizational control.

Organizational control can be viewed as the process of affecting people's behavior to maximize the chances that they will achieve organizational objectives and goals (Flamholtz, 1996). The importance of control in an organization has been confirmed by many researchers, as organizational control is used to direct attention, eagerness as well as encourage individuals to perform in ways that support set objectives (Long *et al.*, 2002). Thus far, much research in the organizational control field has examined accounting-based controls (Bedford and Malmi, 2015). However, the way organizations are managed has changed due to the benefits of digital technologies (Ukko *et al.*, 2019; Mancha and Shankaranarayanan, 2021). Previously, decision-making was based on historical data, but now digital technologies are facilitating accurate decision-making using real-time data (Min *et al.*, 2019; Oh and Jeong, 2019; Wesche and Sonderegger, 2019). Thus, the digital, physical and social realms will become intertwined (Bolton *et al.*, 2018; Saunila *et al.*, 2019). This means that it is reasonable to examine organizational control through formal and social controls, as they affect people's behavior and outcomes through various mechanisms. While formal control usually refers to formal practices – such as activity-based costing, balanced scorecards or target costing (Malmi and Brown, 2008) – social control properties – such as knowledge, skills and commitment – belong to individuals within the firm and are built through dialogue, communication, education and training to guide employees in their everyday jobs (Johnstone, 2018). Since individuals in firms are the main actors in organizational development, considering both formal and social controls is necessary for such development to happen.

Novel digital technologies, such as digital twins, have become an essential part of organizational control. A *digital twin* is defined as a digital replica of a physical entity, namely, a product, process or system. Digital twins include features such as exploration, guidance and gamification that enhance opportunities for organizational control. Digital twins can be used to assist visualization, promote collaboration and further decision-making (Bao *et al.*, 2019; Kaewunruen and Lian, 2019; Oyekan *et al.*, 2019). Furthermore, digital twins enable remote monitoring, prediction and control of strategy implementation using real-time performance measures, data and IoT-enabled dashboards (Aheleroff *et al.*, 2020). Digitally replicating organizational processes allows people to save costs by determining the most efficient ways to conduct business. This allows for performance improvement, since it is possible to use digital replication to see how quickly an organization could respond to a decision. Thus, there is huge potential to develop organizational agility through fast and intelligent decisions based on real-time data (Parmar *et al.*, 2020). Because opportunities to utilize digital twins are vast, they will inevitably affect how organizations are shaped (e.g. through organizational controls). Thus, digital twin features allow for the use of digital twins for formal and social control purposes. Digital twins offer a way forward that explicitly considers how novel digital technologies will alter the formation of control mechanisms. Despite growing interest, research is lacking on novel digital technologies' effects on organizational control. Thus, it is worth studying whether novel digital technologies affect organizational control, specifically social or formal control.

This study aims to examine the connection between different digital-twin characteristics and formal and social control. Specifically, the study aims to investigate whether digital-twin characteristics exploration, guidance and gamification will affect controls, specifically social and formal controls. The study was based on an analysis of survey results from 139 respondents comprising applied university students who can be viewed as the forerunners of utilizing and realizing the potential of such technology. Based on the theoretical framework below, we hypothesized a positive relation between digital-twin characteristics and organizational control.

2. Literature review

2.1 Organizational control theory

Organizational control theory explores the extent to which organizations can exert control to achieve their goals and objectives (Cardinal *et al.*, 2004; Eisenhardt, 1985; Liu *et al.*, 2014). The term *control*, with an emphasis on organizational control, is defined as the process of influencing or controlling the behavior of members of a formal organization to maximize the chances that they will achieve organizational objectives and goals. Considering that organizations include different tasks done by people with different interests, the need for control is critical for aligning the people and tasks with the organization's goals and objectives (Flamholtz, 1996). Merchant and Otley (2006) asserted that the concept of control can encompass factors such as strategic development, strategic control and learning processes, all of which generally lie beyond management accounting's scope. Abernethy and Chua (1996) described an *organizational control system* as a synthesis of control mechanisms that management designs and implements to increase the likelihood that organizational actors will act in ways that are consistent with the dominant organizational coalition's objectives.

As stated, organizational control concerns processes that control people's behavior through which organizations can achieve their goals and objectives. Organizational control can be established through two groups of controls: social and formal control (Cardinal *et al.*, 2004; Eisenhardt, 1985; Liu *et al.*, 2014). Social control commonly is viewed as shared values, norms and beliefs that guide daily work practices (Ouchi, 1979; Schein, 2004). Johnstone (2018) defines *social control* as the norms and values, born from both the organizational and the individual's contexts, which lead employees in their everyday jobs. Furthermore, the social control construct is used to capture the impacts from informal processes that cause employees accumulating values and fundamental assumptions infused within the organization's symbols, rituals, language and social structures (Schein, 2004; Bedford and Malmi, 2015). Johnstone (2019) views the social control construct as relating to individual organizational actors' values, rather than only reflecting leading organizational values and system design. It has been argued that social control properties (e.g. knowledge, skills and commitment) belong to individuals within the firm and are built through dialogue, communication, education and training (Johnstone, 2018). As such, it seems that social control properties are the consequence of both formalized system design, as well as personal experience and internal disposition, as presented by Johnstone (2019). *Formal control* usually refers to formal practices, including activity-based costing/management, a balanced scorecard, value-based management, rolling forecasting and target costing (Malmi and Brown, 2008). Formal controls use mechanisms to specify outcome targets, as well as tools to monitor a variety of performance indicators regarding specified output targets (Stouthuysen *et al.*, 2017).

