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Making or breaking the business case of digital transformation initiatives: the key role of learnings

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ABSTRACT

Purpose: The research aims to investigate how firms can develop their sensing capabilities for Industry 4.0 (I4.0) technology adoption through reframing their opportunity perceptions related to learnings from I4.0 initiatives.

Design/methodology/approach: The research follows a design science research (DSR) approach. Following the case of I4.0 technology introduction at a large food manufacturer, the paper develops a theoretical framework (artefact) and validates the applicability and efficacy of the framework within the case study.

Findings: The theoretical framework highlights the different temporal (short-term/long-term) and locational (direct/indirect) value dimensions of I4.0 opportunities. The findings show that the use of the framework can shift managers' perception regarding the business value of an I4.0 technology implementation. Specifically, the framework reversed initially negative perceptions around a narrowly scoped business case toward an opportunity-oriented attitude exploring further potentials of the technology.

Research limitations/implications: The research adds to the debate when and why firms engage in, and sustain their I4.0 initiatives by providing a novel perspective on firms' sensing capabilities. As a single-case study, the framework requires further validation in practice.

Practical implications: The proposed framework provides practitioners with an extended view concerning the potential value of digital transformation projects and serves as a conversational tool.

Originality/value: The presented wider frame for evaluating digital transformation projects, taking into account the more "intangible" value of their learnings, tackles the fundamental issue of translating explorative innovation efforts into exploitative value - a key challenge when dealing with innovation and one of the main barriers for the digital transformation.

Keywords: Industry 4.0, Innovation, Knowledge mapping, Learning, dynamic capabilities.

28 1. INTRODUCTION

29 In recent years, the Industry 4.0 (I4.0) agenda and the related integration of digital technologies in the manufacturing
30 domain have seen rapid growth (Liao et al., 2017; Ortt et al., 2020). This “industrial digital transformation” promises to
31 generate value through the achievement of operational excellence and by catalysing new, digitally enabled business
32 modes (Kagermann et al., 2013).

33 As such, I4.0 represents a paradigm shift that requires substantial rethinking of business models (Arnold et al., 2016),
34 supply chain organization (Hermann et al., 2019), and/or customer relations (Frank et al., 2019). In other words: a
35 radical change of perception regarding when and how business value is created (Müller, 2019). Yet, despite claims of
36 policy makers and consultancies regarding the benefits of adopting I4.0 technologies, research evidence on unequivocal,
37 positive effects of I4.0 on operational performance or other value creating areas is still scarce and scattered
38 (Kagermann, 2015; Müller and Voigt, 2018; Szász et al., 2020). More so, investigations in *how* business value is
39 created or increased through adoption of I4.0 technologies reveals a complex picture of interlinked, and interdependent
40 effects (Ghadge et al., 2020) and contingencies (Ghobakhloo and Fathi, 2019). Facing such high level of complexity in
41 a widely novel domain, many managers and executives are doubtful about the positive business case for I4.0
42 technologies in general (Pirola et al., 2019; Schmitz et al., 2019), or specific applications such as Industrial Internet of
43 Things (Müller and Voigt, 2018). Recent surveys by leading consultancy firms argue that the resulting uncertain
44 prospects of benefit realization from I4.0 technologies posit a key obstacle for digitalization initiatives across
45 manufacturers (PWC, 2018; Schmitz et al., 2019).

46 Research found that successful I4.0 adopters share a particular mind-set that enables them to venture into such
47 uncertainties. Authors described such firms as ‘entrepreneurial’ or exhibiting a ‘start-up mentality’ (Veile et al., 2020),
48 as focussed on innovation (Müller et al., 2018), or as characterized through enhanced ‘sensing capabilities’ (Demeter et
49 al., 2020; Teece and Linden, 2017). The underlying denominator of such successful adopters is thus their opportunity-
50 orientation, focusing on understanding, exploring, or discovering the potential of the technology (Bordeleau and Felden,
51 2019; Erol et al., 2016). Yet, such research merely illustrates that an opportunity-oriented attitude is a capability of
52 successful I4.0 adopters, but stop short on exploring how such capabilities emerge or can be fostered. Our research
53 therefore asks: *How can manufacturers develop an opportunity-oriented perspective for the adoption of Industry 4.0*
54 *technologies?*

55 To explore this question, we consider opportunity-orientation akin to the sensing capability in Teece’s (2007) dynamic
56 capabilities framework, as a capability that firms can deliberately develop. For the research we thus explored
57 behavioural interventions designed to change attitudes and perceptions of top managers, following a Design Science
58 Research (Hevner et al., 2004) approach. Specifically, we developed a framework to guide conversations about I4.0
59 initiatives in a manner that addresses opportunities that stretch beyond the direct and short-term impact of a specific
60 technology project – thus reframing the management team’s perception of innovation’s categorical boundaries
61 (Raffaelli et al., 2019). We tested the designed intervention with a large Scandinavian food manufacturer and observed
62 important changes in managerial conversations about the technology, namely through an increased discussion of future
63 potential value.

64 We thereby contribute to the growing literature on I4.0 implementation as a process that is contingent on organizational
65 and social developments, as much as on technical factors (Cimini et al., 2020; Frank et al., 2019). Specifically, we
66 provide empirical insights how manufacturers can hone their sensing capabilities through deliberate shifts in
67 conversational patterns. For practice, we present an easy to implement conversational tool that enable these shifts in
68 conversations toward an explorative and opportunity oriented perspective on the business value of a specific
69 technology.

