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Advancing the software development process through the development of technology-enabled dynamic capabilities in a project-based firm: insights from action design research

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Abstract

Purpose – This study aims to extend the dynamic capabilities (DCs) perspective to the project management context. The authors present supporting evidence for analyzing the creation process of DCs during the redesign of the software development process, and they examine the impact of those capabilities on organizational performance and transformation.

Design/methodology/approach – An action design research approach, combined with simulation and qualitative analysis, is adopted to examine the emergence of technology-enabled DCs supported by their microfoundations and the modernization of the software development process in the target firm.

Findings – Analyzing the successful internal transformation of a software development company that was facing a slow and inconsistent product development process reveals the effectiveness of extending the DC perspective to a project-based setting. The implementation of a new project methodology and the introduction of an innovative document-handling system facilitated the renewal of the company's software development process. This led to improvements in lead time and total costs, resulting in enhanced project performance as well as customer and employee satisfaction.

Practical implications – This study draws managerial attention to the microlevel activities of technology-enabled DC formation, such as precise calculations, external expert consultations and tool deployment.

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Originality/value – By applying the sensing–seizing–transforming framework with concomitant microfoundations in a longitudinal way, this article explains the role that technology plays as the basis for DCs and analyzes the cost–benefit balance of DC development in project-based organizations.

Keywords Action design research, Capability emergence, Cost–benefit analysis, Project-based firm, Process technology, Software development, Tool design

Paper type Research paper

1. Introduction

The main contribution of this article is that it seeks to move beyond elucidative and interpretative efforts by shedding light on how project-based companies can (co)design and diffuse dynamic capabilities centered on the purposeful application of essential technologies for more effective operations—an area that is less understood and researched. A prime example is Tesla, whose competitive advantage in the electric car market highlights the importance of proficient project management for new product development (NPD). This includes self-driving functionality (Niedermeyer, 2022), the application of AI (Crider, 2021), and center touchscreens (Hanley, 2022). Such projects, which primarily rely on novel technologies, aim to dynamize the e-car company and enhance its evolutionary fit—a core concept in dynamic capabilities (DCs).

DCs refer to an organization's ability to adapt, innovate, and change in response to market dynamics and competitive pressures (Teece *et al.*, 1997), thereby enhancing the organization's evolutionary fit (Helfat *et al.*, 2007; Teece, 2007). Theorists of the DC perspective argue that this can enable firms to refurbish underperforming units (Galunic and Eisenhardt, 2001), improve resource management (Eisenhardt and Martin, 2000), eliminate nonvalue-adding activities (Bingham *et al.*, 2015), and ameliorate operating processes (Jones *et al.*, 2019; Stadler *et al.*, 2013). Furthermore, scholars contend that DCs play a pivotal role in cultivating lasting competitive advantages by enhancing an organization's capacity to recognize and seize emerging market opportunities (Augier and Teece, 2009; Teece, 2014) or exploit industry trends.

The theory also involves a technology perspective (Chen *et al.*, 2023; Mikalef and Pateli, 2017; Quayson *et al.*, 2023; Saeed *et al.*, 2023). Technology-enabled DCs are concerned with how firms learn about technologies new to them, assess their feasibility, and implement them (Danneels, 2008). Such technology-enabled DCs can help revamp production processes (Danneels, 2016; Stadler *et al.*, 2013), create new competences (Danneels, 2008; Saeed *et al.*, 2023), and develop flexibility and performance (Chen and Lien, 2013; Waleczek *et al.*, 2019).

Given the importance of technology-enabled DCs, scholars in the field of project management have increasingly started to adopt them in empirical investigations (Killen *et al.*, 2012). DC has proven beneficial for NPD teams in the areas of information technologies for project performance (Darawong, 2018), reconfiguration in times of digital transformation (Ellström *et al.*, 2021), project success due to superior technology management (Ettlie *et al.*, 2023), and experiential learning in project-based technology organizations (Killen *et al.*, 2008; Sohani and Singh, 2016). However, a major problem with this kind of application is that scholars have not paid meaningful attention to the emergence of technology-enabled DCs in project-based firms or concomitant performance outcomes. Moreover, there is a lack of knowledge about the key microfoundations encompassing individuals, processes, actions, interactions, structure, and decision rules in the establishment of technology-enabled DCs. From a theoretical perspective, insight into the emergence process of such capabilities, undergirded by their microfoundations, remains limited. Additionally, it is poorly understood how fostering these capabilities can transform business processes and create value for the focal organization. This omission is surprising for several reasons:

(1) Technology has the potential to optimize project management procedures, automate repetitive tasks, and enhance resource allocation, ultimately leading to increased operational efficiency (Froese, 2010). Consequently, technology-enabled DCs allow project-based firms to make more effective use of their resources, reduce expenses, and consistently execute projects within defined timelines and budget constraints.

(2) Technology-enabled DCs can facilitate real-time communication, document sharing, and collaborative project management (Warner and Wäger, 2019), thereby enhancing coordination and fostering knowledge exchange.

(3) DCs enabled by technology can foster innovation within project-based organizations, providing them with the ability to experiment with novel tools and methodologies to enhance project execution and outcomes, thus sustaining a competitive edge.

The potential to unravel this puzzle lies in involving design thinking, which unleashes the analytic and creative potential of the firm to address complex and poorly defined problems by leveraging capability renewal and inherent learning processes. Design thinking, a facilitator of DCs, promotes organizational change (Cautela *et al.*, 2022) and boosts adaptation (Bernardo *et al.*, 2017) through the design of work processes (Lager and Simms, 2023). By leveraging organizational design, the purpose of this article is to provide a more fine-grained inquiry into the modes of emergence and the microfoundations of technology-enabled DCs. In doing so, this study addresses earlier calls for the emergence and microfoundations of DCs (Kay *et al.*, 2018), the cost–benefit balance of capability dynamization (Arend and Bromiley, 2009; Danneels, 2012; Teece, 2007; Winter, 2003), and the tautological issues encountered in DC studies when the measurements of DCs coincide with those of firm performance (Arend and Bromiley, 2009; Hermano *et al.*, 2022; Stadler *et al.*, 2013). In this context, it agrees with Killen *et al.* (2012) that studies should shed more light on the mechanisms of DC frameworks in a project context that lead to competitive advantage. Consequently, the following question is answered in this study:

How does the emergence of technology-enabled DCs contribute to value addition and performance enhancement in project-based firms?

To address this issue, we employed a longitudinal action design research approach (Sein *et al.*, 2011) in which university experts assisted in revamping the focal project-based firm's poorly functioning core processes (i.e. software development) by creating a novel tool—a process development technology—in combination with simulation and qualitative analysis. The target organization is a Hungarian software firm called SOFPRO, which specializes in developing geographic information systems (GISs).

The results of this study demonstrate the emergence of technology-enabled dynamic capabilities (DCs) in project-based firms, building on the foundations and stages of action design research (ADR). These stages align with the major pillars of DCs: problem formulation with sensing, building with seizing, and intervention coupled with reflecting and learning with reconfiguration. The problem formulation as sensing involved identifying operational and resource allocation issues in product development. Supported by skilled employees, researchers collected detailed data on the software development process and associated key performance indicators (KPIs), revealing disparities through sophisticated simulation exercises. In the building stage, a novel tool—a process technology—was created and tentatively deployed. Verified through simulation, this tool demonstrated superior performance for the firm. At this seizing stage, action design researchers, who are continuously part of the ADR team, designed an initial alpha version followed by a more advanced beta version of the tool. This latter beta version provided enhanced utility and performance, leading to subsequent implementation. Intervention coinciding with reconfiguration involved implementing the novel tool in real corporate practice. Success was validated through data-driven evaluations based on previously applied process-related KPIs. Reflecting and learning included a cost–benefit analysis conducted by skilled academics, demonstrating that the software company could achieve a relatively fast payback time for the investment in the new tool. After three years of implementation, university researchers conducted a post hoc analysis, providing additional evidence of the tool's practical durability and confirming earlier performance results.

