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Integrate or separate: lean and digitalization programs through the lens of boundary work management

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Abstract

Purpose – Although benefits are promising, many companies face problems leveraging synergies between Lean and Digitalization at the program management level. This paper aims to identify activities to manage the boundaries of Lean and Digitalization programs.

Design/methodology/approach – The research design follows a cross-industry multiple-case study approach. A total of 14 interviews were conducted with Lean and Digitalization experts from 10 companies. Interview quotes were mapped on a pre-defined list of descriptive codes and iteratively merged and excluded.

Findings – We identified 12 activities by which companies manage the boundaries of their Lean and Digitalization programs. Three distinct boundary management approaches could be identified: collaborative, configurational, and competitive. A collaborative approach fosters governance, the belief in synergies, and the development of combined artifacts. A configurational approach creates combined responsibilities, assesses areas of collaboration, and fosters interaction across the organization. A competitive approach creates unclear responsibilities and exchange, perceives no added value in integration and follows separated implementation of Lean and Digitalization programs.

Originality/value – This study sheds light on the boundaries of Lean and Digitalization programs and identifies activities to manage them. We derive propositions for the Lean and Digitalization program management. Moreover, this study positions itself at the forefront of research investigating how integration of Lean and Digitalization actually occurs or does not occur.

Keywords Lean, Digitalization, Industry 4.0, Integration, Improvement program, Boundaries, Case study

Paper type Research paper

Quick value overview

Interesting because – Lean and Digitalization are widely adopted approaches for process improvement. Lately, research on integration has acknowledged significant growth. However, mostly focused on the interplay between Lean practices and Digital technologies, current discussions lack implications for organizations as a whole. This study intends to resolve this gap by adopting a strategic program management perspective complemented by a boundary work lens.

Theoretical value – Both characteristics, integration and separation have been found across all program dimensions. Lean and Digitalization program boundaries in that regard are either enforced, managed, or downplayed. We developed six unique propositions outlining three distinctive boundary work types. We found that no company entirely falls into one specific boundary work type, but rather establishes various configurations across program dimensions. Moreover, this study concludes that collaboration and configuration are both needed for integration, while competition leads to the separation of Lean and Digitalization programs.

Practical value – This study provides guidelines for Lean and Digitalization program managers. The outlined activities, exemplary quotes, and propositions can be used to reflect on company-specific program configurations. Furthermore, this study helps to strengthen awareness about the program manager's role in actively managing integration at the boundaries of Lean and Digitalization programs.

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1. Introduction

Over decades, manufacturing companies have strived for process improvements to stay ahead of their competitors. Throughout this journey, they have adopted various approaches. This paper investigates two of the most widely recognized ones: Lean and Digitalization. Even though many perspectives exist towards Lean (Cusumano *et al.*, 2021), at its core, Lean puts customer value at the center and reduces waste through incremental improvements (Imai, 1986). Digitalization in the context of manufacturing, in contrast, relies on advanced developments in information technologies, often summarized by the term Industry 4.0 (Kang *et al.*, 2016; Buer *et al.*, 2018). Thereby, Digital technologies such as Internet of Things or Artificial Intelligence progressively find their way into manufacturing, aiming to increase performance levels (Frank *et al.*, 2019).

Although the interplay of Lean and Digitalization recently gained significant attention from research, the discussion about integration has been mostly conceptual (Kumar *et al.*, 2023; Narula *et al.*, 2023). On the one hand, a significant portion of theoretically driven research can be found in literature reviews (cf. Buer *et al.*, 2018; Bittencourt *et al.*, 2021). On the other hand, another portion of empirical research concentrates on the technical aspect of integration. In that regard literature focuses on pairwise comparisons between Lean practices and Digital technologies (cf. Ciano *et al.*, 2021; Cifone *et al.*, 2021; Pagliosa *et al.*, 2021). However, regardless of a broad theoretical consensus on the synergistic effect of Lean and Digitalization (Buer *et al.*, 2021; Lorenz *et al.*, 2019), literature falls short in discussing their relationship from a socio-technological perspective (Hines *et al.*, 2023; Marcon *et al.*, 2022). In particular, implications for the whole organization remain inconclusive (Agostini and Filippini, 2019; Ciano *et al.*, 2021; Rosin *et al.*, 2020; Tortorella and Fettermann, 2018; Yilmaz *et al.*, 2022). That is why Hines *et al.* (2023, p.14) emphasize that Lean and Digitalization literature, to this point, has not sufficiently focused on the integration within the "strategic, people and system/process area [...]". To address this research gap, we view Lean and Digitalization from a program management perspective as we investigate *how* their integration occurs.

This paper starts with a literature review of Lean programs, Lean practices, and the interplay with Digitalization. Furthermore, it introduces the concept of boundary work. After the description of the methodological approach, we present the results of the case study analysis. In the discussion section, we enfold our results in the theoretical foundation.

2. Theoretical background

2.1 Lean programs

Many companies have a Lean program (Netland, 2013). However, these are primarily adapted from what evolved over the years at Toyota (New, 2007). The Toyota Production System (TPS), with its practices and principles (see Shah and Ward (2007) for an overview), found its way into Western companies through the renowned book *The Machine That Changed the World* by Womack *et al.* (1990) (Samuel *et al.*, 2015). Womack *et al.* (1990) outlined practices and principles that eventually aim at continuously improving production in both an effective and efficient way. Since then, companies have tried to copy the success of Toyota with their interpretation of the TPS to increase their operational performance and eventually gain a competitive advantage (Netland, 2013; Netland and Aspelund, 2014).