70 2. THEORETICAL FOUNDATION

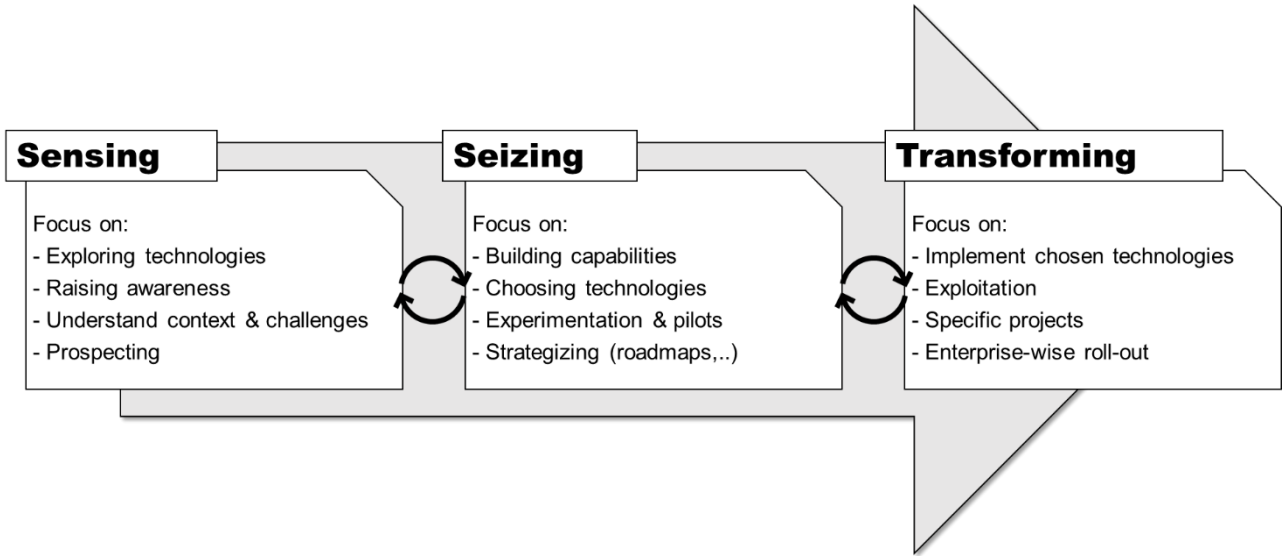
71 The Industry 4.0 (I4.0) agenda promises huge potential for transforming the manufacturing industry by increasing
72 efficiency, improving decision-making, and opening up novel ways for value creation and business model innovation
73 (Kagermann et al., 2013). Yet, many manufacturers seem hesitant in adopting I4.0 technologies (e.g. Moeuf et al., 2018;
74 Müller and Voigt, 2018; Pessot et al., 2020). Thus, research places increasing attention to the questions which types of
75 enterprises venture into digital transformation, and what characterizes those, that succeed (Ortt et al., 2020).

76 These questions shifted attention toward the interaction of technology with its social and organizational context (Frank
77 et al., 2019) and increased attention to the procedural nature of I4.0 adoption. Recent research has characterised I4.0
78 adoption as co-evolution of organizational structure and technology (Cimini et al., 2020), as organizational learning
79 paths (Tortorella et al., 2020), or as transformative organizational change processes (Erol et al., 2016). Several authors
80 suggested that dynamic capabilities theory is a suitable lens to explore and explain these processes (Demeter et al.,
81 2020; Ketonen-Oksi and Järvi, 2018; Teece and Linden, 2017).

82 2.1. Industry 4.0 adoption as expression of dynamic capabilities

83 Dynamic capabilities theory (Teece, 2007; Teece et al., 1997) provides a frame to study strategic reconfigurations of
84 firms in rapidly changing contexts, such as the development of the I4.0 agenda. Teece (2007) suggests three types of
85 interacting dynamic capabilities – sensing, seizing, and transforming – as characteristic of firms that achieve
86 competitive advantage in dynamic environments. This framework has recently been applied to study firms that
87 successfully adopted I4.0 technologies (Demeter et al., 2020; Ketonen-Oksi and Järvi, 2018; Teece and Linden, 2017).
88 Additionally, Bordeleau and Felden (2019) argue in their review of I4.0 literature, that models of organizational change

89 for digital transformation mirror the dynamic capabilities framework (**Error! Reference source not found.**).



90

91 *Figure 1 - Digital Transformation as interacting dynamic capabilities (adapted from Teece and Linden, 2017 and Bordeleau and*
92 *Felden, 2019)*

93

94 A particular focus of the literature on I4.0 adoption through a dynamics capabilities or organizational change lens rests
95 on sensing capabilities, in other words, a firm’s capability to sense and shape opportunities by scanning and interpreting
96 their context, and creating novel modes to engage. Erol et al. (2016) describes a phase of ‘envisioning’ in which
97 companies acquire technological and application knowledge through external experts, and interpret this new knowledge
98 as a contextualized vision for their digital transformation through internal discussion, collaboration, or co-innovation.
99 Ketonen-Oksi and Järvi’s (2018) action-based research on future-orientation highlighted the role of perceiving, and in
100 consequence prospecting opportunities related to adoption of new digital technologies. Less concerned with the micro-
101 foundations of sensing capabilities, Horváth and Szabó (2019) concluded that SMEs, which are less able to identify
102 opportunities from digital technologies, lag behind in I4.0 adoption. Conversely, other research found that enterprises
103 that have adopted I4.0 exhibit an opportunity-oriented “entrepreneurial spirit” (Veile et al., 2020) and are more oriented
104 toward innovations (Müller et al., 2018). Demeter et al. (2020) thus conclude that sensing capabilities play a – if not
105 always dominant – yet essential role for all stages of digitalization in manufacturing, with the “[m]anagers’ perceptions
106 [as] the main drivers of sensing capability” (p. 6).

