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Lean and digital dimensions of organisational culture as antecedents of the intention to use Industry 4.0 technologies

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Abstract

Purpose of the paper: This study focuses on the potential synergies between a lean mindset and the attitude of employees towards digital transformation. On the one hand, lean philosophy and management rely on people to minimise waste and continuously improve processes by increasing efficiency, while on the other hand, digital transformation through Industry 4.0 technologies 'pushes' machines to mimic humans, paving the way for the assimilation of physical systems from cyberspace. In this context, organisational culture, with its multidimensionality, is considered a critical factor for the implementation of digital technologies, consisting of attitudes and behaviours, values and beliefs. This research aims to address those aspects of organisational culture that relate to lean principles and digital transformation, and to explore their possible impact on the ability of organisations to effectively adopt digital technologies.

Key findings: Two technology-related theories - socio-technical systems theory and the unified theory of acceptance and use of technology - are used to operationalise employee attitudes and behaviours, social influence and willingness to change. A review of the relevant literature led to a conceptual framework and a corresponding structural model, that link lean digital organisational culture with the 'intention to use' and the actual use of Industry 4.0 technologies. The constructs in the proposed framework can be used as variables in a measurement model to be empirically validated through a field study. The findings of this developing research aim to highlight the enablers and drawbacks of digital transformation, by providing a human perspective on the adoption and usage of Industry 4.0 technologies.

Practical implications: The integration of lean principles with digitalisation is at the epicentre of an ongoing quest to turn lean into a dynamic form of management by releasing its non-static "dormant" forces through live, "intelligent" adaptation of human-machine interaction

knowledge. In line with this research stream, the composed model is based on a novel form of lean-digital organisational culture hypothesised to act as the foundation for creating a positive organisational climate for enterprises to become both digitalised and lean concurrently. Furthermore, this conceptualisation combines – most probably for the first time – lean digital culture with the intention of employees to use new technologies using a widely accepted model. Thus, what is made possible is to empirically capture the level of pervasiveness of Industry 4.0 technologies within the organisational fabric.

***Type of paper**:* Research paper

1. Introduction

In the current age of the fourth industrial revolution, organisations need to keep up with the rapidly developing digital technologies. However, digital transformation entails more than allocating financial resources for new equipment and upgrading the facilities (Tabrizi et al., 2019). The infrastructure can only then be digitally transformed if the employees embrace 'the new' and accept to adopt. Apart from the benefits that accompany it, the application of new technologies brings challenges, many of which depend on the human factor and its resistance or even fear of possible changes that will disturb the work balance. The maturity of the employees and the leadership of organisations seem to play a decisive role in the success of their intended digital transformation. However, the context and factors influencing the degree of this maturity are still unclear.

This research recognises organisational culture as a critical success factor for digital technologies and sets lean and digital as its dominant dimensions. In an effort to understand the significance of people-related challenges, a concept called sociotechnical blindness was introduced to reflect the limited understanding and control over industry 4.0 technologies that may lead to anxiety and fear of any unknown ramifications (Kaya et al., 2022). In this line of thought, the theory of Socio-Technical Systems (STS) and the Unified Theory of Acceptance and Use of Technology (UTAUT) are used in this research framework to operationalise parameters related to the internal characteristics of employees, such as attitudes and beliefs, social influence, and willingness to change (Pasmore et al., 2019; Venkatesh et al., 2003). The interpretation of users' attitude toward digital technologies is expected to unveil how the mindset of employees toward lean and digital practices may affect the way people address the new technology challenges (Tissir et al., 2023). Understanding this psychological background of digital transformation is of primary importance to enable leaders create the necessary conditions for a smooth transition.

Following this line of reasoning, the remainder of this paper presents a literature snapshot on digital and lean synergies, the digital and lean dimensions of culture, the historical evolution of the models that have drawn on the theories of technology acceptance, ending with a conceptual model. The implications and expected outcomes of this research are discussed in the concluding section.