As previously stated, different types of digital technologies offer huge potential for organizational control; there is a need for more research to understand how digital twins can be pursued within organizations (e.g. for the purpose of organizational control; Parmar *et al.*, 2020). Next, the concept of a digital twin and its characteristics are explained.

2.2 Digital twins and their characteristics

Interest in digital twins has grown in recent years. Grieves introduced the term in 2003 (Grieves, 2014), after which digital twins became more popular and several studies were conducted. Digital twin is defined as a digital replica of a physical entity, such as a product, process or system. According to Tao *et al.* (2018) it comprises three parts: physical product, virtual product and connecting data that bind both the physical and virtual products together. It has been noted that digital twins can be applied to many sectors and technologies

(Khajavi *et al.*, 2019). They also have been identified in a wide range of features that add value (Rasheed *et al.*, 2020) and create great opportunities for the interoperation and fusion of the physical and cyber worlds (Liu *et al.*, 2019). Digital twins already have been exploited in several application areas, e.g. smart cities, manufacturing, health care and aviation (Fuller *et al.*, 2020; Barricelli *et al.*, 2019). Three characteristics of digital twins – exploration, guidance and gamification – will be examined in more detail next.

In today's connected world, data are key to improving planning, understanding and decision making. The digital twin is characterized by two things: rapid development and the ability to make changes to a digital presentation (Aheleroff *et al.*, 2020). These two things support exploration by enabling simulation and testing of ideas before real actions are taken (Kaur *et al.*, 2020; Grieves and Vickers, 2017; Boschert and Rosen, 2016). In terms of exploration, digital twins also aim to digitally simulate the physical object or system's state and behavior, analyze interactive behaviors between different factors of the object or system, create "what if" scenarios and test potential changes' impact on object or system performance (Bao *et al.*, 2019; Tao *et al.*, 2018). With specific simulation models and exploration features, digital twins can solve problems in ways that lead to meaningful real-life solutions (Khajavi *et al.*, 2019).

Using advanced technology, digital twins have features to monitor, control, predict and maintain functions to benefit users by enabling the transmission of data between the physical and virtual worlds (Aheleroff *et al.*, 2020; Khajavi *et al.*, 2019). The ability to synchronize real and digital worlds allows users (e.g. management, employees, designers, operators, maintenance personnel, etc.) to utilize digital twins to monitor and control assets and systems in real time, enabling guidance of operations (Papanagnou, 2020, Bao *et al.*, 2019, Zhuang *et al.*, 2018; Weyer *et al.*, 2016). For example, management can leverage digital twins' guidance features by remotely monitoring and controlling implementation of strategies using real-time performance measures data and IoT-enabled dashboards (Aheleroff *et al.*, 2020). Fueled by sensor updates and historical data, digital twins can replicate the current state of physical objects, processes or systems and predict future behaviors and important changes (Qi *et al.*, 2021; Barricelli *et al.*, 2019; Grieves and Vickers, 2017). They also can provide guidance on fault diagnosis, predictive maintenance and performance analysis (Tao *et al.*, 2019a,b). Also related to guidance**,** digital twins can give users real-time operational guidance or training guidance to learn in virtual reality without fearing the consequences from failure (Tao *et al.*, 2018).

Furthermore, by replicating the physical world in digital space, digital twins can provide gamification possibilities, considering that digital twins' characteristics include different types of gamification aspects. Gamification includes aspects such as competition, rewards and role-playing (cf. Xi and Hamari, 2019). Hall *et al.* (2020) studied how creativity is expressed within digital games, concluding that digital games and gamification can help increase creativity and learning, which can support, e.g. problem-solving capabilities further. Other studies also examine virtual reality and digital twins used for gamification purposes, supporting training, learning and well-being (Olszewski *et al.*, 2020; Cavada and Rogers, 2020; Fan *et al.*, 2021; Gong *et al.*, 2020). According to Cavada and Rogers (2020), using digital twins for serious gaming in the context of smart cities has the potential to impact individual and social well-being positively. Fan *et al.* (2021) note that digital twins enable scenario play and simulation capabilities for training, planning and collaboration purposes.

2.3 Digital twins and organizational control

Digital twins are revolutionizing industry, as well as consumer behavior, as single entity in the physical world can be replicated in the digital space through digital-twin technology (Qi *et al.*, 2021). Many potential and perceived benefits already can be attributed to the digital

twin, such as cutting costs, design time and risk, complexity, and reconfiguration time; enhancing after-sales service, maintenance decision-making, efficiency, safety, security, reliability, manufacturing management, procedures and tools; improving flexibility and competitiveness in manufacturing systems; and fostering innovation (Jones *et al.*, 2020). For instance, cost savings can be achieved, since digital replication of organizational processes can determine the most efficient way to conduct business. Furthermore, performance improvement can be gained, since it is possible to use digital replication of how organizational performance would quickly respond to a specific decision. Thus, there is huge potential to develop organizational agility through fast and intelligent decisions based on real-time data (Parmar *et al.*, 2020). Furthermore, Qi *et al.* (2021) find that, together with artificial intelligence (AI) and machine learning, a digital twin can be utilized for simulation, monitoring, diagnostics, prognostics and optimization, as well as to train users, operators, maintenance staff, service providers, consumers, etc. Because opportunities for utilizing digital twins are so vast, they inevitably will affect how organizations are shaped, e.g. through organizational controls.