Scholars (cf. Dombrowski *et al.*, 2017; Schumacher *et al.*, 2023) understand Lean programs as systems that are "structured into the hierarchic elements [of] goals, business processes, formal principles, methods and tools" (Dombrowski *et al.*, 2016, p. 608). In this paper, we view Lean programs as what Netland (2012, p. 31) defines as a "process improvement program", aligning with the perspective of Pellegrinelli (1997) that programs are infinite and thereby following a common perception in Lean research (e.g. Netland *et al.*, 2015; Hekneby *et al.*, 2022;

Powell and Coughlan, 2020). Lean programs can be described in three dimensions (Netland, 2012): content, process, and structure. The content refers to the practices and tools comprised in the program (Netland, 2012). These practices and tools, such as 5S or visual management, are, while similar in their essence, company-specific (Netland, 2013). The process of a Lean program relates to implementation activities (Netland, 2012). Researchers have found various implementation approaches from company to company (e.g. Bortolotti *et al.*, 2015; Boscari *et al.*, 2016). Typical implementation activities are employee training, maturity assessments, or management commitment (Netland, 2012). Lastly, the structure dimension comprises the organizational form of the program, namely corporate and site Lean teams (Netland, 2012). Yet, besides the sole set-up of the organization, the relationship between teams as well as their roles and responsibilities need to be considered as these determine how the teams work together (Boscari *et al.*, 2016). The combination of activities associated with the three dimensions expresses how Lean programs are managed (Netland, 2012).

2.2 Digitalization and lean practices

The scientific discussion on Lean and Digitalization can be summarized from three perspectives. The first perspective claims that Digitalization reinforces and enables Lean (Buer *et al.*, 2018; Lorenz *et al.*, 2019); the second perspective perceives Lean as the basis for further Digitalization (Buer *et al.*, 2018; Lorenz *et al.*, 2019; Pagliosa *et al.*, 2021; Rossini *et al.*, 2019) and the third perspective based on the aforementioned perspectives explicitly develops implementation frameworks (Rossini *et al.*, 2021; Hines *et al.*, 2023).

The first perspective is represented by research that examines how Digital technologies impact Lean practices (Cifone *et al.*, 2021; Rosin *et al.*, 2020). This literature stream comprises many research studies analyzing the interplay of Digital technologies and Lean practices (or tools), not programs, that demonstrate potential synergies to achieve higher operational performance (Narula *et al.*, 2023; Pagliosa *et al.*, 2021; Tortorella and Fettermann, 2018). For example, Narula *et al.* (2023) found that almost every Digital technology positively impacts Jidoka, Kanban, or work standardization. Following the second perspective, other researchers focused on developing mostly conceptual models describing how Lean practices may serve as a basis for Digital technology adoption (Ciano *et al.*, 2021; Cifone *et al.*, 2021; Tortorella *et al.*, 2021). For example, Cifone *et al.* (2021) demonstrated how the eight waste categories of Lean serve as a starting point for technology selection to eventually improve processes. Comparably, Bittencourt *et al.* (2021) argue that Lean thinking paves the way for successful Digital transformation. Lastly, within the third perspective, researchers outline the pathway of manufacturing companies toward Lean and Digitalization adoption (Ghobakhloo and Fathi, 2020). For example, Tortorella *et al.* (2021) identified three different phases (1. start-up, 2. in-transition, 3. advanced) presenting a step-wise approach in which related Lean practices and Digital technologies can be implemented.

2.3 Digitalization, lean programs, and boundary work

Even though the literature on the interplay of Lean and Digitalization proliferates complementarity and stresses integration, it remains superficial on how integration occurs. To address this gap, we take a program management perspective (content, process, structure), which resides for two reasons:

First, both convey the same goal: improving operational processes. Netland's (2012) definition points to the improvement of operational processes, which is also shared as one of the goals of Digitalization (Westerman *et al.*, 2014). Hence, both Lean and Digitalization are in line with Netland's (2012) definition of improvement programs. Second, as program management literature highlights that programs must be aligned and consolidated (Pellegrinelli, 1997), it provides a suitable perspective to investigate how companies

manage boundaries between Lean and Digitalization programs. Extant literature on Lean and Digitalization has mainly focused on the content dimension, investigating the combination of Lean practices and Digital technologies (Hines *et al.*, 2023). It falls short in paying attention to programs' process and structure dimensions. We will, therefore, focus on the programs and how they are managed. By investigating current Lean and Digitalization programs in the same company, we shed light on the "porous boundaries" of programs (Pellegrinelli *et al.*, 2007, p. 52).

To do so, we additionally make use of the well-known concept of "boundary work". Initially developed by Gieryn (1983), boundary work elucidated the discursive strategies used by scientists to establish clear demarcations between science and non-science domains. Since then, the concept has been applied to various levels of analysis, such as individual, group, organizational, occupational, or institutional (Langley *et al.*, 2019). In the past, scholars have taken a practice-oriented view toward boundaries (e.g. Kellogg *et al.*, 2006) and describe boundary work activities at change programs (Lehtonen and Martinsuo, 2008). In our research context, the concept of boundary work offers a valuable lens through which we analyze the intricate dynamics, tensions, discrepancies, and organizational implications that arise from the co-existence of Lean and Digitalization programs. In particular, we follow the differentiation conceptualized by Langley *et al.* (2019) who distinguish between three types of boundary work: collaborative, configurational, and competitive. The collaborative type ("work at boundaries") mobilizes and accommodates barriers, even though boundaries exist. The configurational type ("work outside boundaries") orchestrates the intersection, combining different ways to benefit from integration or separation. Lastly, the competitive type ("work for boundaries") seeks to separate the workforce and constructs barriers (see Figure 1).

To summarize, we argue that the boundary work concept is beneficial for our research goal. Furthermore, we reason that this concept helps to understand how integration at the boundaries of Lean and Digitalization programs does or does not occur. Accordingly, our research question is:

RQ How do companies manage the boundaries of Lean and Digitalization programs?

3. Methodology

As the topic, from our perspective, has not been investigated in depth, a multiple-case study design appears appropriate for our research (Eisenhardt and Graebner, 2007). The level of analysis addresses the organizational level, where, in particular, corporate improvement programs are investigated. This seems appropriate as most managerial challenges in improvement programs result from the production network (Netland and Ferdows, 2014).