107 Such insights align with general concepts from strategy and innovation management, which highlight the importance of
108 reframing the management team’s perception of innovation’s categorical boundaries (Raffaelli et al., 2019; Tushman
109 and Anderson, 1986) to explore opportunities beyond the existing systems. Thus, sensing capability, understood as the
110 capability to perceive, envision, or prospect opportunities related to novel digital technologies, is arguably a central
111 factor for enabling digital transformation. Yet, as we will highlight in the next section, I4.0 opportunities are – akin to

112 the uncertainty and complexity of any radical innovation (Cooper, 2011) – multifaceted, complex, and often not
113 obvious.

114 2.2. Opportunities of I4.0 – complex patterns of business value generation

115 The I4.0 literature uses the term opportunity widely (Horváth and Szabó, 2019), referring to a plethora of themes, from
116 new business models (Frank et al., 2019; Müller et al., 2018), over increased innovation capacity (Lasi et al., 2014), to
117 performance improvement (Kiel et al., 2017). What ties those ideas together is the notion that I4.0 technologies promise
118 the potential to maintain or increase business value in the future. We thus define opportunity for our purposes as an
119 *uncertain prospect of positive effects on business value*. Following March (1991), we consider such opportunities as
120 both exploitative, building on old “certainties”, and explorative, engaging new possibilities. Opportunity-orientation, in
121 turn relates to the organization’s ability to continuously explore, identify, articulate, and exploit such opportunities.

122 Several authors provide a cautious view on how and when such positive effects on business value can be expected
123 (Kagermann, 2015; Müller and Voigt, 2018). For example, Ghobakhloo and colleagues (Ghobakhloo and Azar, 2018;
124 Ghobakhloo and Fathi, 2019) have challenged the – possibly naïve – notion that there is a direct link between
125 digitalization and business performance, pointing to enabling and impeding contextual factors of the organization, such
126 as organizational structure or pre-existing IT capabilities. Moreover, studies into the causalities of business value
127 creation through digital technologies, such as Ghadge et al. (2020), highlight the complex dynamics through which
128 individual or coupled new digital technologies affect business value. Other studies, such as Cimini et al.’s (2020), point
129 to the co-evolving nature of technology and organizational factors that enable its value creating deployment. Thus, I4.0
130 opportunities appear as a complex narrative of dynamically interacting technological, organizational, and human
131 components (Dregger et al., 2018; Oks et al., 2017) – often changing not only tasks, roles and processes through
132 technology, but also rooting deeper in changed business models (Frank et al., 2019; Müller, 2019) or organizational
133 identity (Wessel et al., 2021).

134 These complex and dynamic interactions render I4.0 opportunities uncertain in three aspects: (1) Expected outcome, (2)
135 Temporal scope, (3) Application scope.

136 (1) Expected outcome: The complexity through which digital technologies may interact with numerous technical,
137 organizational or strategic elements of the organization (Ghadge et al., 2020) limit the possibilities to predict the impact
138 of the technology on performance in specific application areas. Overwhelmed by the vast number of potential
139 technologies, organizations moreover struggle in selecting those that might be most favourable for the specific problem
140 and context (Bosman et al., 2020). Finally, as a still “young” agenda, organizations lack experience to make reasonable
141 assumptions about the potential expected outcomes. Consequentially, managers often lament the unclear business case
142 for a specific technology (Schmitz et al., 2019), or cannot perceive clearly the economic benefits of an I4.0 initiative
143 (Pirola et al., 2019).

144 (2) Temporal scope: Digitalization processes often pass through an extended phase of exploration and experimentation
145 with no immediate contribution to business performance (Erol et al., 2016; Ganzarain and Errasti, 2016). The
146 exploitation of the technology with direct benefits to conventional measures of operational performance thus follows

147 only years after the initial exploration of the technology (Szász et al., 2020). Thus, digitalization processes are uncertain
148 regarding when they will generate business value.

149 (3) Application scope: With the wide reaching implications of novel digital technologies on tasks, processes, structures,
150 and business models, the value generating potential of any such technology is typically not bound to a singular
151 application area. Longitudinal studies on I4.0 adoption in single organizations, such as those by Demeter et al. (2020) or
152 Cimini et al. (2020), illustrate how organizations over time identify additional and unexpected application areas for a
153 specific technology. Innovation studies recognize such “application richness” as potential for further innovation in other
154 domains, enabled by the learnings from the initial experimentation with the technical innovation (McGrath, 1997; Rice
155 et al., 2001). Additionally, learnings from experimentation with I4.0 innovation can supporting further innovation
156 activities at a higher maturity level and, hence, the progression of an organization towards more long-term strategic
157 goals such as servitization. However, the specific potential for extended application, and which of these applications
158 eventually will contribute to business performance and value, are uncertain at the outset of the I4.0 journey.