This paper aims to address the previously mentioned gaps and further contributes to the literature in several ways. First, it breaks away from the elucidative and interpretive endeavors of DC theory and demonstrates how firms can actively participate in (co)designing and diffusing technology-enabled DCs in project-based contexts, thereby mitigating the tautological problem that plagues DC studies regarding performance-enhancing change. Second, through this exploration, the study provides insight into the emergence process of such capabilities and shows how this dynamization process is aided by sets of microfoundations, i.e. microlevel activities, distinct skills, procedures, and disciplines. Third, the study is longitudinal, spanning six years, which not only allows for the design of tool development but also demonstrates how such a process technology disrupts the firm's existing operational logic, improves the speed of core business processes, and enhances strategic flexibility by eliminating nonvalue-creating activities. Finally, as part of the research approach, a straightforward model with high managerial relevance is presented and explained.

The significance of this study lies in its potential to enhance practitioners' comprehension of the economic and strategic value of technology-enabled DCs, particularly regarding their evolutionary fit in the context of the steps and microfoundations involved in their emergence and application. This understanding can be instrumental in successfully revitalizing operational routines and business processes.

2. Literature review

2.1 Conceptualization of DCs and their microfoundations

A comprehensive description of DC involves its ability to systematically address challenges, driven by its capacity to detect opportunities and risks, make well-timed decisions, and efficiently execute strategic decisions and changes, thus guaranteeing alignment with the correct course of action (Ferreira *et al.*, 2020). Capabilities may be differentiated into operational and dynamic capabilities (Drnevich and Kriauciunas, 2011; Winter, 2003). Operational capabilities are tailored to preserve the status quo, which ensures consistent processes on the same scale, while DCs represent more efficient techniques on a potentially broader scale that support preexisting and new products and services for (new) customers (Helfat and Winter, 2011). Along these lines, Zollo and Winter (2002) emphasize that DC constitutes "a learned and stable pattern of collective activity through which the organization systematically generates and modifies its operating routines", with the clear objective of enhancing effectiveness (Zollo and Winter, 2002, p. 340).

One notable area of advancement in DC research has been its disaggregation into the capacity to sense and shape opportunities and threats, to seize such opportunities, and to strengthen competitiveness through enhancement and transformation (Teece, 2007; Katkalo *et al.*, 2010). These three clusters of activities are supported by microfoundations, which constitute the underlying individual- and group-level actions, distinct skills, processes, procedures, organizational structures, decision rules, and disciplines (Eisenhardt *et al.*, 2010; Teece, 2007). These microfoundations are smaller, more granular components that contribute to an organization's ability to adapt, innovate, and respond to changes. They are crucial for understanding how DCs are developed and executed within a company.

The first class of DC, called sensing, is undergirded by microfoundations such as spotting business opportunities, identifying novel customer needs, and tapping into developments in the exogenous areas of science and technology (Teece, 2007). The role of management is integral to maintaining a high degree of mindfulness in this regard. To accomplish strategic renewal, firms can leverage knowledge transfer from partner universities (Ryan *et al.*, 2018; Teece, 2007).

In the second class of DC, a firm seizes a sensed opportunity through the development of new processes, products, or services (Teece, 2007). Seizing requires investment discipline, a commitment to R&D, crafting competences, and adopting new resource combinations to pursue customer needs (Katkalo *et al.*, 2010). Knowledge management, learning, planning, and decision-making form part of seizing efforts, which can be aided by managerial supervision (Augier and Teece, 2009; Ellonen *et al.*, 2009; Lin *et al.*, 2020) and the latter's thinking dispositions (Helfat and Peteraf, 2015). Other microfoundations incorporate decisions regarding the selection of technologies to embed in the product/service or those regarding performance specifications and calculations aimed at delineating the revenue and cost structure of the business (Teece, 2007).

Reconfiguration refers to the implementation of the new processes obtained at the seizing stage to replace less desirable operating routines (Teece, 2007). Such a robust science-based mandate can lead to extensive reworking of an organization and its established structures and procedures. One notable microfoundation necessary for managing transformation is achievement in learning and effective knowledge integration activities, which are directly associated with positive enterprise performance (Ellonen *et al.*, 2009; Farzaneh *et al.*, 2020; Teece, 2007) as well as project success (Mariam *et al.*, 2022).

2.2 Technology-enabled DCs

Jantunen *et al.* (2018) found that better performance can be achieved by leveraging the interaction between DC and operational-level changes in technologies. Technology can refer to any method, process, or system that uses special techniques to achieve a goal (Dictionary of Science, 1986). It can be used to recombine resources to generate surplus revenue by reducing costs (such as personnel costs), adjusting cycle times, and improving quality and flexibility (Stalk, 1988). A routine can be regarded as a fundamental unit of technology and basically refers to a set of instructions detailing how to produce something. Due to their ostensive (guiding and sensing capacity) and performative (embracing specific actions, people, or time) aspects, routines can promote flexibility and change (Feldman and Pentland, 2003), which is precisely why such "*dynamic routines became the foundation for the DCs theory*" (Arndt and Pierce, 2018, p. 416).

The literature suggests that technology can serve as an external enabler for DCs, shaping a company's structure and operations (Danneels, 2008; Mikalef and Pateli, 2017; Quayson *et al.*, 2023; Subramanian *et al.*, 2011). Cetindamar *et al.* (2009) identify technology management activities—such as the identification, selection, acquisition, and application of employed technologies—as fundamental to DC development within an organization. Technology-enabled dynamic capabilities embody specific organizational behaviors aimed at enhancing the focal firm's R&D or new product development competence. This capability involves learning about new technologies not previously applied and identifying promising ones (Danneels, 2008). Additionally, assessing the feasibility of these new technologies (Chen and Lien, 2013; Danneels, 2008, 2016) implies that the firm implements new types of production processes and operations (Danneels, 2008, 2012, 2016). This deliberate effort is complemented by the acquisition of groundbreaking manufacturing technologies, new managerial and organizational skills, and training for engineering personnel (Atuahene-Gima, 2005).

Scholars concur that technology-enabled dynamic capabilities, referred to as second-order competences (Danneels, 2016), play a pivotal role in rejuvenating production processes (Stadler *et al.*, 2013), enhancing competences (Danneels, 2008; Saeed *et al.*, 2023), and refreshing change routines over operating routines (King and Tucci, 2002), ultimately improving the speed of strategic change and firm performance (Chen *et al.*, 2023). Empirical evidence from cross-industry samples of Taiwanese (Chen and Lien, 2013) and German companies (Waleczek *et al.*, 2019) substantiates these claims. Taiwanese firms' technology sensing and technology response capabilities boost their performance relative to that of key competitors (Chen and Lien, 2013). For German companies, technology-enabled dynamic capabilities exert both a positive and significant direct effect, as well as an indirect effect mediated by ordinary capabilities, on firm performance (Waleczek *et al.*, 2019).

2.3 The application of DC and technology perspectives to project management

Not surprisingly, research that addresses DC and technology frameworks has permeated the sphere of project management. Darawong (2018), drawing on a sample of large manufacturing firms, showed that NPD teams that build upon information technologies with sensing, learning, and integrating capabilities can increase project effectiveness. Others have pointed out the positive effect of DC and technology perspectives on the decomposition of digital transformation into specified projects (Ellström *et al.*, 2021), on innovation project success with upstream suppliers in mature and emerging economies (Ettlie *et al.*, 2023), and on digital project benefits and organizational agility for SMEs and large enterprises (van de Wetering, 2021). According to our discussion, prior studies have established the role of microfoundations in this context (Darawong, 2018; Ettlie *et al.*, 2023). In this vein, Warner and Wäger (2019) depict how incumbent firms in traditional industries build DCs to make business improvements and new business models while identifying several digital-technology-grounded microfoundations that underpin the building of digital sensing, digital seizing, and digital transforming capabilities.