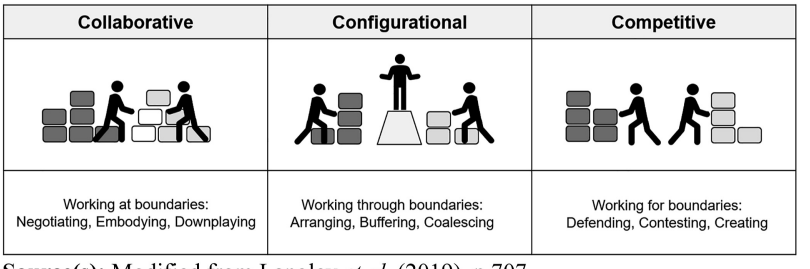

Figure 1.
Boundary work types

Source(s): Modified from Langley *et al.* (2019), p.707

3.1 Case selection

Based on our research question, we carefully selected our case companies. We applied purposive sampling (Bryman and Bell, 2015) and controlled the sample (Voss *et al.*, 2002). Three criteria were used to ensure that selected cases contribute meaningfully to the study results. These criteria were:

(1) *Diversity of cases*: In line with our explorative nature of research, we want to identify a relatively broad set of management approaches of Lean and Digitalization programs. That is why we consider various contextual factors, such as industry or company size.

(2) *Knowledge of key informants*: To improve the overall quality of the study, we controlled the level of knowledge of our interviewees. To ensure a certain level of knowledge, we controlled for years of experience and positions.

(3) *Engagement of participants*: To facilitate data triangulation, we ensured that study participants showed a certain level of interest in the topic. In that way, participants further provided material, e.g. company presentations. Also, by reaching out via e-mail, we explained the study's goal and aligned if participants were willing to share insights prior to our interviews.

In total, we studied ten different cases (see Table 1). Each case company fulfilled the three criteria above. Although our study is cross-industry in nature, the majority of cases stems from the pharmaceutical industry. However, due to the following reasons, we claim that our findings have implications across industries. First, the sample is well distributed regarding production system characteristics (Dittfeld *et al.*, 2022). Six companies fall in the category of process industries, whereas four companies follow discrete manufacturing procedures. Second, the sample is represented by various production and planning approaches ranging from Make-to-Order, Make-to-stock, Assembly-to-order, and Engineer-to-order. Third, as we diversified the pharma sub-sample itself (e.g. different business types such as generics, brand, and contract manufacturers), pharma peculiarities are less pronounced and, thus, less influential on the entire sample. Collectively, these considerations underline the broader applicability of our results beyond the pharmaceutical sector and suggest valuable insights for practitioners and researchers in different industrial contexts.

3.2 Data collection

Our primary data source was grounded in semi-structured interviews, which are a suitable source of evidence for the explorative nature of the study. On the one hand, semi-structured interviews (see appendix for interview guideline) can be flexibly targeted to the studied phenomenon and, on the other hand, provide rich explanations of its complexity (Yin, 2009). To improve construct validity (Yin, 2009), we conducted a test interview and revised the initial version of the interview guideline. We interviewed several key informants with a background in Lean and Digitalization to mitigate a bias towards one perspective. To increase internal validity, two researchers conducted each of the interviews (Eisenhardt, 1989). Interviews were audio-recorded and transcribed after consent from interviewees. After each interview, we conducted a debriefing session to discuss the observations among the researchers. Moreover, we relied on case study protocols written down during the interviews. These protocols were further used to create summary reports, which eventually became a further source of data, increasing the reliability of our research (Voss *et al.*, 2002). We used company internal documentation from recent research engagements to triangulate interview data. The interviews were conducted in German and English based on the interviewees' mother tongue to ensure precise answers.

Case/ #Interview	Interview (min)	Key Informant/#Years of experience	22 Revenue (B€)	# Employees	Industry
A/1	47.13	Head of Technical Operations Digital Excellence/~20 Program Lead and Digital Manufacturing/~15	1.7	2,300	Pharma
A/2	45.25	Operational Excellence Manager/~5			
B/1	49.07	Head of Kaizen/~20	1.9	10,000	Mechanical Engineering
C/1	44.13	Head of Digitalization and Projects/~15	0.15	600	Chemical
D/1	41.00	Director Production Data Analytics/~10 Director Value Chain Management and OPEX/~15	4.2	21,500	Mechanical Engineering
E/1	35.23	Head of Lean Digital/~15	45	83,000	Pharma
E/2	57.43	Head of Lean Digital/~15			
F/1	45.54	Project Manager Technical Engineering/~2 Senior Production Manager/ ~10	3.4	16,500	Medtech
G/1	49.33	Site Head and Managing Director/~13	37.7	100,000	Pharma
G/2	54.57	Global Program Lead Transformation/~13			
H/1	52.25	Operational Excellence Senior Manager/~12	0.25	2,000	Pharma
H/2	53.40	Central Operational Excellence Director/~10			
I/1	23.05	VP, Head of Production System and Smart Manufacturing/~20	29.3	90,000	Pharma
J/1	65.30	Strategy and Transformation Management, Industry 4.0 and OPEX/~12	3.3	7,000	Automotive

Table 1. Overview of case study interviews and informants

Source(s): Authors work

3.3 Data analysis

The study's theoretical foundation served as the basis for the deductive coding process, which was also open to themes that emerged from the data (Miles *et al.*, 2020). We used the software *Atlas.ti* to analyze the interview data. The coding followed two distinctive steps. First, we deductively assigned the interview quotes to a pre-defined list of nine descriptive categories (Saldaña, 2021) based on Netland's (2012) program dimensions and Langley *et al.*'s (2019) boundary work types. Second, for each category, we iteratively consolidated and reduced the number of codes by merging and excluding initial codes (see appendix for coding tree excerpt). Several discussions between the researchers helped to derive the final codes. Moreover, enfolding our findings in the literature (Eisenhardt, 1989) improved the validity and quality of our emergent theory (Voss *et al.*, 2002).

4. Results

4.1 Case studies

Table 2 classifies the Lean and Digitalization programs of the researched companies along the dimensions of content, process, and structure.