159 Taken together these uncertainties make the adoption of I4.0 a risky undertaking, which may impede the willingness
160 and ability of companies with less resources to take these risks (Bosman et al., 2020; Buer et al., 2020). Yet, such a
161 conventional risk/benefit perspective on digitalization technologies is unlikely to be suited for adoption decisions
162 around novel I4.0 technologies. Connecting back to the idea that I4.0 adoption requires sensing capabilities, grounded
163 in exploration, experimentation, and prospection, organizations may be better advised to embrace and open-mindedly
164 investigate these uncertainties (Ketonen-Oksi and Järvi, 2018), than rationalizing them through conventional business
165 cases. In the following, we will develop a theoretical framework that may enable such a focus shift by expanding the
166 vision beyond a narrow project business case. Thereafter, we report on the effects of the application of the framework in
167 a real-world digitalization initiative.

168 3. RESEARCH APPROACH

169 Teece (2007) argues that firms can develop and hone their dynamic capabilities. Thus, our research approach is interested
170 in interventions through which firms can develop their sensing capabilities. To structure the development of such
171 theoretically grounded interventions, ensuring both their academic rigor and practical relevance, we adopted a design
172 science research (DSR) framework (Hevner et al., 2004). This research approach aims at supporting researchers in the
173 generation of instrumental knowledge – such as theoretical frameworks - intended for helping practitioners in addressing
174 empirical problems (Boer et al., 2015; Boyer and Swink, 2008; Holmström et al., 2009; van Aken et al., 2016) such as
175 the one we are addressing.
176

177 The DSR framework structures the research process as starting with a novel and relevant pragmatic problem coming from
178 the environment. The first phase of this research process is abductive: the researcher aims at solving the initial problem
179 taking advantage of existing knowledge and, due to its novelty, introducing a creative element. This is expected to lead
180 to the generation of “new knowledge”, under the form of artefacts, such as a new theoretical framework. The second
181 phase is deductive, validating the proposed artefact through tests in practice (Hevner et al., 2004; Holmström et al., 2009;
182 van Aken et al., 2016).

183 The research took place as a single case study in a Danish-based multinational food manufacturer. The firm experienced
184 issues with the rollout of a digital transformation project, connected to a perceived unclear – if not negative – business
185 case when assessing the initiative only regarding the specific addressed issue. The case company thus is illustrative for
186 investigating the phenomenon of unclear business cases as barriers to I4.0 adoption (Pirola et al., 2019; Schmitz et al.,
187 2019), making it a suitable example for developing and testing the artefact. As a phenomenon that is relatively novel in
188 academic discourse and deeply entangled with its organizational context, a single case study is thus an adequate research
189 approach (Yin, 2009) despite its limitation in generalizability. Specifically, the close collaboration with the firm allowed
190 developing rigorous problem understanding and analysing the effect of the artefact in detail.

191 We used only primary data from our direct and continuous observations from the digitalization project. Two researchers
192 collaborated with company practitioners on the development of the technical innovation, where they collected data on
193 main discussions and events surrounding the project on a continuous basis in two research diaries. Additionally, these
194 two researchers documented two workshops with a wider stakeholder participation through independent notetaking.
195 Supported by a third researcher without affiliation to the company and project (an “outsider” according to Fetterman,
196 2010), the research team continuously reviewed and discussed the collected data to ensure completeness and to align a
197 common understanding of the collected observations. Based on the collected data, the research team discussed how the
198 company practitioners discussed and perceived opportunities associated with the innovation, and – through iterations
199 between literature and our observations – thus developed the framework intended to create opportunity orientation in their
200 discussions. We validated our emerging framework through confrontation with all involved stakeholders during the
201 course of the project (Yin, 2009). This happened through ongoing discussions of the findings with key actors of the
202 digitalization project.

203 For our framework building, we started with a fundamental assumption: learnings obtained from explorative innovation
204 initiatives can be applied elsewhere, and through their application in other contexts, these learnings may increase the
205 value of the original initiatives. By shifting attention toward the value of learnings and long term value of an explorative
206 innovation, we would expect that decision teams could better appreciate the potentiality for value creation, thus increasing
207 their capability to sense opportunities associated with the innovation. To operationalize and test this fundamental
208 assumption, we wanted to develop and test a framework that facilitates identifying and formulating future business
209 opportunities (the exploitative potential) related to learnings obtained during an explorative project. The development of
210 the theoretical framework subsequently connected elements of uncertainty concerning I4.0 opportunities with insights
211 from the innovation literature for facilitating the identification of novel business opportunities. We iteratively developed
212 first elements of the framework, specifically the locational and temporal dimension of I4.0 opportunities, and then
213 aggregated them in our two-dimensional framework (‘digital transformation focus-shift matrix’)

214 To validate the theoretical framework in its context, we defined two validation criteria: (A) Applicability: Does the
215 theoretical framework enable the identification of business opportunities related to an innovation project? (B)
216 Effectiveness: Does the use of the theoretical framework lead the company towards increased support for digital
217 transformation initiatives? The Applicability criteria (A) required that the framework can be applied in its entirety in an
218 industrial setting, specifically that all involved stakeholders can understand and independently adopt the framework and
219 its underlying concept. The effectiveness criteria (B) requires that the adoption of the theoretical framework can shift the

220 perception of the involved stakeholders regarding the innovation project’s business case, i.e. considering not only one,
221 but a multiplicity of opportunities related to the digital transformation initiative.