Malmi and Brown (2008) assert that while much management accounting research has examined accounting-based controls, generally focusing on formal systems, limited knowledge of the effect from other control types remains. For example, Chenhall (2003) asserted that organizational control sometimes is utilized to mention to controls built into activities and procedures, including statistical quality control and just-in-time management. As a more novel approach, Bredmar (2017) offered a case study that clearly illustrated how advanced systems facilitate new opportunities for management when it comes to controlling and planning operations. He concluded that this allows for a discussion about advanced information systems' benefits as tools for directing a digital enterprise, and also offers a deeper illustration of how the organizational control function has developed in scope through these systems. Bredmar (2017) concluded that the digitalization debate and agenda require to evolve an even deeper knowledge of how digital initiatives, such as digital twins, affect organizations. He said that this would be feasible by dealing with concepts such as digital enterprise, which integrates digital technical solutions with organizational challenges and organizational control intent. Digitalization will have profound effects on management accounting research as the tools of the digital economy generate data and reshape organizational procedures (Bhimani, 2020). Given the advancement of the digital transformation in organizations and the potential of digital twins, the implications for organizational control should be further explored.

3. Research model and hypothesis development

3.1 Research model

As a contribution to organizational control theory, this study examines the connection between digital twins and organizational control and specifically aims to examine whether digital twins – in terms of exploration, guidance and gamification – will affect organizational control, specifically social and formal controls. With the expansion of digital technologies, new digital resources are boosting organizational activities and procedures (Bhimani, 2020; Parmar *et al.*, 2020). As more organizations leverage digital technology in novel ways, it will inevitably have a permanent impact on organizational control mechanisms. For example, there has recently been a growing interest in developing autonomous control systems for various real-world applications in different industries and business areas (Lin *et al.*, 2022; Fuller *et al.*, 2020; Barricelli *et al.*, 2019). Utilizing advanced technology (such as digital twins), an independent control system has the ability to achieve a number of objectives with minimal external intervention (Lin *et al.*, 2022) and influence organizational control activities. With the multiple characteristics of digital twins, organizations can monitor, control, predict and

maintain functions in real time to benefit users by enabling data transmission between the physical and virtual worlds (Aheleroff *et al.*, 2020; Khajavi *et al.*, 2019). Rather than being limited to digitizing an organization's processes, digital twins can combine an organization's resources, people and operations, and their interactions, into a single holistic organizational model that updates and evolves with the organization (Parmar *et al.*, 2020).

Undoubtedly, wider use of digital twins with advanced information systems will shape managers' attitudes toward and reliance on traditional information and evolve management practices, influencing the management of information, accounting and controls, and decision-making (Robert *et al.*, 2022; Tiron-Tudor and Deliu, 2021; Bredmar 2017). In addition, according to Parmar *et al.* (2020), the process of building a digital twin is complex and involves more than just technology; it represents a constant change in the way an organization operates. This requires investment in know-how, projects and infrastructure while modifying organizational processes and ways of operating and controlling (Davenport and Westerman, 2018). Figure 1 depicts the proposed research model, which postulates several direct links between digital-twin characteristics (namely exploration, guidance and gamification) and control outcomes (namely social control and formal control). Next, we turn to explanations of specific hypotheses that investigate how organizational control is driven by the characteristics of digital twins.

3.2 Hypothesis development

It has been shown that digital twins provide a variety of options for discovering new solutions, conducting different experiments and merely being curious (Tao *et al.*, 2019a,b; Qi *et al.*, 2021). Digital twins allow for this kind of exploration to be done alone, but also collaboratively, as they can make aspects visible that previously had been visible only to small groups of people (Tao *et al.*, 2018). Thus, digital twins can affect people's shared values and norms, and further guide their everyday work practices (Schein, 2004; Lutz *et al.*, 2020). Additionally, this type of exploration and discovery with digital twins also can facilitate training and learning, as suggested by Qi *et al.* (2021). Digital twins also allow for more accurate information access, better monitoring and prediction, and more interactivity in assessments (Qi *et al.*, 2021). For example, assessment and monitoring traditionally have been viewed as essential means of guidance to provide feedback (Qi *et al.*, 2021). As digital twins can provide information for guidance and reorganization of activities and operations, they simultaneously affect people's comfort zones in terms of accumulating values and basic assumptions (Schein, 2004; Bedford and Malmi, 2015). It has been argued that the use of digital twins for guidance purposes, such as interactivity and feedback, supports learning purposes (Fan *et al.*, 2021; Qi *et al.*, 2021) and assumedly also can affect other social controls, such as beliefs, norms and shared values (Schein, 2004; Lutz *et al.*, 2020). Additionally, digital