Company	Structure	Content	Process
A	- Since 2018, introduction of technical operations team consisting of Lean, management, IT - Digital center of excellence as support and bridging function - Project management office to ensure governance - Project execution with Business and IT project manager ("Two in a box")	- Automatized Overall Equipment Effectiveness (OEE), Capability tracking, Augmented Reality applications, Digital problem solving and shop floor management, simulation tools for bottleneck identification - Comprehensive Lean concept	- Prominent placement of Lean program in the past +10 years; Digitalization programs have evolved separately; integration through top-down push - Stage-Gate Process to let bottom-up ideas emerge and governance through assessment panel - Management through project portfolio considering Lean maturity, Business Cases, and Roadmap alignment
B	- Since 2016, start with Digitalization in the Lean team; with increasing growth outsourced to IT as a staff unit - Cross-functional Smart factory team consisting of IT, Lean Management, Production head, and Technology Engineering - Steering Committee consisting of CEO and Division head - Lean Management with direct reporting to Division head	- Automatized OEE, Semi-Digitalized value streams, Manufacturing Execution System (MES), Digitalized machine park, strong emphasis on in-house developed solutions - Prioritized activities: Connected machines along value chain to improve process visibility, costing, or OEE-related KPI; Digitalization strongly driven through customer requests - Formalized Lean principles	- Lean program is not given top priority in medium-term planning and strategy - Digitalization issued at the highest level in the strategy - Prioritization of Lean-Digitalization activities takes place within the Smart factory team; meeting every month
C	- Direct reporting of Lean and Digitalization management to CEO - Core team Lean and Digitalization with some personnel being part of both core teams; Importance of process know-how of personal	- Automatized OEE, Low Code and Microsoft (MS) Power Platform, Digitalized machine park - Formalized Lean principles	- Lean culture established on the shop floor, Digital culture rather be found in indirect activities - Digitalization projects only if increased efficiency and effectiveness expected - Active Management of two project portfolios, one for Lean and one for Digitalization

(*continued*)

Table 2. Summary of program characteristics

Company	Structure	Content	Process
D	- Functional separation of Lean team and Digitalization team/ Smart Operations, but both are part of the central Industrial Engineering and thereby operatively combined	- Dashboarding and shop floor management, Digitalized machine park, image recognition in assembly and quality control, takt time analysis and AI support at the shop floor - Comprehensive Lean concept	- Started with Lean Program +15 years ago in a top-down approach - Started with Digitalization program in 2018 (at that time not linked to Lean, rather focus on IT architecture) - In 2022, a combined Lean-Digitalization Strategy was developed: Program Management for Digitalization is focused on implementation activities, whereas for Lean it is focused on governance and compliance with standards - Digitalization program helped to revitalize Lean program as mutual benefits have been identified - Cross-functional development of Lean-Digitalization Roadmaps and assessment of key processes across the sites, pilot site identification
E	- Since 2023, Cross-functional team with sponsors (Digital transformation office) - Intentional creation of positions that bridge Lean and Digitalization - Functionally separated teams	- Digital Problem solving, shop floor management and Digital tiers, smart logistics, advanced analytics, Of-the-shelf Digital value stream tool, Digital Lean capability training - Comprehensive Lean concept	- Strong basics in Lean capability building for +10 years (Lean leadership and citizen development) - Currently refinement of Lean-Digitalization strategy - Improvement potential of processes is always identified on the shop floor - Digitalization is considered as another tool, within the Lean toolbox - Heatmap assessment of tools distributed across the network, Smart factory conceptualization

Table 2. (*continued*)

Company	Structure	Content	Process
F	- No formally established structure for common Lean and Digitalization program	- MES in development - Formalized Lean principles	- No Lean strategy established, relying on project-based approach - No Digitalization strategy defined - Digitalization initiatives are partially discontinued after they have not been successful - MES project is steered through a committee and follows a typical IT project approach with regular sprints but is driven by production
G	- Global Lean team was staffed around Digitalization in 2016 - Until 2020, the Digitalization team and program were integrated into global Lean team and program; additionally, partnership was built-up with the IT legacy organization - IT legacy organization and Digitalization team were combined in a loose partnership creating competition - Since 2020, the Digital program was carved out of Lean team and program into a new Digital organization with own Chief Digital Officer - Recent creation of Lean-Digital Site Level responsibilities	- Automatized OEE, electronic batch records, Digital deviation management, Digital tiers, Bottleneck identification and cycle time tools - Comprehensive Lean concept	- Top-down driven Digital transformation and deployment of Digital Lean tools - Ideation phase for creation of Digital Lean took place in 2017 - Since then, feedback on MVPs was gathered and focus relied on self-guided implementation of Digital Lean tools - Implementation guides, tools to demonstrate potential of Digitalized processes, Smart factory conceptualization - Extensive assessment and implementation support from global transformation function for complex sites; self-guided implementation for non-complex sites - Synchronized transformation with Lean-Digital capability building and modifications in infrastructure - Identification of pilot sites

(*continued*)

Table 2.

Company	Structure	Content	Process
H	- Creation of a Digital department in 2019 integrating former IT, automation, and systems - Functional separation but specific collaboration between Lean and Digitalization teams in projects - Matrix with roles and responsibilities	- MES in development, Strong emphasis on in-house developed solutions - AI for FMEA, Digital tiers - Comprehensive Lean concept	- Observation of performance decline led to decision to start Digital transformation - Lean team contributed to and challenged Digital roadmap - Lean team to push for Digital solutions, which require a lot of work from Digital department
I	- Creation of a new role that integrates Production system responsibility and Smart manufacturing in 2021 - Creation of a cross-functional Steering Committee team	- Digital tiers, Advanced Analytics - Comprehensive Lean concept	- Current development of a combined Lean-Digitalization strategy - Create Buy-in into strategy as next step - Use case priority list
J	- No centralized Lean department - Creation of a smart factory team in 2022 - IT partly integrated into smart factory team	- Automation solutions, Digital tiers - Smart factory conceptualization - Formalized Lean principles	- Lean and Digitalization projects are only conducted if they are financed through external projects

Table 2. **Source(s):** Authors work

4.2 Case study analysis

We identified 12 activities by which manufacturing companies manage the boundaries of Lean and Digitalization programs (see Table 3). Four general findings have emerged: First, collaboration for most companies mainly happens within the structure and process dimensions. Second, configuration is essentially realized through the process dimension. Third, competition manifests through all three dimensions. And fourth, although a tendency towards collaboration or competition can be recognized in a few cases (e.g. company D or F), most companies do not follow a single boundary work type. Also, we could not identify activities that are exclusive to any particular group of companies in the sample. The identified boundary work activities are described in detail in the following section.