However, we know surprisingly little about how the emergence and development of DCs occur in project-based firms in which a novel process technology—the tool used to streamline and optimize business processes—may play a critical enabling role in the unfolding of DCs. By leveraging DCs, project-based firms can continuously assess existing processes, identify areas for improvement, and adopt relevant process technologies. After implementation, managers of project-based firms may effectively monitor and control project progress by obtaining insights via data analytics and reporting systems into project performance, resource utilization, and budget tracking. DCs, in combination with process technologies, may facilitate knowledge sharing and collaboration (Jucevičius and Jucevičienė, 2022) within project teams, while project-based firms can harness technology templates to store and share project-related information, lessons learned, and best practices. In addition to the lack of knowledge about capability emergence, the literature does not address the active role of the microfoundations that undergird DC activities in the process of the technology-aided capability emergence of project-based organizations. Relatedly, it would also be fruitful to investigate how technology-enabled DCs affect the performance of such firms.

2.4 The role of design thinking in enhancing dynamic capabilities: a call for active participation and diffusion

To address complex and poorly defined problems, design thinking integrates both analytic and creative phases to foster innovation. This approach contrasts with conventional, narrowly focused, technical, and product-centric methods (Magistretti *et al.*, 2021; Mortati *et al.*, 2023). Thomke's groundbreaking research (1998) in the automotive industry was a pioneering application of a design thinking-based method to explore capability renewal, problem solving, and the associated learning processes. The intersection of DCs and design thinking represents an emerging trend in the innovation literature (Demeter *et al.*, 2021; Lager and Simms, 2023; Oliveira *et al.*, 2024). As a facilitator of dynamic capability, design thinking is embedded in the microfoundations of organizational elements (Cautela *et al.*, 2022). It should be seen as a context-specific DC for innovation that "*manifests and evolves differently among firms and over time*" (Magistretti *et al.*, 2021, p. 646).

Studies on design thinking-infused DCs contribute to a better understanding of organizational change by promoting a company's adaptation (Bernardo *et al.*, 2017). They also emphasize the design of work processes that can be seamlessly adapted to the specific conditions of the process–industrial environment (Lager and Simms, 2023). These studies underscore the importance of problem-solving tools for more effective resource management (Schulze and Brusoni, 2022) and stress the need for a thorough assessment of internal and external resources and knowledge before undertaking transformation projects (Hullova *et al.*, 2019). They also aim to reduce routine and cognition-based inertia in NPD teams (Nagaraj *et al.*, 2020). Within the realm of design thinking, Chirumalla (2021) identified key challenges for process innovation through the lens of DCs, such as inadequate data readiness, a lack of standardization practices for change, competence gaps, and ad hoc problem-solving approaches.

Despite the growing body of research at the intersection of DCs and design thinking, there remains a notable absence of longitudinal studies in this area (Magistretti *et al.*, 2021). We contend that DC studies must move beyond elucidative and interpretive endeavors to actively participate in (co)designing and diffusing technology-enabled DCs and their microfoundations, encompassing individuals, processes, interactions, and structure, especially in the context of project management, where there is a paucity of studies (Magistretti *et al.*, 2021).

3. Research process

Given that change is central to DCs, we employ an action research approach in this study. Spurred by Lewin's (1946) seminal contribution, the action research methodology has gained wide recognition in management research (e.g. Iversen *et al.*, 2004; Novak *et al.*, 2023), particularly in practice-based disciplines such as project management. Action research involves close cooperation between practitioners and researchers to bring about change (Svejvig *et al.*, 2023). This research method is relevant because it can be used to address operational issues encountered by practicing managers and to work as an organizational learning tool while also contributing to theory (Coghlan *et al.*, 2023). It is a valuable approach that involves active participation, reflection, and collaboration within the organization to drive learning and improve practices. Furthermore, it can yield invaluable data essential for theory development in the field of innovation management, with outcomes that should offer practical value.

This research utilizes a particular form of action research called ADR, which brings the design of practice-inspired artifacts into sharp focus (Peffers *et al.*, 2018). Essentially, "*ADR is a research method for generating prescriptive design knowledge through building and evaluating . . . artifacts in an organizational setting*" (Sein *et al.*, 2011, p. 40). Since it is a practice-inspired research method, it addresses a problem situation witnessed within a particular organizational setting by intervening and evaluating while also building and evaluating an artifact, a tool for practitioners, to tackle the field problems embodied by the encountered situation (Sein *et al.*, 2011). Design theorists emphasize that the properties of an artifact should support decision-makers in achieving certain goals and attaining procedural rationality through the artifact's properties (Walls *et al.*, 1992). Finally, the objective of a design science approach is primarily to generate technology-based solutions to relevant business problems (Gillier *et al.*, 2012; Hevner *et al.*, 2004).

3.1 Study context

The selected organization is a project-based firm that has been active in software development and system integration projects since the 1990s. The company, located in Budapest, has 18 employees and outsources specific tasks to external engineers. International insurance companies and administrative bodies compose the largest part of its customer base. Historically, the firm has applied a legacy software development methodology (termed PRINCE2) in product development, including in the development of its GEOMAP software. GEOMAP is a map-based service that builds upon thin-client applications, requires no prior setup and is directly accessible from an internet browser. SOFPRO regularly updates GEOMAP. During these cycles, new functions or modifications of existing product functions are developed. The elaboration of those functions, however, completely deranged the release process, and embedding them caused delays in the original process plan. The firm realized that it could wait to develop new functions and instead determined what it wanted to accomplish (Kosztyán, 2015). Hence, SOFPRO's main organizational problem was its reliance on a slow and impeded software development process, and this problem compelled its senior management to approach a group of university researchers with expertise, which was led by one of the authors of this paper.

3.2 Analytical considerations for ADR

The process of ADR, taken from Sein *et al.* (2011) and applied by subsequent researchers (i.e. Reibenspiess *et al.*, 2022; Wiesche *et al.*, 2024), progresses through several phases. The initial phase involves problem formulation, during which researchers identify and conceptualize the research opportunity, formulate research questions, and define the problem within a specific problem domain. The subsequent phase, building, intervention, and evaluation, centers on the development of an IT artifact, intervention in the organizational context, and evaluation of outcomes through iterative processes. The third phase is reflection and learning, which encompasses reflecting on the outcomes, learning from the intervention, and refining the understanding of both the problem and its solution. Finally, the fourth phase is the formalization of learning, which involves translating learning into design principles for a range of solutions, sharing outcomes with practitioners, and formalizing results for dissemination. Within ADR, researchers (not limited to the authors) have contributed to all phases of this study. The active research collaboration commenced in August 2014 and terminated in June 2016. To verify the durability of the implemented artifact for the focal firm's business processes in software development, a post hoc analysis was conducted between December 2017 and January 2020. Table 1 demonstrates the chronological event listing of the ADR procedure, highlighting its longitudinal nature, and details the focus group discussions, semistructured interviews, technology reviews, analytical methods (i.e. simulations and ANOVAs), validity checks and post hoc follow-up interviews.

The ADR team comprised academics, two chief software development engineers, two chief test engineers, and the general manager of SOFPRO, who ensured the necessary priority and attention for the ADR project. Prior to rationalizing the business process, all stakeholders were aware that resolving SOFPRO's organizational problems required updated project planning and associated work organizations to achieve improved KPIs and quality.

4. Initial design steps of tool development through expert problem formulation

4.1 Initial problem formulation

In the preliminary analysis and framing phase, the principal task of the researchers was to identify any discrepancies between the ideal sample release plan and the actual software

Timeline	ADR process highlights	Extended explanation
August 2014–March 2015	Problem formulation	University researchers identified discrepancies between the ideal sample release plan and the actual software development process at SOFPRO's GEOMAP software. Focus groups with engineers and the general manager examined 35 prior cycles. Simulations of 10,000 periods, using past activity durations and wage costs, revealed that KPIs of core business process values were double those of the ideal plan. Academics conducted a technology review to systematically evaluate the existing PRINCE2 software development methodology applied. Additionally, a workshop defined crucial project goals for business process rationalization
April 2015	Building the tool	Expert academics determined the suitability of the Scrum methodology for replacing PRINCE2, showing improvements in project time and cost. The newly designed tool combined Scrum methodology with Google Docs, reducing activities, project time, and costs. This novel process technology reduced the number of activities and improved coordination through online document editing. ANOVA comparison showed the new tool had lower costs and lead times. Academics, with support from key stakeholders, conducted risk analysis through interviews and workshops
May 2015–June 2016	Intervention	The ADR team implemented the designed tool at SOFPRO and validated it with 17 development cycles. Before the guided implementation, internal stakeholders (development and test engineers, managers) obtained training on Scrum and Google Docs altogether with a study material. Researchers conducted a cost–benefit analysis of the entire deployment project, demonstrating that the software company could obtain a relatively fast payback time for the investment in the new tool
December 2017–January 2020	Post hoc analysis	Researchers conducted a post hoc analysis to provide additional evidence of the tool's practical durability using 38 development cycles, which confirmed earlier performance results and validated the tool's utility for SOFPRO

Source(s): By authors

Table 1. Summary of the longitudinal ADR process highlights at the focal firm's business process rationalization

development process in practice. To achieve this goal, focus group discussions were conducted with various software and test engineers, as well as the general manager, to gather diverse perspectives, insights, and feedback through interactive sessions guided by questions on established work methods at SOFPRO.