2. Literature review

2.1 Digital and lean synergies

Research on the synergies of lean management and Industry 4.0 digital technologies is at an early stage. The literature review indicates that integrating lean management principles with Industry 4.0 technologies can bring significant operational benefits and improve the performance and sustainability of businesses and organisations (Buer et al., 2021; Vinodh et al., 2021). One of the few relevant empirical studies identifies two patterns of digital

transformation: sustaining and disruptive. The first pattern consists of incremental and horizontal culture-oriented digital changes characterized by people's participation and achieving continuous process improvement, while the second consists of few and highly disruptive and radical changes (Rossini et al., 2021).

The digital transformation, accelerated during Covid-19, revealed the need to move from a just-in-time production logic to a 'dynamic' resilience - 'just in case' rationale (Meyer & Schwarze, 2021). Similarly, the supply chain perspective has shifted to a digitally supported balance between supply and demand, maintaining safety stocks and just-in-time production (Brakman et al., 2020; Schaupp, 2022). Proponents of lean thinking are refocusing on the effectiveness of lean management, with an emphasis on streamlining rather than eliminating inventory (Milewski, 2022).

Duerr et al. (2018) draw on the organisational culture model by Edgar Schein (1985) and explore the artefacts, the espoused beliefs and values, and the underlying assumptions of digitalized companies and define digital organisational culture as the motivation for firms to transform. Digital transformation calls for positive intelligent automation behaviours paired with creative thinking, empathy and intuition (Yu et al., 2022). Drawing on socio-technical system theory, industry 4.0 technologies moderate the relationship between lean alike socio-technical practices and performance in terms of workers' health, quality, and productivity (Tortorella et al., 2022).

As lean management relies heavily on people (respect for people is a key lean principle), there is a risk that Industry 4.0 technical solutions that have not integrated lean philosophy will lead to implementation failures in terms of both productivity and job satisfaction (Adrian et al., 2020). In addition, autonomy is one of the principles of lean management that fits well with unmanned vehicles or other similar Industry 4.0 advancements. Furthermore, lean philosophy is anchored in decentralized control that provides autonomy to employees, with an emphasis on simplicity and transparency (Buer et al., 2021). Following a similar development, traditional centralised IT systems are gradually being replaced by the decentralizing (distributed) technologies of Industry 4.0, such as the Internet of Things and cyber-physical systems (Buer et al., 2021).

It is widely accepted that lean thinking can tackle complex management problems effectively and efficiently. The ultimate goal of Industry 4.0 technologies to connect people and machines is, by definition, an extremely complicated endeavour. In this context, lean-digital synergies can address complexity and improve performance (Tissir et al., 2023). Surprisingly, one of the pillars of lean, jidoka - a machine with human intelligence - somehow assimilated artificial intelligence (AI) long before it emerged. AI can act and react as Andon, in an integrated form of lean digital warning systems, providing operators with timely information that could only be guessed at before the advent of AI (Liker, 2020). The successful lean principle of empowering workers and treating them with respect as people - not as machines that merely produce goods - can be applied to Industry 4.0 technologies, where machines 'behave' as people.

The rapid development of Industry 4.0 applications, such as artificial intelligence, is causing stress for workers, and the way they respond will affect the success of adopting these new

technologies (Zhu et al., 2021). Organisational culture is critical to developing new systems and implementing creative and innovative technologies (Frisk & Bannister, 2017). Evidence suggests that different dimensions of culture influence attitudes and behaviours toward information security (Aseeri & Kang, 2023). Digital transformation is successful in organisations whose leaders have gone back to basics: focusing on changing the mindset of their members, or otherwise the organisational culture, before deciding which digital tools to use and how to use them. In other words, for digital transformation to be proven successful, it is the future that members envision for their organisation that drives the technology - not the other way around (Tabrizi et al., 2019).