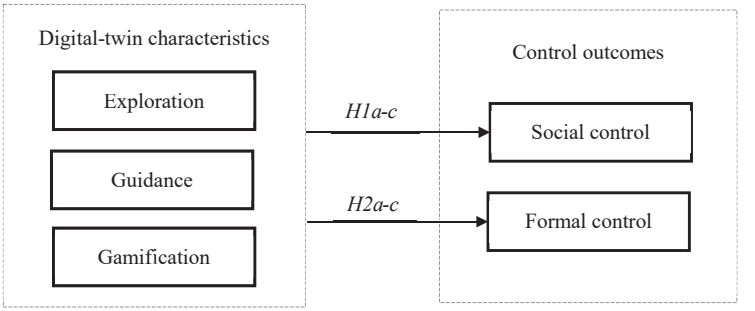

Figure 1.
Research model and hypotheses

twins also provide gamification possibilities. Digital twins' characteristics can include different types of aspects, such as competition, rewards or role-playing, and according to Hall *et al.* (2020), digital games and gamification can contribute to increasing creativity and learning, which can further support, for example, problem-solving capabilities (Carvalho *et al.*, 2015). Koren and Klamma (2018) demonstrated that digital twins can be used to create interactive visual analytics charts for formulating new types of innovative training solutions in high-tech workplace settings. As such, digital twins' gamification aspect can increase communication and dialogue that, according to Johnstone (2018), refer to social control properties. Whereas Baptista and Oliveira (2019) demonstrated that gamification can support learning and enjoyment, among other things, digital twins' gamification characteristics also can support these aspects and, thus, positively affect social controls. Based on the arguments presented above, the following hypotheses related to digital twins' characteristics are presented:

H1. Digital twins' characteristics associate with social control:

H1a. The exploration level associates with social control.

H1b. The guidance level associates with social control.

H1c. The gamification level associates with social control.

Advanced technologies play a critical role at companies – not only assisting managers but also providing them with guidance for making decisions (Min *et al.*, 2019; Oh and Jeong, 2019; Wesche and Sonderegger, 2019). Many scholars have examined how technology's traditionally subordinate role as a tool for simple calculations and typewriting has morphed into an advanced form, often acting as a teammate or partner, with characteristics such as interactivity, the ability to provide immediate feedback and monitoring in decision-support systems that enable high guidance levels through complex analyses and interpretations (Brynjolfsson and McAfee, 2014; Lisboa and Taktak, 2006; Richards *et al.*, 2019; Wesche and Sonderegger, 2019). According to Wesche and Sonderegger (2019), advanced technologies with characteristics that include the ability to test ideas before real actions, as well as investigative and discovery abilities, allow for more leadership functions in terms of task and resource allocation, planning and performance feedback. In this regard, Uber Technologies is an appropriate example, as it provides an advanced automated management system through real-time monitoring and efficient resource allocation based on customers' locations when they need rides. This technology, along with high levels of exploration (e.g. investigation, discovery, and curiosity) and guidance (e.g. interactivity, immediate feedback, direction and monitoring), not only optimizes supply demands but also can be utilized as a rolling program for continuous assessment and forecasting. According to Oh and Jeong (2019), smart factories that utilize technologies with abilities such as visibility, flexibility, responsiveness, integrity and automaticity can achieve formal controls – including scheduling, control, optimization, productivity and efficient use of resources and allocation – through high exploration, guidance and gamification levels. Min *et al.* (2019) found that digital twins can be viewed as an influential option for operational excellence and production-control optimization through higher automation, digitization, visualization, modeling and integration levels. In the retail industry, virtual reality's efficacy through gamification characteristics (e.g. roleplaying, low failure), exploration (e.g. designing and testing before actual action) and guidance (e.g. immediate feedback and suggestions) has been used to design layouts in stores and warehouses because of the quick acquisition of results and a higher level of control in the shelf-layout environment (Pizzi *et al.*, 2019). Thus, based on the issues discussed above, the final hypotheses are presented:

H2. Digital twins' characteristics associate with formal control:

H2a. The exploration level associates with formal control.

H2b. The guidance level associates with formal control.

H2c. The gamification level associates with formal control.

4. Methodology

This study is based on an analysis of survey results from 139 respondents. We examined digital twins through three characteristics: exploration, guidance and gamification. The effects were examined by considering two different uses: social control and formal control. All the scales were built on previous research and adapted for this study through a pre-test in collaboration with researchers. Statistical analyses, conducted using SPSS software, were used to test the hypotheses.

4.1 Sample and data collection

The study data were gathered from applied university students via a survey questionnaire written in Finnish. As the business environment rapidly changes, the traditional operating environment will evolve hand in hand with a digital business environment for more comprehensive development, which is currently leading pioneering companies toward a metaverse. A metaverse is not all companies' goal, but almost without exception, the digital environment, which is formed alongside the physical operating environment, will change the way companies operate. It opens up many opportunities and forces companies to adapt to a changing operating environment. It also changes corporate governance practices from both social and formal control perspectives. Companies are moving toward digital environments in different ways and at different stages; therefore, to support the transition and a new kind of understanding, it is important to understand future employees' views (current students) as well. From the perspective of the research design, university students form a relevant target group through which to study the topic. The university setting is ideal for researching the novel digital twin phenomenon, given that it is an ideal atmosphere for forerunners to utilize and realize such technology's potential. Moreover, using the characteristics of digital twins for organizational control is not limited to production and manufacturing. Rather, digital twins can be used for a variety of purposes and have an effect on all lives. University students represent the age group and generation for whom digitalization has been part of the majority of their lives. They are familiar with the use of digital twins, enabling them to more reliably answer questions during the study. When people understand the impact of the characteristics of digital twins on their own lives, they can efficiently utilize them for different aspects of their careers, including for organizational control. Thus, it is important and relevant to examine the opinions of forerunners (students in this study) about the different characteristics of digital twins, and how those characteristics are associated with organizational control. In addition, the study population comprised students who use digital twins either in their studies or in their personal lives. As university students, they actively cooperate with companies through assignments, theses and internships. They comprise the group that is able to respond to the use of digital twins from different perspectives, and that is starting their careers. Furthermore, university students make for great informants because they decrease random error variance compared with testing a broader sample.