Software engineers at SOFPRO create a sample release plan for each development cycle that delineates the usual tasks for the given release period. The events ("E") and activities ("A") of the sample release plan are listed in Table 2. The planned duration of the activities is in line with the Hungarian Labor Code, which prescribes 8 working hours a day and a 10-min break per hour. The planned costs of activities are calculated using company data. Due to privacy requirements, academics have created a fictitious currency, CT$, for use in this study. Activity costs are obtained by biasing real wage data, as expressed in Hungarian Forint, in such a way that the ratio of the values remains unchanged.

In Table 2, parallel activities are denoted with gray shading. The first step of the sample release plan is the design of initial features as defined by the real and latent needs of users (A1). The next step involves updating functions and their priorities (A2). After specifying the

No	Events (E), Activities (A)	Planned duration (hours)	Planned cost (CT$)
E1	Development cycle is started	0	0.00
A1	Design initial features	1.5	50.38
E2	Initial features have been designed	0	0.00
A2	Design priorities (scores) of the functions	0.25	3.97
E3	Functions and their priorities have been updated	0	0.00
A3	Specifying planned tasks and their allocation	0.25	3.97
E4	Planned tasks have been specified and allocated	0	0.00
A4	Specifying the development plan	2.5	64.86
E5	The development plan has been specified	0	0.00
A5	Complete task group 1	26	310.49
E6	Task group 1 has been completed	0	0.00
A6	Developer testing of the task group 1	13	155.25
A7	Complete task group 2	26	364.03
E7	Task group 2 has been completed	0	0.00
A8	Developer testing of the task group 2	13	182.01
E8	Developer testing status: there is no syntax error	0	0.00
A9	Application user's test (testing phase I): reporting errors	16	298.56
E9	Application user's test (testing phase I): all errors have been reported	0	0.00
A10	Fixing bugs and errors (testing phase I)	8	207.54
E10	Bugs and errors have been fixed (testing phase I)	0	0.00
A11	Developer tests and bug fixing (testing phase II)	4	103.77
E11	End of testing phase II. Status: the application is error-free	0	0.00
A12	User end tests. Classifying reported errors. Prioritization	4	74.64
E12	End user tests have been terminated. There are no errors to be repaired	0	0.00
A13	Publishing the current release	0.5	7.00
E13	The current release has been published	0	0.00
A14	Final meeting	4	312.75
E14	End and minutes of the final meeting	0	0.00
	The correction of the parallel completion (hour)	-36	
	Sum	**80**	**2,139.22**

Source(s): By authors

Table 2.
The sample release plan

development plan (A4), development tasks are divided into 2 groups, each supervised by a 1-1 engineer (A6 and A8). The subsequent testing of the application's users (A9) is also part of the process and entails the fixing of potential bugs. Any errors found are incorporated into the test minutes. The next step involves developer tests and bug fixing (A11), which is followed by user-end tests (A12). Once the software appears to be flawless, the project manager and the chief engineer publish the current release (A13). The last activity is the final meeting (A14), which is critical for common learning purposes. During the meeting, participants reviewed the planned tasks, any emergent problems and the types of functions needed in future development cycles.

As indicated by the data, this process takes approximately 80 h and costs approximately 2,139.22 CT$. Researchers and company managers examined a total of 35 prior software development cycles, which provided rich insights for comparisons. The researchers concluded that there was a massive discrepancy in the two performance metrics from the sample release plan in each of the 35 prior cycles that required deeper analysis and problem diagnosing. Additionally, the new software development method should not allow for the development of new functions during the cycle.

4.2 Problem formulation in the actual software development process

Action design researchers prepared the authentic software development process, which lists the actual events and activities and incorporates the most likely activity-based duration and cost values (available upon request). To judge the costs of each activity, they identified the labor expenses for each activity. After analysis, the number of activities increased from 14 to 21 due to the repetition of certain activities around the specification of development plans for new functions, which increased the lead time by 67.5 h and the total cost by 1,699.33 CT$ compared to the ideal process depicted in Table 2. In total, the duration of the deadline slip is 8.4 days. From the client's perspective, this equates to a one-week delay of the update, which is deemed unacceptable by company management.

Next, researchers employed a simulation to statistically buttress the above results. They assembled the data from the company information system, noting the activity durations and wage costs of all 35 former release cycles. They crafted an Excel table with the 21 activities listed in columns and the 35 former cycles listed in rows. For each period, researchers calculated the total process time (TPT), which consistently accounts for the longest duration among parallel activities. They also calculated the total process cost (TPC) values and resorted to expert estimates of the most likely, optimistic, and pessimistic values for an activity.

Subsequently, researchers performed simulations for 10,000 periods. Random numbers falling within the range of optimistic and pessimistic estimates for each activity were generated. The total project lead-time and total project costs for each development process were then calculated. In the case of parallel activities, researchers have consistently considered the longest duration. Variance analysis was conducted, which revealed no significant difference between the averages of the company and simulated data, thereby indicating their homogeneity. Consequently, action design researchers determined that the TPT is 160.4 h and that the TPC is 4,109.02 CT$.

Compared to the values of the sample release plan, the values of both TPT and TPC are roughly double, meaning that SOFPRO would only be able to finish a project that was originally planned to be conducted in less than 10 days with a 10-day delay (!). Such a situation is unacceptable for users, and leaving these parameters unchanged could seriously undermine the firm's corporate reputation, which might work against the success factors adopted by the project team (Atkinson, 1999; Yu *et al.*, 2005). Furthermore, this situation could erode the current customer base, which is unacceptable from the perspective of company management. The analysis confirmed the company management's suspicion that the software development process at SOFPRO required a radical overhaul, which could be achieved through the design of a process technology-based tool. Notably, during problem diagnosis, straightforward collaborative competence evolves between researchers and the firm's employees, which constitutes a precursor to eliciting an effective tool.

5. Building, intervention, and evaluation

5.1 Building the new method in the frame of project planning

5.1.1 Scrum as a candidate tool. Given the issues explored within the previous diagnosing stage, the newer and more commonly employed Scrum methodology was adopted to apply to ill-functioning processes. Scrum belongs to the family of incremental models that are part of the agile methodology (Wysocki, 2012). According to the assessment of the experienced university experts consulted, this methodology is an appropriate candidate for replacing PRINCE2.

A new release process based on the Scrum methodology simplified the number of activities from 21 to 16. Through simulation, as explained previously, of the Scrum methodology, action researchers determined that the total project time is 123.9 h, and the total project cost is 3,230.07 CT$. In comparison to the current process, Scrum demonstrated a substantial reduction in the estimation of both performance criteria, establishing it as a strong candidate for tool design. The TPT was reduced by 36.5 h, which is equal to 4.6 working days. Moreover, the TPC also showed radical improvement, being reduced by 878.95 CT$, which represents a 21% decrease from the simulation results of the real process.