222 We validated the framework in the course of two workshops involving all the stakeholders that previously took part in
223 the innovation project (including the researchers). During the first workshop, the researchers presented a mapping of
224 learnings from the digitalization initiative. The stakeholders first discussed those proposed learnings, and explored,
225 second, their potential applicability in the company against the two dimensions of the framework – locational and
226 temporal. In the second workshop, the involved stakeholders discussed against the dimensions of the framework how the
227 additional applications of such learnings and the related business opportunities were affecting the business case of the
228 innovation initiative. We used observations from the workshop, and post-hoc reflections of stakeholders on the workshop
229 to assess the validity of the framework against the defined criteria of applicability and effectiveness.

230 4. DEVELOPING THE DIGITAL TRANSFORMATION FOCUS SHIFT FRAMEWORK

231 In section 2, we have established that opportunities of I4.0 technologies are uncertain regarding their outcome, their
232 temporal scope, and their application scope. In consequence, the potential business value of a novel technology – and
233 the costs associated with capturing such value – are difficult to assess by means of conventional business cases. Hence,
234 instead of merely expanding the business case template by new metrics, we suggest that decision-makers require a
235 fundamental focus-shift to judge the overall potential of a specific I4.0 technology – a shift toward opportunity-
236 orientation that potentially enhances their sensing capabilities. In the following, we develop a theoretical framework for
237 such a focus-shift.

238 According to the DSR framework, adopted in this research, our framework addresses a practical issue by building on
239 extant knowledge. More specifically, we build on the previously identified types of uncertainty of I4.0 adoption
240 opportunities and insights on value generation from the innovation literature. Thus, we first introduce different value
241 categories associated with innovations, and map them against the uncertainties of I4.0 adoption. This allows us to
242 introduce novel perspectives on locational uncertainty (Where is value generated?; Figure 2) and temporal uncertainty
243 (When is value generated?; Figure 3). Finally, we combine these two uncertainty dimensions by outlining a progression
244 that enables a holistic business case evaluation (Figure 4).

245 4.1. Categories of value generation through innovation

246 Business opportunities related to I4.0 innovations expand beyond the mere adoption of an innovation to solve specific
247 and well-defined problems (Cimini et al., 2020; Demeter et al., 2020). Innovation management literature suggests that
248 innovation provide additional value, on one hand, through its potential application to address additional issues (Bowman
249 and Hurry, 1993; McGrath, 1997; Rice et al., 2001) and, on the other, its use to catalyse and support further innovation
250 (Rice et al., 2001).

251 Reflecting these insights against our observations in the case, we defined three distinct “value categories” to compose our
252 theoretical framework. Each value category represents one aspect how innovation initiatives and the related learnings can
253 create business opportunities. These are:

- 254 • Problem solving: The ability of the digital transformation initiative to effectively address the initial problem
255 which triggered it;
- 256 • Extended potential: The potential applications of the digital transformation initiative – or of its learnings – to
257 address other problems, either supporting the pursuit of the original performance objective or generating value
258 in other directions;
- 259 • Innovation: The use of the learnings obtained through the digital transformation initiative to support further
260 transformation initiatives, possibly aligned with a company’s strategic direction and goals, acting as a foundation
261 for maturity growth.

262 4.2. Localization of value: the concept of business case ecosystem

263 Following the outlined value categories, we conclude, in accordance with the idea of localization uncertainty, that the
264 benefits of such projects often materialize well beyond the original scope. Thus, the localization and attribution of value
265 require contextualization of the innovation project in its wider environment.

266 To enable such contextualization, we propose the use of the ecosystem analogy, increasingly popular in innovation studies
267 (Gomes et al., 2018). The ecosystem view aims to capture value creation stretching beyond the original organizational
268 boundaries (Kapoor and Lee, 2013). For example, Venkatraman et al. (2014) conceptualize digital business innovations
269 as pertaining to platforms of initiatives and actions within and across organizations. In the same way, we argue that digital
270 transformation initiatives typically are set up within specific boundaries, such as defined purposes, budgets, teams,
271 schedules, and the like. Nevertheless, such initiatives heavily interact with their environment, through social relations,
272 the use of shared resources, the use of knowledge, and so forth. Moreover, any digitalization project is likely to contribute
273 to broader strategic programme capturing numerous organizational initiatives (Ghobakhloo, 2018). Thus, we can consider
274 even purely intra-organizational digital transformation projects as pertaining to an ecosystem of other projects with
275 individual business cases.

276 Using the ecosystem analogy (Figure 2), we thus can extend the value propositions included in the business case of a
277 digital transformation project. On one hand, value can then be direct, addressing the issues and the performance objectives
278 that triggered the digitalization project and the development of a solution (thus considered in the conventional assessment
279 of a business case). On the other hand, value may be indirect, or addressing additional issues and contributing to different
280 performance objectives, but still generating valuable effects beyond such localized boundaries. Indirect value could have
281 either a mono-directional or a dynamic relation with the developed solution: take advantage of the solution and,
282 potentially, providing inputs to catalyse its further development.