2.2 Lean culture

Lean culture was first identified in Toyota where lean philosophy was developed. Nevertheless, there is a dearth of measurement efforts of this culture. What remains underinvestigated is the beneficial impact of smart technologies on peoples' physical and psychological working environment, and their organisational behaviour, in turn (Gaiardelli et al. (2019). Lean management has long been considered as a sociotechnical system (Paez et al., 2004). The fourth industrial revolution brought machines and humans closer than ever before (Vinodh et al., 2021). One of the major barriers to the effective implementation of I 4.0 technologies is the lack of understanding of the interplay between technologies and human beings (Stentoft et al., 2021). Following this line of thought, this study draws on the sociotechnical systems theory to delve into the synergies of lean and digital mechanisms.

The socio-technical systems theory (SST) originally formulated by Trist and Bamforth (1951) aimed at improving work performance focusing on how employees tackle technological difficulty and uncertainty in an effective manner (Yu et al., 2022b). In the following decades the approach failed to spread due to the reluctance of leadership to bestow greater autonomy to the employees. Nowadays, SST has become more relevant than ever, since artificial intelligence and other I4.0 applications have brought to the business foreground the human-machine interaction challenge (Pasmore et al., 2019; Yu et al., 2022b).

Paro and Gerolamo (2017) have drawn on the four-dimensional interpretation of organisational culture (adhocratic, hierarchical, market and clan) and have adopted the Competing Values Framework (Cameron and Quinn, 2006) that uses the Organisational Culture Assessment Instrument (OCAI) survey as a method of data collection. OCAI questionnaire consists of six assessment items: dominant characteristics, organisational leadership, management of people and employee, organisational glue, strategic emphasis and criteria for success (Paro and Gerolamo, 2017).

2.3 Digital culture

Organisational culture is often underlined as an important factor in the adoption of technologies yet challenging since it takes a long time to thrive (Yu et al., 2022). Duerr et al. (2018) have drawn on Schein's interpretation of organisation culture as a multi-level concept consisting of artefacts, espoused values and beliefs, and underlying assumptions and composed an evaluation scheme of digital organisational culture (see Table 1). Aseeri and Kang (2023) proposed a data-

oriented organisational culture: the responsiveness to accepting new big data analytics technological improvements and the ability to adapt to emerging technological improvements associated with big data security and quality. Several studies have used a four-item scale to measure digital culture that entails clear orientation, natural process evolution, collaboration and sharing (Zhen et al., 2021).

Table 1. Digital organisational culture in terms of artifacts, values & beliefs, and underlying assumption – Source: Own elaboration based on Duerr et al. (2018)

Digital organisational culture	
Artifacts	
What can be observed, felt, and heard when an individual enters a new culture	
Cross-functional teams	Product development employees are mingled with IT employees in cross-functional teams to combine the skills and capabilities to integrate 'digital materiality' into non-digital products and the know-how to handle digitalized products.
Physical and virtual collaboration	The office space has been restructured with the elimination of isolated departments and the creation of space where everyone sits together.
	Teamwork happening virtually is equally important to teamwork happening in the office without walls.
Dual structures	There is a balance between digital innovations and development of the core business.
Collaboration with startups	Our firm collaborates with startups to accelerate innovation.
Platforms with partners and competitors	We use platforms to ensure the sharing, transparency, and integrity of data.
	We see platforms as a way for open exchange where our products / services can be *tested and refined*.
Customer integration	Customers and firms are developing products jointly ('co-creation').
Values and Beliefs	
The espoused goals, ideals, norms, standards, and moral principles that can be captured through interviews and questionnaires	
Startup mentality	Colleagues can come up with something completely different.
	Employees show bravery to try out new things.
Failure culture	Employees are encouraged to test risky ideas without being sanctioned, to motivate employees to try out new things and come up with novel solutions.
Embracing digital skills	The required skill set has changed, demanding new skills and an open mindset to digital technology.
	The employees have capabilities that are no longer needed.
Power equality	The roles are clearly assigned but employees are all allowed to contribute in a structured way.
	Power has moved towards the middle and lower management and is less concentrated on top.