4.2.1 Structure. Collaborative approach - To work at boundaries, we noticed many cases organize Lean and Digital representatives in *cross-functional working groups*. The main goal of those groups is to create a platform for mutual understanding, communication, enhancement of ownership, and alignment of business needs. These working groups are equipped with decision-making powers defining governance structures and therefore play an essential role in the management of Lean and Digitalization programs. In addition, a few companies *integrate their Lean teams into Digital departments.* The manifestation of this phenomenon is explicitly evident through the spin-off of Lean resources, whose reporting lines shifted to within the Digital organization. The focus of these digitally-enclaved Lean teams has been on the technologically driven aspect of Lean transformations, as they were driving the development of Digital Lean practices early on. In that regard, Case G, B, and H mentioned that the first attempts to digitalize shop floor applications were made within the

	Structure	Content	Process
Collaborative	Creation of cross-functional working groups [A; B; D; E; H; I; J]	Mutual opportunity consideration for use cases and program elements [A; C; D; G; H]	Joint Definition or Refinement of Lean-Digital Strategies [A; B; C; D; E; G; H; I]
	Integration of Lean teams into Digital departments [B; G; H]		Closely aligned evaluation, design, and deployment of Digital use cases [A; B; C; D; E; G; H]
Configurational	Accountability creation with combined Lean-Digital responsibilities [C; G; H; I]	Coordination of content definition and content-responsibility allocation of Lean and Digitalization programs [B; D; E; F; G; H]	Management of Lean and Digitalization program stakeholders during strategy deployment [A; B; C; D; E; G; H; I]
Competitive	Generation of unclear responsibilities and structures [B; E; F; G; J]	Prioritization of program elements and technologies by Digital or Lean teams without considering their influencing effect on each other [A; B; D; F]	Separated Definition of Lean and Digitalization Strategies [A; B; F; G; H; J]
			Unaligned evaluation, design, and deployment of Digital use cases [B; G; H]

Source(s): Authors work

Table 3. Lean and digitalization program management activities

Lean team. Case B: *"It started together because it was seen that they belong together and that they cross-fertilize each other."*

Configurational approach - To work outside of boundaries, companies install *roles that combine Lean-Digital responsibilities and functions*. For example, Company G created a new function that connects Lean and Digital responsibility at the site. Other companies create shared responsibilities and functions at a corporate level with fully implemented reporting lines to Lean and Digital site representatives. As a main driver for combined responsibilities and functions, companies expect to better ensure a connection between the assignment of resources and performance improvement.

Competitive approach - To work for boundaries, companies unintentionally create *unclear responsibilities and structures.* This is expressed in inconsistent exchange and reporting lines between corporate and site Lean and Digital functions. Companies made the experience that the unalignment of their Lean and Digital programs engendered an escalation in interdepartmental competition. The cases also reveal that a lack of mutual exchange can be reinforced when Lean and Digitalization teams are not part of the same department, even though both teams report to the same supervisor. Company G describes: "*We never had so much of an assurance that whatever ideas we were escalating were actually taken into consideration. Or if for one reason the Digital team felt that the idea was not convincing enough, or if they were already overcrowded [. . .] we could not make sure we decide what ideas were kept or not."* We even noticed that when Lean and Digital functions formally collaborate in the aforementioned cross-functional working groups, the competitive approach can be identified as well. Here individuals work for boundaries: *"All of those champions are people from the same team, [. . .] the CIO as an IT guy [is] doing his own stuff."*

4.2.2 Content. Collaborative approach - To work at boundaries, companies increasingly revise and define the content dimension of Lean and Digitalization programs. Considering both programs' tools and elements, we identify statements about growing collaboration and synergy. We labeled the collaborative approach *mutual opportunity consideration for use cases and program elements*. In that regard, companies refer to use cases like Digital problem-solving, visual boards, idea-tracking systems or projects of mutual interest (e.g. deviation management system development). More often, the automatized calculation, visualization, and improvement of KPIs have been named as the main reason for joint work. The rationale for collaboration manifests itself in the fact that performance improvements with traditional Lean tools are slowly decreasing. Company G's transformation program manager stated that new approaches are needed to increase performance*: "And this Digital data will now be perceived as being the next frontier. So, it's a win-win partnership"*

Configurational approach - To work outside of boundaries, the *content definition and content-responsibility allocation of Lean and Digitalization programs must be coordinated*. We have found that coordination of responsibility is mainly related to the technical complexity of tools. In essence, three types of responsibility allocations have been identified. First, lower complexity tools such as dashboards or low code solutions are mainly orchestrated within the Lean team, and thus in the Lean program. Second, Digital solutions that require advanced programming skills, IT infrastructure expertise, or knowledge of data-heavy applications are mainly allocated to the Digitalization team, and thus the Digitalization program. Third, if Lean practices such as Digital value streams result in complex programming tasks, the coordination of content is continuously assessed and monitored. In that regard, Company D specified that the partnership between Lean and Digitalization teams follows a fluid transition: *"It cannot be either or. For example, Digital shop floor management [. . .] is a typical topic, that is related to Digitalization, even if it was originally initiated by us, but [. . .] if it then makes sense [. . .], due to the form or mass of the data or perhaps the lack of clarity, to apply Digital solutions, we will work together with our colleagues."*

Competitive approach - To work for boundaries, we noticed that specific *program elements and technologies are prioritized by Digitalization or Lean teams without considering their influencing effect on each other*. We mostly observed that a competitive approach does not acknowledge the synergistic effect of alignment on program and tool levels. For example, Company E has established two distinct workstreams following similar goals. However, their content is not coordinated, and dedicated Lean program elements are only represented within one workstream. Moreover, the difficulty of integrating Digital technologies into day-to-day operations highlights general skepticism on the tool level. Failed Digital efforts seem to fuel that belief. Describing the consequence of this, Company A exhibited that they are not even considering how Digital technologies could support the Lean program. The manager revealed: *"I had to almost force our [Lean] responsible to at least consider this issue [Process Mining] and look at what would be possible in our environment with what we have."*