The students came from a variety of disciplines, but most were majoring in business, technology and health care. The total population size was around 1,000, calculated based on the daily attendance of students on the campus from which the data were collected. Respondents were selected based on random sampling, which was viewed as necessary to ensure that each member of the population had an equal probability of being chosen. We distributed the survey only to those who agreed to respond to the survey. We contacted

the potential respondents by following a random sampling method. Thus, around 1,000 people were potential to be chosen for the study but not all were contacted. This process aimed to gain an unbiased set of responses from the total population. Data gathering ceased when 150 paper forms were returned to the researchers, after which the responses were screened, and invalid responses (e.g. if most items were unanswered or if the best possible answer was selected in all items) were excluded from the analysis. A total of 139 valid responses were received, which was viewed as adequate in terms of sample size (Krejcie and Morgan, 1970) and response rate (Saunders *et al.*, 2007) in this type of research. Data from the 139 responses came from different types of students. With 46% of the respondents less than 25 years old, 34% between 25 and 40, and 20% over 40. Males represented 57% of the sample and females 43%.

4.2 Measures

The study's analytical unit is the individual respondent's perceptions of digital twins' characteristics and uses. The survey utilized the following measures of these (see Table 1 for further details).

Digital twins' characteristics. Digital twins' characteristics reflect the three variables measured using a 13-item scale informed by prior research that the authors modified to the items. Digital twins' characteristics refer to these three variables: 1) exploration (three items), 2) guidance (four items) and 3) gamification (six items). The respondents were asked to answer the items by thinking about one of the digital twins they use. They were asked to indicate whether they associated the digital twin with the terms on a seven-point Likert-type scale (Strongly disagree, 1 – Strongly agree, 7).

Control outcomes. Uses of digital twins for organizational control were measured using a five-item scale informed by prior research that the authors modified to the items. Control outcomes refer to these two variables: social control (two items) and formal control (three items). The respondents were asked to indicate their usage level of digital twins through a four-point Likert-type scale (Weak, 1 – Excellent, 4).

Respondents' genders and ages may influence the use of digital twins because they may have different interests regarding content and functionalities. Therefore, respondents' ages and genders were included as control measures because they were likely to affect the results.

4.3 Bias

Common method bias can cause problems when the same respondent is answering the whole survey (Podsakoff and Organ, 1986). Both statistical and procedural remedies were used to avoid such bias. In terms of statistical remedies, Harman's single-factor test was performed by conducting a principal component analysis of all studied items, revealing a seven-factor result, with the first factor explaining only 29.35% of the variance. The first factor did not load remarkably on all items either. Thus, common method bias is not a serious issue in this study. In terms of procedural remedies, the respondents were allowed to answer anonymously, i.e. they were less likely to tailor their answers to be more socially desirable. The items were designed carefully, with special attention paid to their wordings' clarity. Random selection of the sample reduced the possibility of voluntary response bias and under-coverage bias, allowing for sample representativeness and ensuring that the sample adequately depicted different views.

5. Results

5.1 Validity and reliability

Before testing the hypothesis, different measures were conducted to evaluate validity and reliability of the variables. The results of the reliability and validity tests are shown in

Table 1.
Survey items

Characteristics	Definition	Items constructed based on	Form of items	Items	Abbreviation
Exploration	The activity of analyzing interactive behaviors between different factors	Bao *et al.* (2019), Tao *et al.* (2018)	Think about one of the digital twins you use. Please assess on a scale of strongly disagree to strongly agree whether the digital twin associates with the following terms	Investigation Discovery Curiosity	EXPL_1 EXPL_2 EXPL_3
Guidance	Ability to better manage and control assets and systems in real time	Papanagnou (2020), Bao *et al.* (2019), Zhuong *et al.* (2018)	Think about one of the digital twins you use. Please assess on a scale of strongly disagree to strongly agree whether the digital twin associates with the following terms	Interactivity Immediate feedback Direction Monitoring	GUI_1 GUI_2 GUI_3 GUI_4
Gamification	Activities to solve problems by applying game elements' characteristics	Olszewski *et al.* (2020), Cavada and Rogers (2020), Fan *et al.* (2021), Gong *et al.* (2020)	Think about one of the digital twins you use. Please assess on a scale of strongly disagree to strongly agree whether the digital twin associates with the following terms	Role-playing Narrative Competition Surprise Low failure Rewards	GAM_1 GAM_2 GAM_3 GAM_4 GAM_5 GAM_6
Social control	Shared values and norms that guide daily work practices	Ouchi (1979), Schein (2004)	Think about one of the digital twins you use. Please assess on a scale of weak to excellent the usage level of digital twin for the following purposes	Learning Comfort	SOC_1 SOC_2
Formal control	Formal practices that guide daily work	Malmi and Brown (2008), Stouthuysen *et al.* (2017)	Think about one of the digital twins you use. Please assess on a scale of weak to excellent the usage level of digital twin for the following purposes	Predictability Save time Facilitate decision-making	FOR_1 FOR_2 FOR_3