5.1.2 Improving the tool through a document-handling mechanism. Next, a document-handling mechanism was proposed that could improve the level of coordination and eventually the success of the proposed project management methodology. Google Docs was suggested to minimize the time and costs spent on their handling and harmonization, making it feasible to skip the "meeting of design activity" step and continue the project through "sprint design: design priorities of the functions" (A2 in Table 3). Similarly, the new process does not necessitate the "meeting of test results". The subsequent activities involving "Fixing bugs and errors (testing phase I)" (A10 in Table 3) and "Developer tests and bug fixing (testing phase II)" (A11 in Table 3) are both reduced by 1 h, while the activity "User end tests. The reported errors were classified. Prioritization" (A12 in Table 3) is reduced by 2 h.

As a major milestone, the newly designed tool, developed from Scrum and the Google Docs document-handling method, is shown in Table 3. The significant advantages of this new process include the fact that plan documents are edited online, so all parties involved can view the same status, which minimizes misunderstandings.

The data depicted in Table 3 show that the number of activities decreased from 21 (16) to 14, as witnessed in the actual process (in the simple Scrum case). In the subsequent phase, researchers employed simulation once more. By applying the Scrum methodology in conjunction with Google Docs, the analysis revealed a TPT of 111.2 h, with TPC totaling 2,819.21 CT$.

In Table 4, we provide a succinct summary of the main results (TPT and TPC) of the original and proposed processes that also reflect the steps of tool design. The table reveals that the TPT was reduced from 123.9 h to 111.2 h, saving 12.7 working hours. The complete savings in the TPT were 49.2 h (30.67%). The implementation of the Google Docs method along with the Scrum method also radically reduced the TPC values by 410.86 CT$ (from 3,230.07 CT$ to 2,819.21 CT$). Compared with the original method, the complete reduction in TPC now totaled 1,289.81 CT$ (31.39%). The data make it clear that Scrum would significantly improve performance from the perspectives of lead time and total costs through the introduction of an appropriate coordination mechanism for the administration and harmonization of plan and test documents. As a result, more fluent and disciplined interactions between software engineers and clients became feasible. We received an update of the business process, where a scheduled plan is also specified. Owing to this plan, the make span of the process can be reduced when more time is available to test the features. Since software development projects are human resource intensive, the planned resource costs increase as the project plan is reduced.

No	Events (E), Activities (A)	Planned duration (hours, 2015)	Planned Costs (CT$, 2015)	Planned duration (hours, 2023)	Planned Costs (CT$, 2023)♣
		most likely	most likely	most likely	most likely
E1	New release developing phase has been started	0	0.00	0	0.00
A1	Sprint design: Designing initial features	1.5	50.38	1.2	76.58
E2	Initial features have been designed	0	0.00	0	0.00
A2	Sprint design: Design priorities (scores) of the functions	0.25	3.97	0.2	6.03
E3	Functions and their priorities are updated	0	0.00	0	0.00
A3	Specifying planned tasks and their allocation	0.25	3.97	0.2	6.03
E4	Planned tasks have been specified and allocated	0	0.00	0	0.00
A4	Specifying the development (and scheduling)* plan	2	51.89	2.2	108.45
E5	The development (and scheduling*) plan has been specified	0	0.00	0	0.00
A5	Complete task group 1	30	358.26	27	612.62
E6	Task group 1 has been completed	0	0.00	0	0.00
A6	Developer testing of the task group 1	15	179.13	18	408.42
A7	Complete task group 2	30	420.03	26	691.65
E7	Task group 2 has been completed	0	0.00	0	0.00
A8	Developer testing of the task group 2	15	210.02	17	452.24
E8	Developer testing status: there are no syntax errors	0	0.00	0	0.00
A9	Application user's test (testing phase I): reporting errors. Required new functions are scheduled into the new sprint	15	279.90	17	602.72
E9	Application user's test (testing phase I): all errors and required new functions have been reported. New functions are in the new sprint	0	0.00	0	0.00
A10	Fixing bugs and errors (testing phase I)	13	337.26	12	591.50
E10	Bugs and errors have been fixed (testing phase I)	0	0.00	0	0.00
A11	Developer tests and bug fixing (testing phase II)	7	181.60	7	345.04
E11	End of testing phase II.	0	0.00	0	0.00
A12	User end tests. Classifying reported errors. Prioritization	12	223.92	11	389.99
E12	End user tests have been terminated. There are no errors to be repaired	0	0.00	0	0.00
A13	Publishing the current release	0.5	7.00	0.4	10.64
E13	The current release has been published	0	0.00	0	0.00
A14	Final sprint meeting	4	312.75	3	445.67
E14	End of the final meeting	0	0.00	0	0.00

Note(s): *From 2022, the development plan includes a detailed scheduling plan
♣The increase in costs followed the increase in inflation and the increase in salaries
Source(s): By authors

Table 3. The process developed from Scrum and Google Docs

Table 4.
Overview of the main results in tool design

Steps of tool design	Discussion within the article	Total project lead time (TPT) – hours	Total project cost (TPC) – CT$
The sample release plan	4.1	80	2139.22
Simulation of the current sample release process*	4.2	160.4	4109.02
Scrum simulation*	5.1.1	123.9	3230.07
The process built upon Scrum and Google Docs (simulation)*	5.1.2	111.2	2819.21
Accomplished rationalization of the software dev. process with Scrum and Google Docs (mean values after 17 cycles)	5.2	118.9	2950.20

Note(s): *Results reported with a 95% significance level
Source(s): By authors

5.2 Intervention: implementing the designed tool at SOFPRO

SOFPRO, following the logical structure depicted in Table 3, revamped its software development process. User involvement reduced the number of requests for the new functions, and users had to concede those to be embedded in the ensuing sprint. The validation period at SOFPRO took place from May 2015 to June 2016 and consisted of an additional 17 development cycles. SOFPRO has accumulated ample experience in GEOMAP development by working simultaneously for several municipalities to facilitate tool validation. The accomplished rationalization of the software development process was based on Scrum and heavily relied on coordination benefits via Google Docs in the design and testing activities. The results (118.9 h for TPT and 2,950.20 CT$ for TPC) are depicted in the bottom line of Table 4. The data show that TPT (TPC) was reduced by 41.5 h (1,158.82 CT$), or 26% (28%), compared to the simulated former real release process. These results corroborate expectations that projects using agile development diminish cost and lead time values while achieving greater client satisfaction.

5.3 Evaluation through supplemental robustness analyses

Authentic and concurrent evaluation is a pivotal characteristic of ADRs (Sein *et al.*, 2011). In ADR, evaluation occurs continuously throughout the research process, not just after the building phase. Rather than separating evaluation from the design and implementation stages, ADR integrates it with the ongoing development and adjustment of artifacts and organizational practices. Evaluation cycles may include the assessment of both alpha and beta versions, enhancing authenticity. The alpha version is an early design from the ADR team that serves as a lightweight intervention, resulting in an artifact (tool) with limited organizational usability (Sein *et al.*, 2011, p. 42). Building upon this, the beta version constitutes a more mature artifact, allowing for comprehensive intervention by the ADR team. For instance, in this case, the Scrum software development method described in section 5.1.1 represented the alpha version, revealing some unanticipated consequences of task coordination. The adoption of document-handling mechanisms provided a remedy, encapsulated by the beta version in section 5.1.2, which exhibited better value and utility outcomes judged by the ADR team.

All former task duration and cost demands are stored in the ERP system. The empirical distributions of make spans and costs are used in the simulation and robustness checks. Four moments (mean, standard deviation, skewness, and kurtosis) are applied for fitting a theoretical 4-parameter distribution from Pearson's distribution family for each task value.

As additional robustness checks after the building phase, academics conducted a one-way ANOVA to compare the time and cost data among the different processes. The authenticity-enhancing analysis demonstrated that both Scrum and Scrum combined with Google Docs significantly reduced both project lead times and costs vis-à-vis the original real process (see Tables A1–A3 in the Appendix). A total of 30,000 simulations were conducted based on task distributions derived from previous projects. For each simulation, four statistical moments—mean, standard deviation, skewness, and kurtosis—were calculated across all task durations and costs. Using these moments, researchers fitted theoretical distributions from the Pearson distribution family to the empirical distributions. This approach enables the generation of diverse scenarios. Through these checks between the building and intervention phases, the ADR team engaged in an iterative process to solve “wicked problems” (Sein *et al.*, 2011, p. 43) by using the designed tools to increase their understanding of the organizational environment.