4.2.3 Process. Collaborative approach - To work at boundaries, Lean and Digitalization teams collaborate when *jointly defining or refining their strategies*. Company I's Lean and Digitalization manager justified the combination in a joint strategy by stating that process improvement needs to precede Digitalization, ensuring the implementation of scalable technologies. Even though all interviewees stated that they have separated Lean and Digital roadmaps, they also indicated that both roadmaps are regularly challenged and revised by both teams. That is why Company E summarized: *"We're linking Lean and Digital in our roadmaps more and more. They're not 100% linked, but they're getting more and more intertwined with each generation."*. On the strategy and roadmap execution level, we discovered that Lean and Digitalization teams are *closely aligned when evaluating, designing, and deploying Digital use cases*. For example, when collaborating closely in the evaluation phase, Company D sees great potential in creating value stream maps extended by data flows,

data sources, and data sinks visualized in a respective data map: *"So, you have striking examples, you can also show the process and demonstrate the concrete added value of Digitalization on this basis."* Within the design phase of use cases, we see that Lean teams provide valuable feedback on the business case or support the design of minimum viable products. Thereby, Lean teams usually present specific problems and root causes from a business side, while Digitalization teams rather focus on developing and professionalizing use cases. During deployment, Lean and Digitalization teams jointly proceed and facilitate adoption across the organization. In that period, they attend mutual meetings, develop organization-wide communication strategies and create guidelines to implement use cases: *"It also leads the team to work more in partnership. So now we are building this integrated offer by having a transformational leader working hand-in-hand with the Digital product owner and the [Lean] academy owner."*

Configurational approach - To work outside of boundaries, we noticed that positions with shared responsibilities focus on *managing Lean and Digital stakeholders during strategy deployment*. Company I's program manager highlighted that she does not own the headcounts for the combined strategy and thus has to put much effort into engaging and managing stakeholders across the network. Company G's transformation program manager highlighted the critical role of a certain Lean maturity in that regard: *"We have selected a bit of entrepreneur sites in the network. So, for each topic, we pick one or two sites which we consider as the most advanced and work hand-in-hand with them to deploy this integrated offer."* Company C's manager pointed out that he focuses on presenting the benefits of a combined approach and making the combined strategy visible and understandable to employees. His configurational work is expressed by infecting people with quick wins for formulated needs and bringing them to a tactical level by getting momentum for the strategy.

Competitive approach - To work for boundaries, we acknowledged activities that are mainly related to building boundaries through *separated definition and implementation of Lean and Digitalization strategies*. In that regard, Company G described that the Lean team's ability to influence the Lean Digitalization program was only given at an early stage: *"We got in there in the ideation of forming Digital products in the very beginning. But since then, as a [Lean] group, the ability to influence the development of new products beyond the initial list has been pretty limited."* Company H's Lean manager described that their conflicts with the Digitalization team resulted from an unaligned definition of their vision. While the vision of the Digitalization team manifested itself in "*a fully Digital company"*, the vision of the Lean team was orientated towards *"an extreme productive company."*. As a second competitive activity, we perceived the *unaligned evaluation, design, and deployment of Digital use cases*. Company F highlighted that no structured way of planning and implementing Lean or Digitalization projects was established. Company A described that an assessment of collaboration rarely happens before starting a project. In other cases, we noticed that Lean and Digitalization teams had difficulties aligning priorities and synchronizing the program implementation. The Lean manager of Company G reported that both teams tried to push their programs into the organization: *"So each team was shooting a bit their own priorities, and sometimes it could result in the transformation without the Digital deployment. The Digital product program team was pushing for the adoption of their tools. In parallel, we were doing the performance improvement program with its own priorities."*

5. Discussion

This study aims to answer the research question: *How do companies manage the boundaries of Lean and Digitalization programs?* Addressing our research question, we further discuss the identified activities from the viewpoint of our theoretical lens and derive general propositions for the boundary work management of Lean and Digitalization programs.

5.1 Structure

The case study demonstrated that companies create explicit structures to foster collaborative decision-making. These structures can manifest themselves in various ways, such as cross-functional working groups, Lean teams which are integrated into Digital departments, and lastly combined Lean-Digital functions and responsibilities. All of those structures follow the mandate to foster governance relations across Lean and Digital personnel. Literature findings already demonstrated that such structures can facilitate the exchange between different knowledge communities, when no common expertise is established (Star and Griesemer, 1989). In the context of Digitalization, literature suggests that the role of interdisciplinary project teams becomes more important (Veile *et al.*, 2020). For example, Prifti *et al.* (2017) and Hecklau *et al.* (2016) both highlight the crucial role of the ability to collaborate. As the interplay between Digitalization and team collaboration has not been extensively studied in the context of Lean so far (Rosin *et al.*, 2020), we add anecdotal evidence showing that companies indeed overcome organizational boundaries through collaborative decision-making and governance. We thereby formulate the following *Proposition 1: Companies manage the boundaries of Lean and Digitalization programs by explicitly defining structures and governance models such as cross-functional working groups (collaborative) and combined roles and responsibilities (configurational).*

Although no company stated to intentionally misalign their programs, most cases also demonstrated competitive boundary work management. This type is supported by unclear responsibilities, working groups in which divergent power relations are evident, or inconsistent exchange across the organization. At this moment, we provide evidence for the necessary inter-related management as stated by Hines *et al.* (2023), that one "should not fall into the trap of a disconnected approach to Lean Industry 4.0, where Lean sits within the operations or supply chain functions whereas Industry 4.0 sits within engineering or [information and communications technologies] ICT (Hines *et al.*, 2023, p. 80)." Hence, we reason the following *Proposition 2: Companies build up boundaries of Lean and Digitalization programs when roles, responsibilities, and rules for organizational exchange are not clearly defined (competitive).*