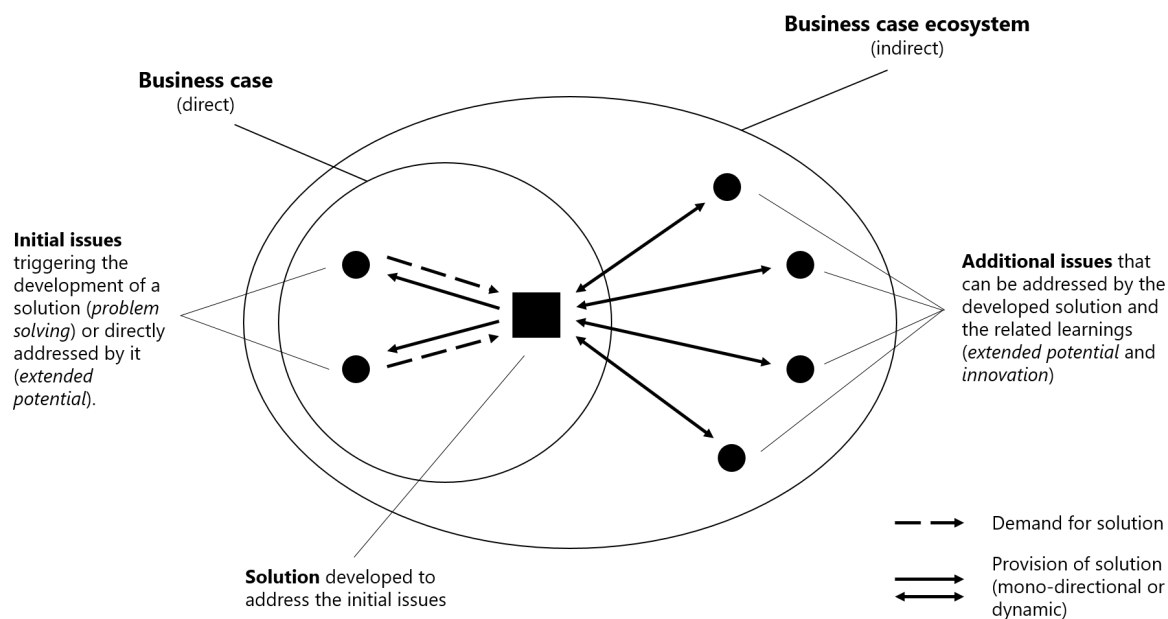


Figure 2 - Local dimension of value in innovation initiatives: The business-case ecosystem

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286 While indirect value can have tangible financial effects in terms of efficiency increases, cost savings, and so forth, they
 287 are often not present in the initial evaluation of an innovation project, or even fully realized at the end of a project. Hence,
 288 to evaluate the value of a digital transformation project in its entirety, the appraisal needs to capture both the direct and
 289 the indirect value related to the project. Thus, to argue for its business case, the discussion should reflect a whole spectrum
 290 of projects and related improvements that may benefit from the learnings obtained from the initiative. We argue that the
 291 adoption of this ecosystem perspective would, most likely, support the perceived economic feasibility of digital
 292 transformation projects.

293 4.3. Timing of value: the temporality of innovation projects

294 Radical innovation – such as I4.0 technology adoption – often has year-long cycle times, leading to substantial time-lags
 295 between deployment of the innovation and value capture, and unclear value paths linking the innovation and later captured
 296 business value (Paulson et al., 2007). Thus, in a context where most conventional projects are appraised based on hard
 297 metrics such as return on investment, the lagging value of innovation projects becomes harder to discern. In the
 298 manufacturing domain, with relatively stable conditions, the temporal focus is highly skewed towards the exploitative,
 299 short-term perspective (March, 1991; O’Reilly and Tushman, 2013). This focus manifests through an orientation towards
 300 continuous improvement. Yet, digital transformation as a radical innovation may require more time due to their (often)
 301 explorative nature.

302 To enhance an organization’s ability to appraise the value of a digital innovation holistically, interventions, thus, need to
 303 tackle time directly. By changing the temporal perspective, innovation projects are not *either* short-term, measurable and
 304 predictable, *or* long-term, fuzzy opportunity engines, but often both. Consequentially, our theoretical framework is
 305 designed to take into account the temporal dimension and relates it to the different value categories (Figure 2).