Table 2. All variables were unidimensional and all item loadings were above the 0.5 minimum threshold (Hair *et al.*, 2014) inside each factor. Additionally, the nonexistence of remarkable cross-loadings supported discriminant validity. Then, different measures, such as Cronbach's alpha, average variance extracted (AVE) and composite reliability (CR), were calculated. As Table 2 shows, four out of five variables had Cronbach's alpha values over the proposed limit of 0.6 (i.e. construct reliability was supported; De Vellis, 1991). In the social control factor, Cronbach's alpha was below 0.60; therefore, construct reliability could be questioned. However, for variables with a small number of items and for new scales, a lower Cronbach's alpha is admissible (Nunnally, 1978). Consequently, as the Cronbach's alpha value lies near the threshold, reliability is unlikely to be a significant problem. The accepted value for AVE is 0.5; however, a value less than 0.5 would be acceptable if the CR value is higher than 0.7, and the convergent validity can be confirmed (Fornell and Larcker, 1981). AVE met the accepted threshold for all variables except gamification, and due to the explanation and the value of CR, the convergent validity of gamification was also confirmed. As the CR value for all variables was higher than 0.7, the variables' reliability was confirmed. Finally, Table 3 confirms the discriminant validity of the construct as each value of the

Characteristics		Loadings	α	AVE	CR	Results
Exploration	EXPL_1	0.818	0.737	0.656>0.5	0.851> 0.7	$\sqrt{AVE}$> correlation between constructs
	EXPL_2	0.859		⬇	⬇	⬇
	EXPL_3	0.748		Convergent validity	Reliability	Discriminant validity
Guidance	GUI_1	0.796	0.760	0.583>0.5	0.848>0.7	$\sqrt{AVE}$> correlation between constructs
	GUI_2	0.788		⬇	⬇	⬇
	GUI_3	0.723		Convergent validity	Reliability	Discriminant validity
	GUI_4	0.744				
Gamification	GAM_1	0.606	0.733	0.432 <0.5	0.819>0.7	$\sqrt{AVE}$> correlation between constructs
	GAM_2	0.658		⬇	⬇	⬇
	GAM_3	0.651		Conditional Convergent validity*	Reliability	Discriminant validity
	GAM_4	0.721				
	GAM_5	0.585				
	GAM_6	0.711				
Social control	SOC_1	0.838	0.574	0.702 > 0.5	0.825>0.7	$\sqrt{AVE}$> correlation between constructs
	SOC_2	0.838		⬇	⬇	⬇
				Convergent validity	Reliability	Discriminant validity
Formal control	FOR_1	0.802	0.624	0.575 > 0.5	0.802>0.7	$\sqrt{AVE}$> correlation between constructs
	FOR_2	0.776		⬇	⬇	⬇
	FOR_3	0.693		Convergent validity	Reliability	Discriminant validity

Note(s): * As CR is more than 0.7, convergent validity has been confirmed (Fornell and Larcker, 1981)

Table 2. Results of validity and reliability

construct correlation is less than the square root of AVE (Fornell and Larcker, 1981). Table 3 also presents all variables' means, standard deviations and correlations. These results indicate support for the hypothesized relationships.

5.2 Hypothesis testing

Table 4 presents the results from regression analysis (conducted with IBM SPSS Statistics 26) regarding the effects from digital-twin characteristics on social and formal control. The base models are presented in Table 4, in which Models 1a and 1b include only the control variables. Models 2a and 2b show the direct effects from digital twins' characteristics on the dependent variables, i.e. the use of digital twins. Both models, which considered social control and formal control, are significant at the $p \leq 0.001$ level ($R^2 = 0.27$ and 0.21). Coefficients of exploration ($p \leq 0.01$) and gamification ($p \leq 0.01$) are positive and significant for social control, but guidance's effect on social control is insignificant. Thus, the results provide support for Hypotheses 1a and 1c, but not 1b. Exploration ($p \leq 0.01$) and guidance ($p \leq 0.05$) positively and significantly affect formal control, but gamification's effect on formal control is insignificant. The results support Hypotheses 2a and 2b, but not 2c.

These findings indicate that digital twins can be used efficiently for social control if they have high levels of two characteristics: exploration and gamification. Guidance is not that relevant in social use, and if digital twins are used for formal control, they should have exploration and guidance characteristics. Gamification is not that relevant in formal use.

Table 3.
Correlation matrix

	Mean	St. Dev	1	2	3	4	5
1 Exploration	5.23	1.22	0.810[a]				
2 Guidance	4.80	1.25	0.473[***]	0.764[a]			
3 Gamification	4.08	1.06	0.406[***]	0.339[***]	0.657[a]		
4 Social control	3.15	0.62	0.422[***]	0.285[***]	0.371[***]	0.838[a]	
5 Formal control	3.13	0.62	0.384[***]	0.331[***]	0.210[*]	0.489[***]	0.758[a]

Note(s): [a] Square root of AVE, Sig. [***] ≤ 0.001, [**] $0.001 < p \leq 0.01$, [*] $0.01 < p \leq 0.05$