5.2 Content

Our findings demonstrate that the content dimension of Lean and Digitalization programs is, if well-managed, of collaborative nature, endorsing synergies between Lean and Digitalization programs. What was most apparent in that regard was that both Lean and Digitalization teams have to acknowledge that collaboration benefits each other's programs. Being measured against the same targets and key figures in particular strengthens collaboration. Conversely, a competitive approach becomes apparent when prioritization of content is manifested without evaluating the effect on each other's program. Overall, we add to literature that mainly has focused on synergistic effects between Lean practices and Digital technologies (e.g. Ciano *et al., 2021;* Cifone *et al.*, 2021*;* Pagliosa *et al.*, 2021) providing a nuanced view and emphasize the critical role of organizational belief in synergies. We formulate the following *Proposition 3: Companies manage the boundaries of Lean and Digitalization programs when they believe in a synergistic effect of program elements (collaborative), they build up boundaries when no added value for integration is identified (competitive).*

Our analysis further revealed that boundaries between Lean and Digitalization programs can follow seamless transitions that are effectively managed by dedicated functions. These functions oversee the efforts by making a case-by-case evaluation of program synergies. In that regard, they allocate responsibilities (be it Lean or Digital) to the content dimension of programs. We noticed that allocating the program content to either the Digitalization team or the Lean team based on required expertise effectively reduces complexity and prevents the

teams from handling projects beyond their capabilities. Digitalization teams often find themselves assessing technical feasibility, IT integration, and development of use cases. In contrast, Lean teams take over facilitator roles and provide feedback from the business side during Digitalization projects. As Lean encourages a high level of organizational participation, literature findings (e.g. Wilkinson *et al.*, 1993) let us assume that Lean teams are suitable for this activity. Langley *et al.* (2019, p. 718) emphasize that "collaborative boundary work is often made possible through the skillful activities of particular people managing the ambiguities of belonging to and navigating different worlds". Hence, we formulate *Proposition 4: Companies manage the boundaries of Lean and Digitalization programs by allocating program content and responsibilities, which often depends on the required expertise, complexity of tasks, tools, or technologies (configurational).*

5.3 Process

Furthermore, we have seen that boundaries between Lean and Digitalization teams are downplayed to accomplish common tasks (Apesoa-Varano, 2013). Both teams align their strategies and ensure implementation by engaging early on and providing feedback to each other. This integration is usually reflected in shared artifacts, for example, Lean-Digital strategies, commonly developed roadmaps, and use cases. When deploying the use cases, a lot of companies follow company-specific strategy deployment processes creating pilots, as well as selecting, convincing, and interacting with stakeholders. We thereby highlight that the deployment of Lean and Digitalization is, at its core, related to socio-technological interaction (Tortorella *et al.*, 2019) and should not be reduced to the technical side of it (e.g. Hines *et al.*, 2023). We formulate the following *Proposition 5: Companies manage the boundaries of Lean and Digitalization programs by implementing a continuous process from joint strategy development to strategy deployment (collaborative) and socially interact across the organization (configurational).*

Lastly, we add to the rather optimistic scientific discussion on integration which mostly focused on Lean practices and Digital technologies (Tortorella *et al.*, 2021). Hereby, we emphasize that the combination of Lean and Digitalization consistently leads to complex organizational challenges. Considering the outlined program perspective, we have noticed that Lean and Digitalization teams pushed their own programs and thereby excluded each other or neglected their interrelatedness. The pushback phenomenon and competitive behavior between Lean and Digitalization teams has not gained much attention within the scientific discussion so far, but is very well known in boundary work literature (Ezzamel and Burns, 2005; Lefsrud and Meyer, 2012). To add to the discussion in our field, we formulate the following *Proposition 6: Companies build up boundaries of Lean and Digitalization programs by not following a continuous process from strategy development to strategy deployment and thereby neglect the interrelatedness of Lean and Digitalization programs (competitive).*

6. Conclusion

Acknowledging that a large body of literature has evolved around technical integration of Lean and Digitalization, we expand the current discussion. By considering a program management perspective (Netland, 2012) in combination with the boundary work approach (Langley *et al.*, 2019), we provided a first-of its kind perspective to the phenomenon of integration. Based on our theoretical grounding, we analyzed interview data from 10 companies from various industries. As a result, we propose a comprehensive overview of 12 activities to manage boundaries in Lean and Digitalization programs, describing how integration does (or does not) occur. Furthermore, we have derived six propositions serving as the basis for forthcoming research endeavors. The findings of our study have important contributions to both theory and practice.

6.1 Theoretical contribution

We add to literature in three ways. First, and more generally, we follow Hines *et al.* (2023) call for more interdisciplinary studies. In particular, we complement earlier research by proposing new research avenues that evolve at the intersection between Lean and Digitalization. The combining lens, in our understanding the program management perspective together with the boundary work concept, revealed interesting findings that add to research that has so far mainly focused on technological integration (cf. Ciano *et al.*, 2021; Rossini *et al.*, 2021). In that regard, we draw attention to a more holistic perspective of Lean and Digitalization, echoing for example Ghobakhloo and Fathi (2020) adding to the literature stream of Lean programs (cf. Netland and Aspelund, 2014)

Second, we provide anecdotical evidence that a collaborative way of working, in our case collaborative boundary work, paves the way for successful Digital transformation. We support earlier findings from Tortorella *et al.* (2019) that Lean helps to align socio-technological changes by strengthening behaviors that enable the integration of modern technological advancements. We highlight the importance of management and configurational approaches to steer and deal with the complexity of Digital transformations (Neumeyer and Liu, 2021). In fact, while managing Lean and Digitalization programs, the boundaries should be continuously assessed and rearranged, so that both programs stimulate each other.

Third, we present another perspective on the optimistic debate about Lean and Digitalization integration (Tortorella *et al.*, 2021). As illustrated by Tortorella *et al.* (2019), a pure technological adoption of Digitalization does not result in expected benefits. We argue that reasons can also be found in poor boundary management, as our results show that competitive boundary work also exists for Lean and Digitalization programs. Hence, we see that the competitive boundary work type, expressed by unaligned efforts and can, to some extent, also explain why Lean and Digitalization programs fail (Baudin and Netland, 2023).