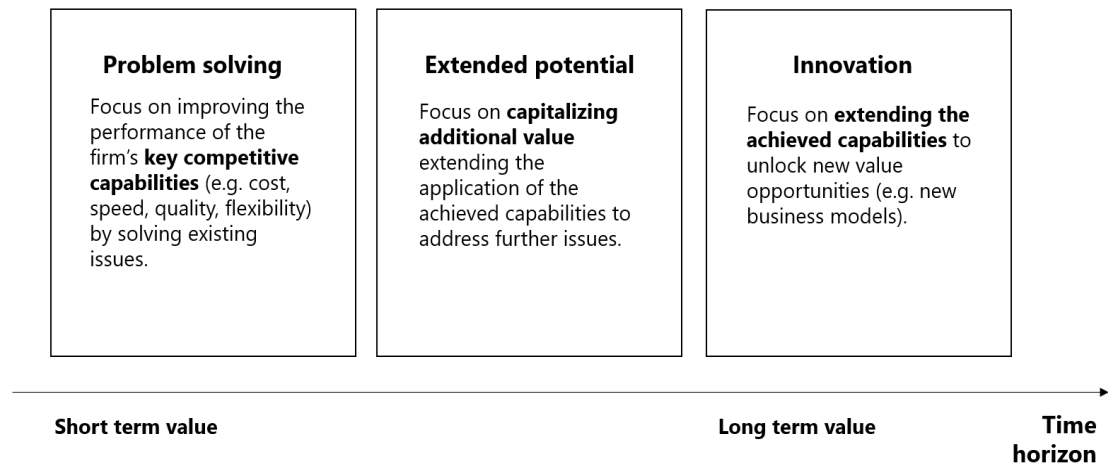


Figure 3 - Temporal dimension of value in innovation initiatives

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In summary, we argue that an innovation project may start from a well-defined problem, but can end up looking (and bringing value) further in time. However, looking further requires a different understanding of value as something that is not necessarily measurable just yet. Therefore, to holistically appraise an innovation project, decision-makers need to consider both the short-term effects on known issues and the potential long-term effects of future opportunities – whether know or unknown - generated through the innovation project.

4.4. The digital transformation focus-shift matrix: going beyond problem solving

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Taking into account the three value categories we proposed and relating them to the two dimensions– temporality and localization –, we can outline a matrix, which is describing our digital transformation focus-shift framework and, more specifically, how the managerial focus can shift beyond problem solving (Figure 4).

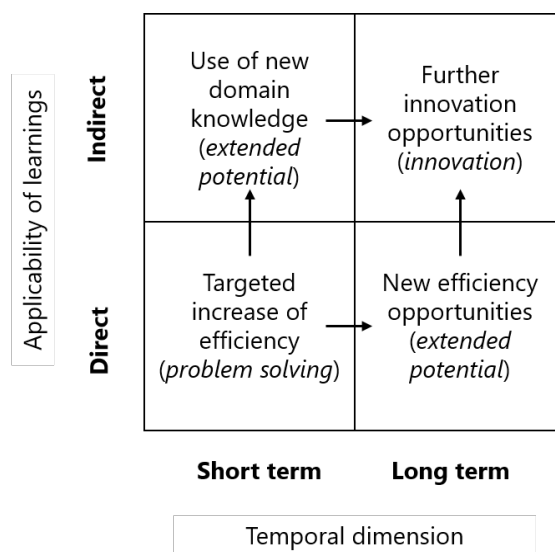


Figure 4 - Digital transformation focus-shift matrix

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321 Starting from the initial problem solving focus, typical for innovation projects directly targeting a specific performance
322 objective and the increase of efficiency in its regards, we suggest three additional value areas. These concern the
323 application of the learnings obtained through the digital transformation project for capturing additional value, either
324 directly or indirectly and either in the short- or long-term.

325 The use of *new domain knowledge* relates to the foreseeable, short-term application of the learnings - obtained during the
326 digital transformation project from extensively working, for instance, with a specific technology - to address other issues
327 and different performance objectives. As this would not contribute to the improvement of the specific performance
328 objective that initially triggered the project, the related business opportunities are only indirectly supporting the business
329 case of the digital transformation initiative. Nevertheless, it is worth considering that such support is obtained through the
330 deployment of learnings (e.g. technological or organizational capabilities) that have already been obtained and, therefore,
331 does not require further development investments.

332 The *new efficiency opportunities* relate to initially unknown value creation potentials emerged from the digital
333 transformation project (and from working with the addressed issue) and with an effect on the initially targeted
334 performance objective. While these may require further development of the obtained learnings to capture such new
335 efficiency opportunities – hence a long-term horizon – it would also directly support the business case concerning the
336 digital transformation project.

337 The *further innovation opportunities* concern the role of the obtained learnings in acting as a building block for generating
338 further and more complex learnings, increasing the digital maturity of the company and making it possible to tackle more
339 (e.g. technologically) advanced and ambitious projects. On one hand, the development and use of new domain knowledge
340 act as a starting point for further innovation. The recognition of novel issues to be addressed with the obtained learnings
341 may provide inspiration for further innovation, highlighting new potential problems to be addressed and directing the
342 innovation path towards them. On the other hand, the identification and capturing of new efficiency opportunities as it
343 drives the further development of the obtained learnings facilitates the innovation progression (i.e. by progressively
344 extending technological or organizational capabilities). If to be captured, the value of further innovation opportunities is
345 certainly linked to a long-term horizon. This would make it an indirect contributor to a digital transformation project's
346 business case. Nevertheless, such value contribution is certainly challenging to quantify. While organizational decision-
347 makers may be aware of past examples, these do not provide a robust indication of value magnitude of future business
348 opportunities. If this makes their potential value less tangible, it is also true that to continuously pursue them remains
349 crucial for the digital maturity progression of a company – ultimately for its digital transformation (Colli et al., 2019a).

350 We do not intend this theoretical framework as a template for business case appraisal for digitalization projects, but rather
351 as an enabler for organizations to review and adapt their current practices of project appraisals. By identifying how they
352 reflect different value categories in their practices, processes, and routines, they can consciously shift their focus allowing
353 more balanced evaluations of digital transformation projects.