Table 4.
Regression results

Dependent variables	Social control				Formal control			
	Model 1a		Model 2a		Model 1b		Model 2b	
Independent variables	β	Std. error	β	Std. error	β	Std. error	β	Std. error
Controls								
Age	0.006	0.005	0.002	0.004	0.006	0.005	0.002	0.005
Gender	0.108	0.109	0.151	0.098	0.123	0.109	0.140	0.102
Main effects								
Exploration			0.139[**]	0.046			0.150[**]	0.048
Guidance			0.068	0.045			0.104[*]	0.047
Gamification			0.147[**]	0.049			0.009	0.051
Model summary								
F	1.162		9.569[***]		1.273		6.844[***]	
R^2	0.018		0.275		0.019		0.214	
Adjusted R^2	0.002		0.246		0.004		0.182	

Note(s): Sig. [***] ≤ 0.001, [**] $0.001 < p \leq 0.01$, [*] $0.01 < p \leq 0.05$

6. Discussion

This study examined the effects from the use of digital twins on organizational controls in terms of social and formal control. The effects were studied through the three digital-twin characteristics, namely exploration, guidance and gamification. The results are based on the real-life and professional experiences of 139 applied university students in technology and business. The selected approach can be viewed as novel, as most previous discussions and research on organizational controls have focused on examining management accounting systems and their effects on people's behavior (Malmi and Brown, 2008; Bedford and Malmi, 2015). The study's findings highlight how using digital twins positively affects both social and formal controls. Thus, this supports Bredmar's (2017) notion that the digitalization debate and agenda around advanced information systems and technologies need to be developed, along with a deeper understanding of how the organizational control function has evolved and changed in scope through these systems and how digital initiatives, such as digital twins, affect organizations. The present study's main findings are discussed below.

Referring to social controls (H1), exploration and gamification significantly affect social controls positively, but no significant effect from digital twins' guidance aspect was found. Several factors might explain this result. First, it seems that real-time reflection in virtual spaces enables various experiments, discovering and problem solving, i.e. exploration (Tao *et al.*, 2019a,b; Qi *et al.*, 2021), which provides learning possibilities for humans dealing with digital twins, further allowing them to operate in their comfort zones in terms of beliefs, norms and shared values (Ouchi, 1979; Schein, 2004; Johnstone, 2018). Second, the findings highlight digital twins' gamification aspect, suggesting that the use of digital twins may include role-playing, digital games and competition elements (Hall *et al.*, 2020), which affect creativity, innovation, enjoyment and learning (Carvalho *et al.*, 2015; Baptista and Oliveira, 2019) and allow individuals to operate in their comfort zones further in terms of beliefs, norms and shared values. Third, the use of digital twins for guidance purposes seems to be problematic when considering the effects on social controls. In line with Johnstone (2018), the interpretation can be that the aspect of guidance pertains more to individual organizational actors' values than a reflection of guiding organizational values. Based on the findings, it is likely that guidance is viewed as a restrictive action that can hinder its ability to use digital twins to exert social control. A digital twin is a systematic method created through mathematical algorithms, but social control concerns people's beliefs, which is non-systematic and can develop and change over time. Thus, pursuing social control, which is tacit and implicit, with digital twins is not efficient or relevant.

Referring to formal controls (H2), exploration and guidance significantly affect formal controls positively, but no significant effect was found from digital twins' gamification aspect. Several factors can explain this result. First, it seems that digital twins can utilize technologies through their modeling, visibility, flexibility, responsiveness, integrity and automaticity characteristics (Min *et al.*, 2019; Oh and Jeong, 2019), which enable discovery through curiosity and exploration. This type of exploration, in turn, affects formal controls in terms of predictability, efficiency and decision-making and can be viewed as an influential option for operational excellence and production-control optimization (Min *et al.*, 2019). Second, regarding digital twins' guidance aspect, it seems that digital twins may enable more leadership functions in terms of task and resource allocation, planning and performance feedback (Wesche and Sonderegger, 2019) that, in turn, affect formal controls and their outcome targets. This positive effect may be due to more accurate and reliable data that advanced technologies produce. Third, it seems that digital twins' gamification aspect does not affect formal controls like it does with social controls. Gamification involves many degrees of freedom and does not necessarily contain specific outcome targets, which often are required in formal controls (Stouthuysen *et al.*, 2017). As formal control relies on established, formal practices, it may even be in conflict with gamification.

Using a student sample provides a novel perspective for the results, as students can be viewed as early adopters of digital twin usage, with respondents having used digital-twin solutions actively. Using them to study the use of digital twins as part of management practice is reasonable, as they are likely to set requirements for sophisticated technologies in their future working careers as well. Finally, it is possible that the reason for digital twins' positive impacts on both social and formal controls is tied to more advanced and sophisticated market technologies. Thus, this study supports the notions that advanced technologies not only assist managers but also direct their decision-making (Min *et al.*, 2019; Oh and Jeong, 2019; Wesche and Sonderegger, 2019), as well as operate as partners for decision-support systems that enable complex analyses and interpretations (Brynjolfsson and McAfee, 2014; Lisboa and Taktak, 2006; Richards *et al.*, 2019; Wesche and Sonderegger, 2019).

7. Conclusions

Even though increased digitalization as a phenomenon has been noted in organizational control studies, research on digital twins as control mechanisms mainly has been lacking. This study examined the relationships among digital twins' characteristics and organizational control. This study contributes to contemporary literature on organizational control by considering digital twins' multiple characteristics and their contribution to two different control outcomes. The digital twins' characteristics were studied through three characteristics: exploration, guidance and gamification. The control outcomes were examined by considering two different forms: social control and formal control. The study's results were based on an analysis of survey results from 139 respondents comprising applied university students.