6.2 Managerial contribution

Various scattered Lean and Digitalization projects represent one of the reasons that prevent the full exploitation of Lean and Digitalization programs. Our results demonstrate that competitive activities amplify separation, while collaborative and configurational activities enhance integration. Moreover, it became apparent that collaboration in one program dimension does not necessarily imply collaboration in another dimension. Our findings suggest that collaborative approaches predominantly unfold based on stakeholders´ belief in synergies and prior alignment on goals. In contrast, configurational approaches become evident when collaboration is formally imposed. Thereby, a configurational approach is characterized by an "external" perspective (outside of collaboration) that defines roles and responsibilities (for collaboration) when collaboration does not take place from within. Based on our findings we expect that both approaches, collaborative and configurational, are needed for integration. However, we leave it up to the managers to decide which of these two integrational paths to take. The proposed framework (see Table 3) can be used to systematically identify activities to determine the integration of Lean and Digitalization programs. The six generalized propositions additionally serve as guidelines to support managerial actions.

6.3 Limitations

Several limitations hold the opportunity for future research. First, given that our study is pioneering in its focus on the boundaries of Lean and Digitalization programs, it remains inherently descriptive in nature. For instance, we have not conducted assessments to establish a performance correlation, which is why the examination of the relationship between program integration and performance has been omitted. Second, we have not investigated contingency factors that determine and influence the configuration of activities.

Researching this phenomenon can lead to a more profound analysis that determines the activities that ideally should be followed considering the company's situation. Third, the multiple-case study approach comes with a trade-off. On the one hand, case studies offer broad insights into various units. On the other hand, they fall short of getting a detailed perspective on specific units.

Considering all three limitations, we propose three possible future research directions. First, we recommend that forthcoming studies will perform single case study analysis and longitudinal data analysis to highlight the dynamics between Lean and Digitalization programs. Second, we suggest using other data collection methods, such as surveys, to allow the testing of propositions in the form of hypotheses which can extend the theoretical body. Third, we leave open opportunities for research in the context of other units of analysis such as small and medium-sized companies which may handle the integration of Lean and Digitalization programs differently.

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Appendix

Interview Guideline

(1) Professional Background

(2) Introduction

- How would you describe the maturity of Lean and Digitalization in your organization?
- How does the interplay of Lean and Digitalization look like at your company?
- By which characteristics do Digital programs differ from Lean improvement programs?
- Do you already perceive any benefits from integrating Lean and Digitalization and how does the integration look like?

(3) Structure

- Can you briefly explain how you structure the organization of your Digital Lean improvement program?
- Have you successively aligned your Lean and Digitalization organization(s)?
- Can you explain your governance approach towards Digital Lean improvement programs?

(4) Content

- What topics do you address within your Digitalization initiatives and Lean programs?
- To what extend are the addressed topics interlinked or integrated?
- How do these topics influence each other?

(5) Process

- Is Lean (strategy, roadmaps etc.) driving Digitalization or the other way around?
- How do you deploy your Digital Lean improvement programs?
- How do you proceed in deploying a new tool and to what extend is Lean integrated?
- How do you ensure that collaboration between different Lean and Digitalization organizations and individuals is guaranteed?

(6) Outlook

- What are factors which you find relevant so that true integration between Lean and Digitalization can be achieved?
- What are the key learnings concerning the interaction between Lean and Digitalization?
- What have been the major challenges/pain points in aligning Digital to the business strategy and how do you overcome them?
- What next steps have you planned in your organization for Digitalization in your Lean context?

Source(s): Authors work

Improvement program dimension	Boundary work type	Descriptive activity	Exemplary quote (interview)
Structure	Collaborative	Creation of cross-functional working groups	*"I think the creation of the Digital transformation office is helping to connect IT to the business more. It was like we are having trouble. You know, like IT would complain and say, we need to pull from the business. But they didn't know how to create that pull. And so, I think the Digital transformation office is really helping IT connect to true business problems and create that pull and create a more integrated strategy then."* [E]
	Configurational	Accountability creation with combined Lean-Digital responsibilities	*"I am responsible for our production system and smart manufacturing. So, everything to do with Digitalization, I'm responsible for absolutely everything. So that doesn't mean that I own all of the teams, but it means that I own the strategy and I own the connectivity between continuous improvement and Digitalization. Because there's a lot of opportunity in our industry and we want to make sure that we're channeling the right opportunity for the right problems."* [I]
	Competitive	Generation of unclear responsibilities and structures	*"We all have silos, and then we have IT running their strategy and running topics of manufacturing enterprise system, where we have all our production."* [J]
Content	Collaborative	Mutual opportunity consideration for use cases and program elements	*"Digital cannot be successful without the [Lean] team and vice versa the [Lean] team start to see that for some topics like deviations management as equipment utilization, you need access to new data, if you really want to generate breakthroughs."* [G]
	Configurational	Coordination of content definition and content-responsibility allocation of Lean and Digitalization programs	*"When we talk about predictive maintenance solutions, for example, there is always a discussion about where this topic should be located. Is it more about TPM and thus Lean or is the Digital solution in the foreground. This is really a topic for constant discussion and consideration in individual cases."* [D]
	Competitive	Prioritization of program elements and technologies by Digitalization or Lean teams without considering their influencing effect on each other	*"I would just like to have more visualization for people in the shop floor area. Nothing progresses because other things are more important."* [B]

Table A1.
Coding tree excerpt

(*continued*)

Improvement program dimension	Boundary work type	Descriptive activity	Exemplary quote (interview)
Process	Collaborative	Closely aligned evaluation, design and, deployment of Digital use cases	*"You do it at the at the shop floor. You find the waste and you eliminate the waste. And however, you choose to eliminate the waste, I don't care right now. If eliminating the waste is using a Digital tool, then do it right. I mean, it's not perfect, but it is about looking at the problem and then deciding at each individual case what's the solution to the problem."* [E]
	Configurational	Management of Lean and Digitalization program stakeholders during strategy deployment	*"Then there is this gap where they don't get the strategy implemented and I just try to use these small steps to achieve quick-wins. Be it in Lean, be it in Digitalization, we try to take people along with it. And I always try to make the theory digestible as much as possible. It is then the job of people like me to present this, to make it visible, to formulate it in an understandable way."* [C]
	Competitive	Unaligned evaluation, design and, deployment of Digital use cases	*"Exactly, so when a customer comes and says I need the data from this and that product, then that is of course much, much higher prioritized than a request from my side, because the customer comes first and then the resources are put into it."* [B]

Source(s): Authors work

Table A1.

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