	Each employee can make improvements.
Mutual decision-making	Departmental decisions are now made jointly.
IT as a business creator	IT unit or department is now more than a service provider.
	IT is playing a crucial role in decision-making.
Underlying assumptions	
Phenomena that are often taken for granted and not recognised – remain unexplained when insiders are asked about OC values. Information is gathered by observing behavior carefully	
Increasingly demanding digital customers	We feel a pressure from demanding customers who request the affordances of smart, connected products.
Necessity for increased agility	We need improved agility to react faster to changes and to protect ourselves from faster competitors.
Perceived need for digital skills	We are lacking skills needed for digitalization, and, even worse, often digital talents favor hip competitors.
Buoyant integration of IT into innovating	We need to understand IT and its employees as an integral part of the product we sell.

2.4 Technology acceptance

For the purpose of this study, literature was reviewed to identify links between technological evolution and people within organisations. The concept of technology adoption/acceptance emerged as a prevalent topic (Venkatesh et al., 2023). Venkatesh et al. (2003) identified eight prominent technology acceptance models. According to the theory of planned behavior, behavioral intention is determined by the attitude towards behavior, subjective norms, and perceived behavioral control (Ajzen, 1991). Following the technology acceptance model, perceived usefulness and perceived ease of use define attitude toward using. All acceptance models are based on a sequence of users' or potential users' attitudes and behaviors. The individual reactions to using technologies affect the intentions of people to use those technologies, and their actual use, in turn.

Numerous researchers use the Unified Theory of Acceptance and Use of Technology (UTAUT) model that lends an integrative view to user acceptance of new systems and technologies (Gupta et al., 2008). According to the theoretical foundation of the model, performance expectancy, effort expectancy and social influence define behavioural intention to use a system or technology, while the intention to use determines the actual usage (Venkatesh, 2003; 2012). *Performance expectancy* reflects the expected benefits accrued from the adoption and consequent use of the relevant technology. In the particular research context, it can measure the extent to which employees believe that using industry 4.0 technologies will help them fulfil their work goals and improve their performance. *Effort expectancy* reflects employees' perception of the challenges they may encounter when using digital technologies in their working environment. *Social influence* reflects employees' perceptions about what other stakeholders, such as their colleagues and managers, believe about them and their work. The facilitating conditions refer to allocating resources for the use of new technologies at work. In addition, gender, age, experience, and voluntariness of use are often considered moderating factors. The *intention to use* reflects the extent to which the employees intend or continue to

use industry 4.0 technologies in their work. The *use of technology* reflects the actual usage of digital technologies in terms of duration, frequency, and intensity (Venkatesh et al., 2008; 2012).

Over the years, the UTAUT has evolved to include more factors, such as *anxiety* and user *resistance* (Hoque & Serwar, 2017). Users of new systems or technologies feel anxious about losing control over their regular work activities and decision-making processes, and they resist the change that new technologies can bring about (Donmez-Turan, 2020). At a more intense level of anxiety, users of digital technologies fear being replaced by artificial intelligence or other digital advancements (Wang & Wang, 2022). Furthermore, hedonic motivation (enjoyable technology) and price value ("value for money") have been integrated into the original model as factors potentially influencing behavioural intention to use new technologies (Nordhoff et al., 2020; Venkatesh et al., 2012; 2016).