6. Reflecting and learning

The reflection and learning stage involves a deliberate examination of the preceding ADR steps and is linked with guided emergence—a crucial aspect of the ADR procedure. This stage aims to highlight both the tool created by the researchers and its continuous evolution through organizational use, perspectives, participants, and the outcomes of further authentic evaluation (Sein *et al.*, 2011). During the initial problem formulation stage, academics conducted a technology review to systematically evaluate the existing PRINCE2 software development methodology applied at GEOMAP, assessing its features, functionalities, strengths, and weaknesses. This critical analysis was based on a literature review, facilitated technical assessment, and a comparison with other methodologies, including the suggested agile Scrum in Building.

Reflecting on the ensuing complex business process rationalization, in the Problem Formulation stage, the ADR team, aided by a workshop session, collaboratively defined the most crucial project goals of business process rationalization, reaching a consensus that encompassed project, product, and process objectives. The project goals included reducing the SOFPRO project release cycle time and costs by 30%. The product goals aimed for a 99.9% uptime for the 24/7 online document management system, the implementation of multiuser editing, version control, and saving solutions, ensuring ease of use, and the inclusion of basic text and spreadsheet editing functions. The process goals focused on adhering to project deadlines, ensuring compliance with Scrum methodology standards, and meeting contemporary requirements for document management. Additionally, the goals included adhering to the budget, realizing the expected profit, and optimizing the utilization of resources.

As the culminating task of the Building phase, academics, supported by key internal stakeholders through semistructured interviews and workshop sessions, conducted a risk analysis encompassing various risk categories, including environmental, general project, commercial and financial, personnel, technical and outcome, and implementation risks. Each category was capable of containing multiple types of risks. For each risk, the risk factor was calculated based on the probability of occurrence and potential damage. Using the risk table, a risk portfolio was assembled. The risk portfolio visually highlighted the areas of the project that required special attention, as they could significantly influence the success of implementing the new methodology and regulations. However, it was determined that the project was overall low risk. Additionally, risk mitigation measures were developed.

To appraise the practical value of the designed and implemented tool, academics performed a cost–benefit analysis of SOFPRO’s entire deployment project (shown in Table 5), considering the wage costs for each activity within the project, such as research,

Table 5.
The detailed durations and costs of project activities

Activity	Duration (hour)	Costs (CT$)
The introduction of the project on Scrum and Google Docs	**173.5**	**3126.4**
Research activity	**150**	**2379**
Literature review	86	1363.96
Empirical analyses	64	1015.04
Planning	**1.5**	**23.8**
Preparation	0.5	7.9
Planning	1	15.9
Training	**21**	**645.4**
Preparation and completion of study material	16	254.4
Scrum training	3	234.6
Google docs training	2	156.4
Closure	**1**	**78.2**
Final meeting	1	78.2

Source(s): By authors

design, training, and the final meeting. The costs (duration) totaled 3,126.4 CT$ (173.5 h). As shown in the data of Table 4 (by the difference between the numbers in the second and last row from the last column), the company could achieve a 1,158.82 CT$ savings during a sprint, thereby gaining 350.06 CT$ by the end of the third sprint. The data demonstrate that the software company can gain 41.5 h of savings during a sprint over that achievable through the old process (160.4 h minus 118.9 h). Therefore, the payback time for the investment project in tool deployment is shorter after the fourth sprint.

The deviations of TPT and TPC are depicted in a decision tree in Figure A1 from the Appendix. Figure A1 shows that the least makespan and least cost are produced by Scrum and Google Docs. Academics revisited the company and conducted a post hoc analysis (see Table A4 in the Appendix), accounting for 38 development cycles from December 2017 to January 2020. As the performance results remained consistent, this analysis provided additional evidence of the practical durability of the designed and implemented tool. Table A4 indicates that although durations could be further reduced, the rise in salaries, reflecting the overall economic trends in Hungary, has resulted in higher costs.

7. Discussion and implications

In accordance with the final formalization of the learning stage in the ADR framework by Sein *et al.* (2011), sections 7.1 and 7.2 present the knowledge created for both theory and practice.

7.1 Implications for theory and research

By applying detailed ADR protocols, we contribute to the subtleties of the DC construct by exploring the emergence of technology-enabled DCs in a project-based company. With respect to ADR, problem formulation began with the detailed identification of the main organizational problem faced by SOFPRO. Researchers created the sample and the actual software development process that considers all relevant events, activities, and costs. The simulation exercise revealed significant disparities that necessitated effective remedies. Skilled academics with ample experience suggested replacing PRINCE2 with the Scrum methodology, a process technology. Managerial attention helped in the identification of both inefficiencies and business opportunities. As witnessed in this case, collaboration with external experts can boost the ability to recognize capability gaps and apply positive attitudinal modifications (Novak *et al.*, 2023; Ryan *et al.*, 2018) at the target firm. This step in the ADR process encompasses the sensing construct, as previously defined in section 2.1.

The building of the new problem-solving method centered on the development of a new Scrum-based release process supported by a document-handling mechanism, a tool designed for the client's practitioners, and subsequent testing. The simulation results revealed the reasons behind the application and signaled the improvement of the firm's technological competence. This step entailed scrupulous planning and learning efforts from the involved parties (Teece, 2007) and ensuring better structuration of processes through the aid of elaborate procedures and rules (Lin *et al.*, 2020). Knowledge-oriented leadership (Mariam *et al.*, 2022), managerial supervision (Augier and Teece, 2009; Teece, 2007) and thinking disposition (Helfat and Peteraf, 2015) buttressed this process. Building thus corresponds to seizing.

At SOFPRO, the intervention involved harnessing the tool developed in the preceding step. This application corresponds to the reconfiguration phase. Using data from actual process implementation, the calculations confirm the realization of anticipated organizational benefits, with further support from post hoc analyses. A cost–benefit analysis revealed a short payback time for the capability investment. Drawing from seminal conceptual works, Winter (2003) warns of the need to closely monitor the cost–benefit balance of investments in DCs. Helfat and Winter (2011) emphasize that the development of DCs must result in improved production. Therefore, an additional value of the designed and implemented tool for the target organization is the rapid payback time, which has often been overlooked in prior empirical DC studies. We reaffirm that the success of learning and knowledge integration are vital microfoundations in the reconfiguration process (Ellonen *et al.*, 2009; Ryan *et al.*, 2018; Teece, 2007). Additionally, Helfat and Peteraf (2015) underscored the significance of managers' cognitive capabilities in the reconfiguration process. In the SOFPRO case, the owner and general manager effectively communicated a clear vision, inspiring organizational members and endorsing the proposed tool.

Extending the earlier examination, the findings are consistent with previous research (Helfat *et al.*, 2007; Jones *et al.*, 2019; Teece, 2007), highlighting the pivotal role of DC in enhancing firm performance and profitability. Furthermore, the results align with the observations made by Drnevich and Kriauciunas (2011), indicating that complex and heterogeneous DC positively influences enterprise performance. Substantiating these findings, during follow-up interviews, SOFPRO executives confirmed the enhanced strategic latitude of the firm. Consequently, SOFPRO pursued a portfolio-broadening strategy, a noteworthy initiative for software firms (Fosfuri *et al.*, 2020; Sebrek, 2015), by diversifying its customer base. As the CEO aptly stated in the post hoc interviews, "*Now we can also compete in other GIS software niches, addressing utility companies and news portals, while retaining our foothold in our original market niches*."

Based on the aforementioned findings, the emergence of technology-enabled DCs was driven by the design steps in tool development, underpinned by the combined processes of sensing, seizing, and reconfiguring, along with their critical microfoundations, as delineated by Teece (2007) and Eisenhardt *et al.* (2010). Each capacity and its underlying microfoundations made a substantial contribution to value addition, subsequently resulting in sustained performance improvement for the target project-based firm. Importantly, this study shows how technology-enabled DCs were (co)designed and diffused in a project-based context, thereby addressing the tautological problem of reliably associating them with performance-enhancing change, a pervasive issue in the field (Arend and Bromiley, 2009; Hermano *et al.*, 2022; Stadler *et al.*, 2013). These findings directly address the study's research question.