The findings from the regression analysis indicated that digital twins can be used efficiently for social control if they have high levels of two characteristics – exploration and gamification – and for formal control if they have exploration and guidance characteristics. The study's specific theoretical and managerial contributions are summarized below, along with suggestions for future research and the study's limitations.

7.1 Theoretical implications

From the theoretical implications perspective, this study contributes to extant research in the following ways.

First, the study is the first to examine digital twins' effects from an organizational control perspective systematically. Thus, this study increases the theoretical understanding of the increasing role of digital twins in society. While there exists a growing theoretical interest in the adoption and utilization of digital twins, studies from a managerial perspective on the phenomenon are rare. A theoretical understanding of the role of digital twins as organizational control mechanisms is especially lacking. This study's results significantly contribute to the organization control literature by increasing the understanding of digital twins as a control mechanism. While extant organizational control studies' focus has been on more traditional control mechanisms, such as performance measurement systems, the future of that research stream also will be shaped by increased digitalization. For instance, advanced digital technologies such as digital twins can be used for organizational control in such a way that they use digital replication of a specific decision in a certain situation to understand how that decision would respond to that exact situation. Then they can decide to continue or quit that decision. This would provide agility and enable a fast response by the organization and help it to be efficient in organizational control. As such, this study provides an interesting theoretical understanding of digital twin characteristics and their effects.

While the utilization of digital twins in different types of organizations is growing, theoretical understanding about their utilization is needed, not only from technical or operations optimization perspectives. Digital twins affect people's behavior in different ways, and this study demonstrates their effects from the organizational control perspective.

Second, this study diverges from previous technical-oriented research by investigating digital twins in a human context. Previous studies, for example in the field of operations management, have largely ignored the digital twin characteristics that affect peoples' behavior. As such, this study increases the theoretical understanding of digital twin characteristics on human behavior by considering the multiple digital-twin characteristics and investigates their contribution to two different uses of digital twins: social and formal control. In addition to highlighting the need to study digital twins from the organizational context perspective, the results demonstrate the importance of various digital-twin characteristics. Two of the studied characteristics, exploration and gamification, affect the extent to which digital twins can be utilized for social control. However, guidance is not that relevant in social use. Exploration and guidance's role is significant for the extent to which digital twins can be utilized for formal control, whereas gamification's role is insignificant. The presented consequences of using digital twins can guide further studies by offering precepts on how digital twins can be understood and managed in human settings.

7.2 Managerial implications

From a managerial implication perspective, this study shows that while the utilization of digital twins is increasing and advanced solutions are being adopted by different industries, digital twins should not only be considered from a technical approach. One important managerial contribution of the study is increasing the understanding that digital twins will affect organizational control mechanisms in the future, whether or not organizations want them to. While it is important for organizations to understand that digital twins will affect organizational controls, it is even more essential to understand how they will affect them. As such, this study shows which characteristics managers should take into account when using digital twins for organizational control, specifically social and formal control. Managers who are involved with management control systems should consider the important role of digital twins in organizational control and utilize this type of information system (digital twin–based) as part of a management control system to make precise decisions and improve performance.

Moreover, managers can leverage these research findings when introducing new digital tools for management purposes. Furthermore, using this study's results, managers can enhance their companies' digital transformation by acknowledging digital twins' multiple facets, thereby promoting utilization of these tools for business development and management needs. While digital twins are designed and implemented in different contexts and for different purposes, there is usually a huge number of characteristics available that all pay. As such, it would be important for digital twin users to understand more about their potential purposes and how different characteristics affect them. It does not make sense to invest in useless characteristics that do not impact use. For example, if a digital twin will be used for formal control purposes, it would not make sense to implement gamification characteristics, based on current research. Instead, attention should be paid to exploration and guidance characteristics. Likewise, if the digital twin will be used for social control purposes, guidance characteristics are not worth investing in heavily either.

7.3 Limitations and future research

This research has limitations that should be overcome through future research. *Digital twin* may be relatively new concept to many people, so its wide-ranging exploitation and possibilities are not fully understood. Our study also was limited to just three digital-twin

characteristics: exploration, guidance and gamification. Furthermore, this study did not examine user experiences on operational and management levels concerning how digital twins affect formal and social control in terms of digital twins' characteristics. Thus, using a student sample can be viewed as a limitation of this study. However, applied university students are thoroughly engaged in management practice through the nature of their studies, and the results are thus considered to provide a real picture of the topic under investigation. Therefore, although students are considered to be excellent informants for our study, the results need to be validated with other samples.

We also used a relatively small sample size, and 46% of the respondents were less than 25 years old, so the age distribution may have distorted the sample. Furthermore, respondents' gender and age may influence the use of digital twins because they may have different interests regarding content and functionalities. Finally, concerning the social control factor, Cronbach's alpha was below 0.60, i.e. its reliability could be questioned. Also, in the regression analysis, the missing data in some responses undermine the study's validity and reliability.

Thus, we recommend further real-life case studies on how digital twins could be used efficiently for social and formal control, as well as the mechanisms through which different digital twins' characteristics affect social and formal control. Also, a need exists to investigate digital twins' characteristics further to fully understand digital twins' possibilities and benefits from a business perspective. Thus, in the future, we could build an even deeper understanding of how digital initiatives, such as digital twins, affect organizations and organizational behavior.

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