Certain UTAUT studies were motivated by the importance of soft, non-technical factors, such as culture (Dasgupta & Gupta, 2019), charismatic leadership (Neufeld et al., 2007), and team climate for innovation on technology use (Liang et al., 2010). Dasgupta and Gupta (2019) have focused on espoused organisational culture values and their potential influence on the employees' intention to use information systems. They drew upon Schein's multilayer approach, according to which culture builds upon artefacts, norms and values, and underlying assumptions, and composed a measurement scheme of culture based on the four-dimensional model of Denison and Mishra (1995). This last model interprets organisational culture in terms of adaptability, involvement, mission, and consistency (Table 2)

Table 2. Organisational culture in terms of adaptability, involvement, mission, and consistency – Source: Own elaboration based on Denison and Mishra (1995)

Cultural component	Statement
Involvement	Most people in this company have input into the decisions that affect them.
	Cooperation and collaboration across functional roles is actively encouraged.
Consistency	There is a high level of agreement about the way that we do things in this company.
	Our approach to doing business is very consistent and predictable.
Adaptability	Customers' comments and recommendations often lead to changes in this organisation.
	This organisation is very responsive and changes easily.
Mission	This company has a long-term purpose and direction.
	There is a shared vision on what this organisation will be like in the future.

3. Conceptual model – Structural model – Research hypotheses

Based on the existing theoretical and empirical background, this study seeks to operationalise two dimensions of organisational culture, oriented towards lean management and digital transformation, in the belief that these two dimensions - whether combined or independent - can promote the adoption of digital technologies. In other words, this study aims to identify the possible synergies of these two culture dimensions on the diffusion of Industry 4.0 technologies in organisations. The conceptual framework (Fig. 1) of the proposed research brings together, for the first time, the binary form of lean-digital culture with the UTAUT model.

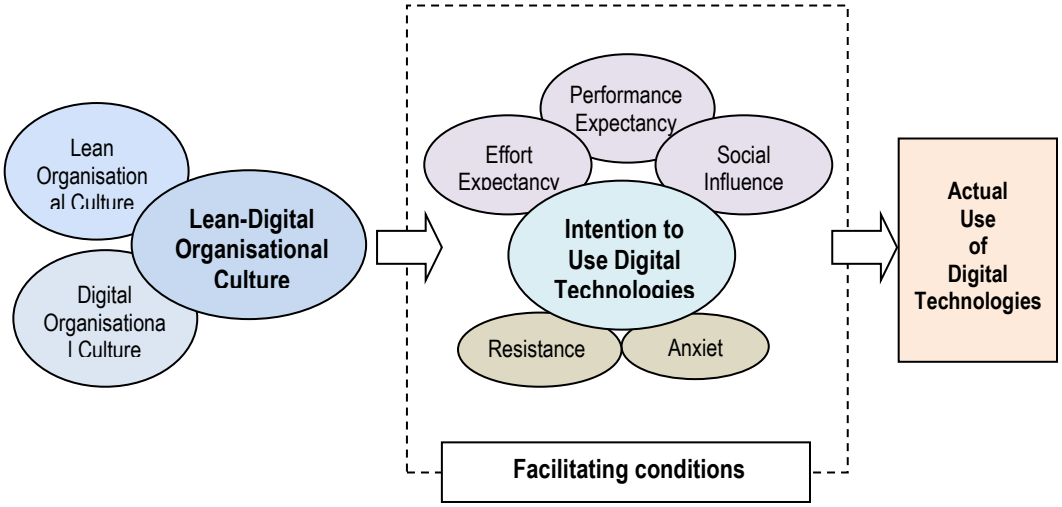

Figure 1. Conceptual framework

Cultivating a lean digital mindset is expected to increase the intention to use and, in turn, the actual use of digital technologies. Based on some of the most recent studies on UTAUT, the composed framework included two constructs that are negatively related to employees' intention to adopt and use Industry 4.0 technologies: anxiety and resistance to change. Once the constructs have been identified and compiled, a structural model can be created to incorporate certain hypothesised relationships. (Fig. 2).