The newly designed tool for the focal organization, SOFPRO, to address its operational problems combines the agile software development methodology, Scrum, with the application of the Google Docs document-handling method for better coordination. The results of this ADR study indicate that this introduced tool, a process technology, exhibits properties akin to those of technology-enabled DCs (Chen *et al.*, 2023; Mikalef and Pateli, 2017; Quayson *et al.*, 2023; Saeed *et al.*, 2023) and has the potential to deliver several benefits to the target organization within the context of projects. First, it significantly enhances the speed (Dykes *et al.*, 2019) of software development. Second, it disrupts the firm's existing operational logic (Teece, 2007) and routines (Zollo and Winter, 2002), consequently positively impacting the overall cost of the software development process.

A critical advantage of the tool lies in its capacity to eliminate redundant activities that fail to maximize business value throughout the software development process. This capability aligns with the elimination of non-value-creating activities in DC development, as observed by Bingham *et al.* (2015). Additionally, the combination of Scrum with document handling enhances strategic planning capabilities, thereby facilitating the smoothing of production capacity, as suggested by Helfat and Winter (2011), and expands strategic flexibility. Moreover, the tool directly enhances customer satisfaction and software engineer satisfaction.

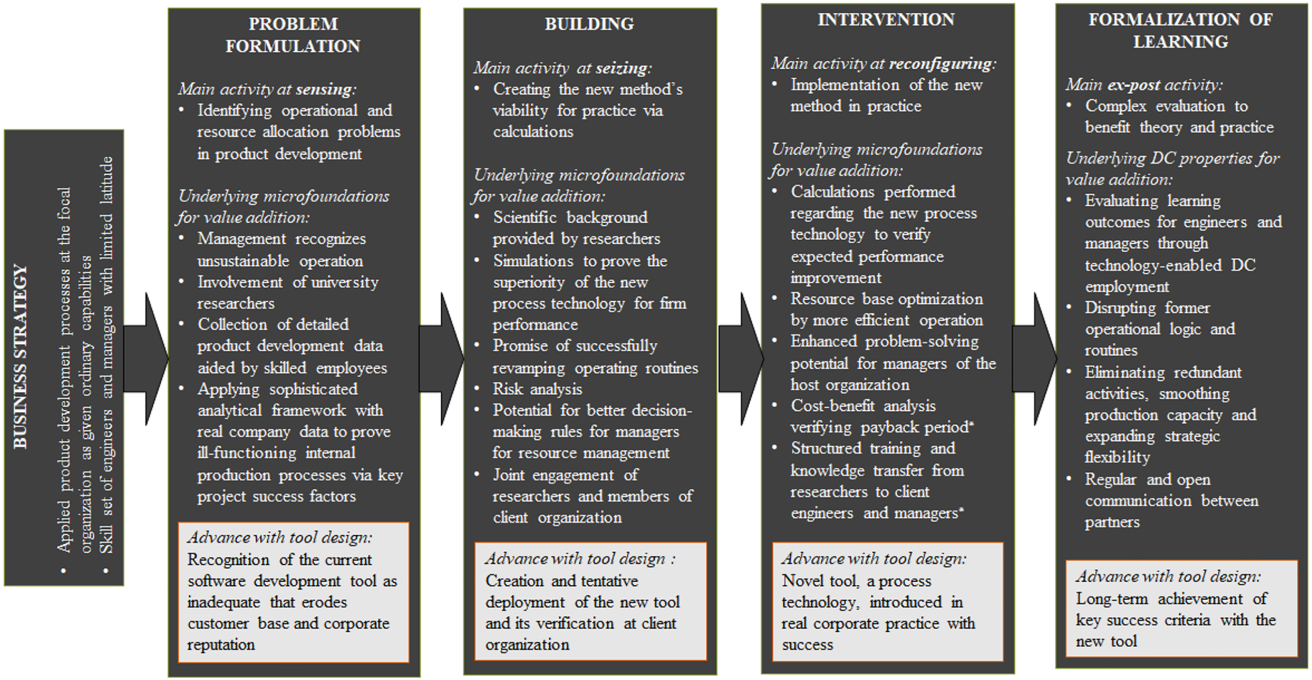
In summary, the SOFPRO resource base has significantly benefited from the reduced time and cost involved in GEOMAP software development. Moreover, through the rationalization process, valuable engineering resources have been freed up for new business endeavors. As a result, the designed tool addresses field problems analogous to those discussed by Sein *et al.* (2011), wherein the focal project-based organization can achieve procedural rationality.

As emphasized by Kay *et al.* (2018), the case presented here culminates in a highly relevant integrated model for managers, illustrating the guided emergence and mechanisms of technology-enabled DCs, as depicted in Figure 1.

7.2 Implications for practice

This paper makes notable practical contributions to the project management discipline by describing the optimization of the software development process in a project-based Hungarian firm. The SOFPRO company has recognized the need for the redesign of its slow and insufficient software development process and invited university researchers to assist in this process. First, the researchers started by conducting a thorough assessment and diagnostic of the company's initial software development process. Their evaluation identified areas of inefficiency and key issues such as slow release cycles, poor communication among the project team, inadequate testing procedures, and outdated project methodology.

Second, key employees at SOFPRO, along with action design researchers within the ADR team, collaborated to formulate a comprehensive research plan delineating its steps, methodologies, and timelines. They prioritized lessening the development cycle time and cost, improving collaboration, and enhancing customer satisfaction. To achieve this objective, collaborative workshops and training sessions were organized to share knowledge and best practices on modern software development methodologies. SOFPRO had a high level of confidence in the capabilities and expertise of action design researchers. The researchers were provided access to the necessary resources, relevant data, and software development tools. As emphasized in Sein *et al.*'s (2011) ADR framework, regular and open communication within the project team, including that of action researchers, enabled the



Note(s): *For simplification, the intervention stage depicted in Figure 1 encompasses reflecting and learning. For a more detailed discussion on this aspect, please refer to section 6
Source(s): By authors

Figure 1. The integrated model for the emergence of technology-enabled DCs through ADR

exchange of ideas, the sharing of progress, and the addressing of any concerns or questions. This transparency and trust in the skills and expertise of the researchers facilitated a clear understanding of the problems and potential solutions and allowed meaningful insights to emerge. The company had confidence that, with the researcher's assistance, they could attain actionable results in implementing novel process technology. The owner and the general manager of the examined company also showed strong dedication to the ADR process, which had a positive impact on its implementation and outcomes. It is sufficient to say that management demonstrated a full commitment to optimizing SOFPRO's software development process. The study confirmed that the support and determination of company leadership are crucial for the success of any initiative and enhance a firm's DCs (Augier and Teece, 2009; Mariam *et al.*, 2022). One of the key takeaways of this research for DC-seeking managers is the conscious process of complex strategic capability renewal (Farzaneh *et al.*, 2020), in which tolerance for all participants during capability dynamization bears fruit over time.

Since the company saw the new project methodology as promising and was convinced based on Atkinson's (1999) success criteria, the proposed project management methodology appears to have the potential to deliver the project on time, within budget, and with the desired level of quality. In addition to the increased efficiency aligned with strategic goals, stakeholders felt engaged and satisfied with the project results. Organizational learning was fostered: researchers provided training on the Scrum methodology and handling Google Docs related to the designed tool to enhance the skills of the development team, which benefited from professional learning and growth.

Finally, ADR, aided by guided emergence, yielded positive outcomes and contributed to the company's overall success in software development and the creation of technology-enabled DCs. The results of the study highlight the usefulness of Teece's (2007) sensing-seizing-transforming framework for establishing new processes and enhancing project performance. We demonstrated how ADR, through tool development and implementation supported by DC microfoundations, facilitated organizational learning in innovation projects. The involvement of researchers brought fresh perspectives and expertise to the company, fostering collaboration within the project team.

8. Concluding remarks, limitations, and suggestions for future research

The contribution to research and practice in project- and technology-enabled organizations is threefold. First, we extend, integrate, and apply DC perspectives within the project management context, aiming to (co)design and diffuse technology-enabled DCs to enhance project outcomes. Second, we illustrate the pivotal role played by sensing, seizing, and reconfiguring capacities, grounded in their microfoundations, in the transformation of operational routines to improve performance (Helfat and Winter, 2011; Teece, 2007; Teece *et al.*, 1997). Third, based on the findings, we emphasize the importance of technology-enabled DCs for value creation and performance, underscoring their relevance through a newly designed tool within project-based firms. While scholars (Cetindamar *et al.*, 2009; Subramanian *et al.*, 2011; Waleczek *et al.*, 2019) have explored various contexts for technology-enabled DCs, this research provides specific insights into their application within the unique dynamics of project-based organizations, particularly focusing on the design steps of tool development.

In terms of limitations, importantly, this study was conducted within a single company and industrial context. Therefore, generalizing the findings to a broader sample of firms and industries should be done cautiously. Additionally, the relevance and applicability of the simulation-based methodology employed in this study may be restricted to settings where the production process can be decomposed into discrete steps. A natural extension of this work would involve examining the economic and strategic value of technology-enabled DC formation using a longitudinal approach with a larger and more diverse sample. Such an extension would allow for a more comprehensive evaluation of the growth in strategic latitude and the relative organizational performance of project-based firms. We hope that this research will serve as a catalyst for future studies in this direction.

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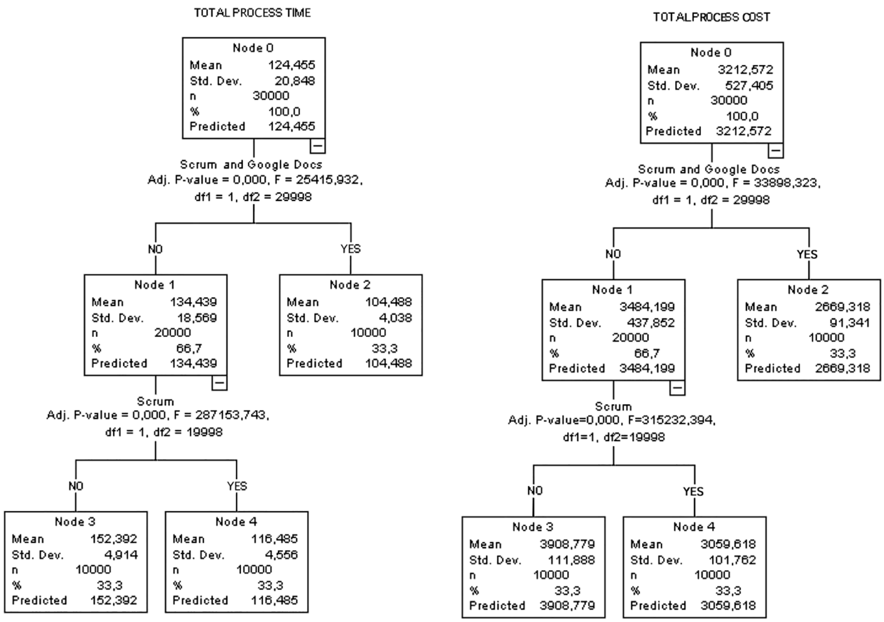
Appendix

The results of the employed classification regression tree (CRT) as a decision tree to compare TPTs and TPCs based on simulations (see Figure A1).



Source(s): By authors

Figure A1. The results of the classification regression tree (CRT) for TPT and TPC

ANOVA of the Scrum process based on 30,000 simulations (see Table A1).

Table A1. ANOVA table of simulation results based on the Scrum process

		Sum of squares	Degree of freedom	Mean sum of squares	*F* value	*p* value
TPT	Between groups	11,707,373.550	1	11,707,373.550	263,717.975	0.000
	Within groups	1,331,717.307	29,998	44.394		
	Sum	13,039,090.856	29,999			
TPC	Between groups	7,270,572,133.529	1	7,270,572,133.529	203,109.762	0.000
	Within groups	1,073,816,544.198	29,998	35,796.271		
	Sum	8,344,388,677.727	29,999			

Source(s): By authors

ANOVA of the Scrum-Google Docs process based on 30,000 simulations (see Table A2) (2015).

		Sum of squares	Degree of freedom	Mean sum of squares	F value	p value
TPT	Between groups	5,980,457.226	1	5,980,457.226	25,415.932	0.000
	Within groups	7,058,633.630	29,998	235.303		
	Sum	13,039,090.856	29.999			
TPC	Between groups	4,426,871,042.482	1	4,426,871,042.482	33,898.323	0.000
	Within groups	3,917,517,635.244	29,998	130,592.627		
	Sum	8,344,388,677.726	29,999			

Source(s): By authors

Table A2. ANOVA table of simulation results based on the Scrum and Google Docs process (2015)

ANOVA of the Scrum-Google Docs process based on 30,000 simulations (see Table A3) (2023).

		Sum of squares	Degree of freedom	Mean sum of squares	F value	p value
TPT	Between groups	5,672,342.532	1	5,672,342.532	25,120.234	0.000
	Within groups	7,011,331.422	29,998	233.727		
	Sum	12,683,673.954	29.999			
TPC	Between groups	5,221,673,044.134	1	5,221,673,044.134	34,395.356	0.000
	Within groups	4,817,111,253.299	29,998	160,581.081		
	Sum	10,038,784,297.433	29,999			

Table A3. ANOVA table of simulation results based on the Scrum and Google Docs process (2023)

Mean values of TPTs and TPCs in the validation phases (Table A4).

No	Events (E), Activities (A)	Mean durations (2015 May–2016 June) 17 cycles	Mean costs (CT$) (2015 May–2016 June) 17 cycles	Mean durations (2017 December–2020 January) 38 cycles	Mean costs (CT$) (2017 December–2020 January) 38 cycles
E1	New release developing phase has been started	0	0.00	0	0.00
A1	Sprint design: Designing initial features	1.4	50.08	1.3	67.26
E2	Initial features have been designed	0	0.00	0	0.00
A2	Sprint design: Design priorities (scores) of the functions	0.24	3.88	0.22	5.01
E3	Functions and their priorities are updated	0	0.00	0	0.00
A3	Specifying planned tasks and their allocation	0.24	3.88	0.23	5.02
E4	Planned tasks have been specified and allocated	0	0.00	0	0.00
A4	Specifying the development (and scheduling)* plan	2.1	51.85	2.2	95.45
E5	The development (and scheduling*) plan has been specified	0	0.00	0	0.00
A5	Complete task group 1	29.5	361.14	28.2	511.45
E6	Task group 1 has been completed	0	0.00	0	0.00
A6	Developer testing of the task group 1	15.3	181.35	17.2	208.25
A7	Complete task group 2	30.5	430.23	26.5	593.44
E7	Task group 2 has been completed	0	0.00	0	0.00
A8	Developer testing of the task group 2	15.2	221.12	16.1	352.34
E8	Developer testing status: there are no syntax errors	0	0.00	0	0.00
A9	Application user's test (testing phase I): reporting errors. Required new functions are scheduled into the new sprint	15.8	292.10	15.9	402.25
E9	Application user's test (testing phase I): all errors and required new functions have been reported. New functions are in the new sprint	0	0.00	0	0.00
A10	Fixing bugs and errors (testing phase I)	11.3	317.11	11.9	471.50
E10	Bugs and errors have been fixed (testing phase I)	0	0.00	0	0.00
A11	Developer tests and bug fixing (testing phase II)	7.7	191.60	7.1	245.14
E11	End of testing phase II.	0	0.00	0	0.00
A12	User end tests. Classifying reported errors. Prioritization	13.3	243.66	12.1	311.15
E12	End user tests have been terminated. There are no errors to be repaired	0	0.00	0	0.00
A13	Publishing the current release	0.3	4.00	0.4	6.64
E13	The current release has been published	0	0.00	0	0.00
A14	Final sprint meeting	3.6	292.15	3.2	345.67
E14	End of the final meeting	0	0.00	0	0.00

Source(s): By authors

Table A4. Mean values of real TPTs and TPCs of applied Scrum and Google Docs processes across different time periods

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