4. Scientific and societal impact - Expected benefits

This research focuses on people, highlighting lean and digital culture as a critical success factor for the adoption of digital technologies. Through a literature review, the unified theory of acceptance and technology use, combined with the socio-technical systems theory, led to the synthesis of a conceptual framework in which the dimensions of lean and digital organisational culture are integrated. A field study can use this framework to measure the impact of lean-

digital organisational culture on the acceptance and the usage of digital technologies in business environments.

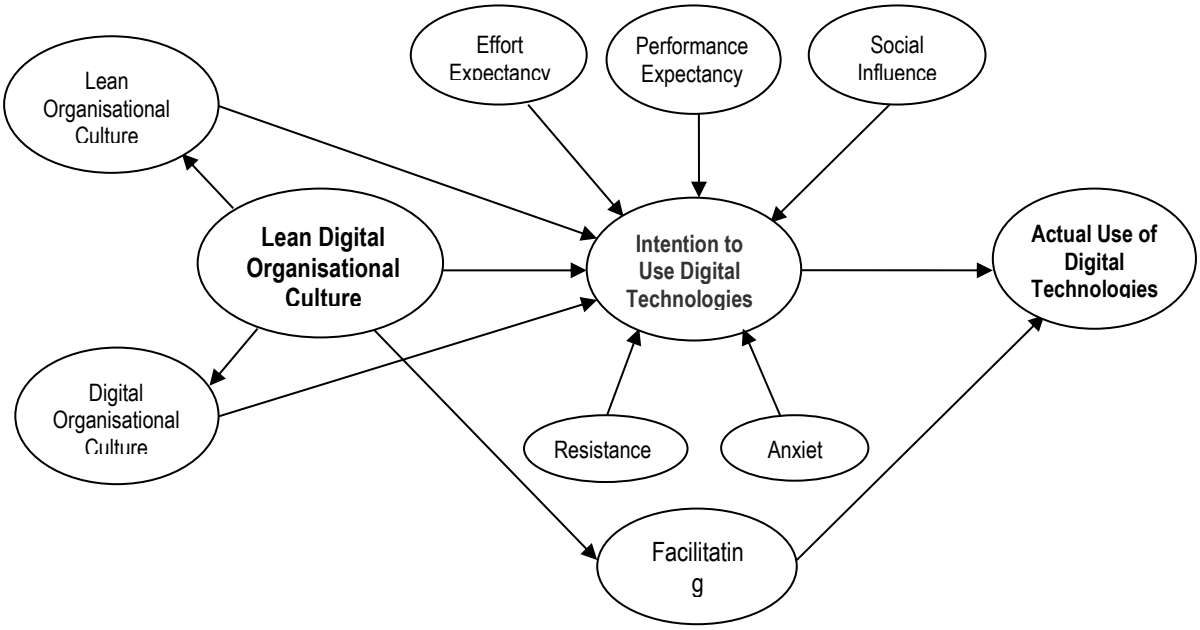

Figure 2. Structural model

The empirical validation of the proposed paths is expected to highlight the factors that either facilitate or hinder the adoption and use of digital technologies. Cultivating a work environment where lean principles go hand in hand with digital transformation activities, is expected to empower employees in their efforts to adopt Industry 4.0 technologies, by overcoming any reservations or shortcomings. This behavioural, people-centred approach will contribute to the effective adoption of digital technologies by organisations. Leadership could use the findings to foster an environment of positive response to change with employee engagement.

4.1 Research implications

The integration of lean principles with digitalisation is at the epicentre of an ongoing quest to turn lean into a dynamic form of management by releasing its non-static "dormant" forces through live, "intelligent" adaptation of human-machine interaction knowledge (Hoellthaler et al., 2018,2019; Raji et al., 2021a,b; Tissir et al., 2023; Uriarte et al., 2018). In line with this research stream, the composed model is based on a novel form of lean-digital organisational culture hypothesised to act as the foundation for creating a positive organisational climate for enterprises to become both digitalised and lean concurrently. Furthermore, this conceptualisation combines – most probably for the first time – lean digital culture with the

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