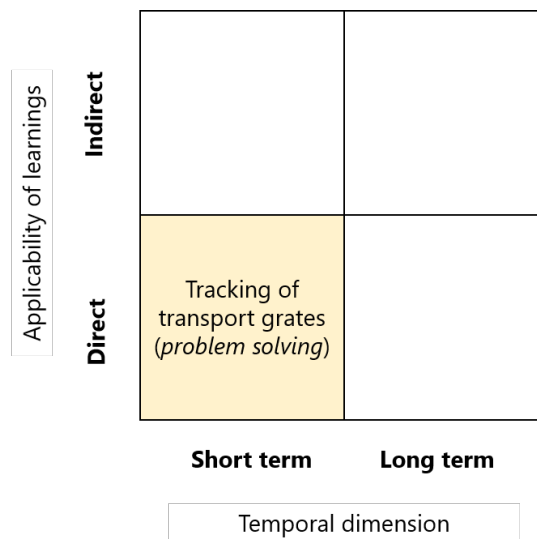
354 **5. ARTEFACT DEVELOPMENT IN CONTEXT**

355 Following the DSR framework (Hevner et al., 2004), we iteratively developed and validated the proposed theoretical
356 framework in an industrial setting against the validation criteria we preliminarily specified (applicability and
357 effectiveness, as defined in Section 3).

358 **5.1. The industrial case**

359 We developed the theoretical framework in the context of a Danish-based multinational organization, operating
360 worldwide in the food sector. In collaboration with a Danish technology provider and Aalborg University, the company
361 started a digital transformation project with the intention to reduce its operational costs. This project had been
362 preliminarily scoped by the company around the loss of transport grates, metal structures on wheels used for collecting
363 and transporting products within and outside company premises. The quantity of lost transport grates had a significant
364 impact on operational costs, both directly – related to the need for buying new grates – and indirectly – related to
365 production efficiency loss due to their unexpected unavailability. The main hypotheses regarding the nature of the issue
366 were (1) that these grates were forgotten on the outskirts of customers’ warehouses and (2) that competitors were using
367 these grates for their own external or internal logistic activities.

368 The project stakeholders agreed to address the problem investigating the development of an IoT based solution capable
369 of tracking them and, more importantly, of providing the company with data about their location. This need for
370 transparency across the company’s supply chain implied the availability of data concerning both the identity and location
371 of each transport grate. This would give the company the chance to both quantify the temporarily unavailable grates,
372 regulating production processes accordingly, and to identify and locate the “lost” ones. A key success requirement for the
373 project and the to-be developed IoT solution was, in addition to its effectiveness in addressing the problem (i.e. problem
374 solving; Figure 5), the presence of a positive business case.



375

376

Figure 5 - Initial digitalization initiative focus

377 The digital transformation project has been structured around an agile approach based on design thinking and divided into
378 two demonstration cases (i.e. iterations). The second demonstration case was intended as a chance to refine the solution
379 developed in the first one – if successful – or to develop a different solution – if not.

380 The two demonstration cases involved two company representatives (i.e. digital strategy manager and plant manager),
381 responsible for the provision of case-specific information, four engineers – including the project manager - from an
382 external technology provider, responsible for the provision of technical knowledge and for the technical development of
383 the solution, and two researchers (i.e. two of the authors of this paper) engaged in the Industry 4.0 agenda, responsible
384 for the provision of knowledge concerning innovation, operations and supply chain management.

385 5.2. Problem solving and the business case challenge

386 The first demonstration case led to the development of a solution that involved the deployment of GPS sensors
387 transmitting data over Sigfox (i.e. a communication service) in order to track the transport grates across the company's
388 supply chain and making it possible for the company to reach out to the ones that had not been returned. The solution
389 successfully addressed the initial issue by generating visibility concerning the transport grates' location. In addition to
390 that, its testing verified the initial hypothesis concerning the illegal use of transport grates by competitors. However, even
391 assuming a 100% reduction of the transport grates loss, the cost of the proposed solution was perceived as too high.

392 The second demonstration case was, therefore, focused on the development of an alternative solution, based on a cheaper
393 technology. The technology provider suggested Bluetooth 5.0 and 5.1 (BT5.0 and BT5.1) due to its lower cost, combined
394 with Node-Red (i.e. a cloud platform) for processing and visualizing the collected data. However, due to the characteristics
395 of the selected technology (i.e. shorter data transmission range), the second demonstration cases focused on tracking
396 transmission grates within the company's premises. This enabled the provision of a count of the available ones, addressing
397 the indirect cost caused by the loss of transport grates (i.e. production efficiency loss). While it was not possible to quantify
398 it due to the lack of data, the estimated business case concerning the solution developed in the second demonstration case
399 was still perceived as negative.

400 The involved management representatives considered the performed digital transformation project as not successful from
401 a financial perspective: it did not convince the company stakeholders to implement the developed solution. If the
402 developed solutions were capable to address the problem effectively, the perceived value potential was not enough to
403 justify the investment. Nevertheless, the project generated a number of leanings.

404 5.3. From learnings to business opportunities: shifting the focus towards extended potential and 405 innovation

406 To explicate the learnings obtained from the project, and thus be able to reflect upon their potential value, we initially
407 mapped them, isolating the single functions that the developed solutions were able to perform. These concerned:

- 408 • The automatic tracking of the grates, including identity and location data (i.e. using GPS technology outside the
409 company – demonstration case 1 – and BT5.0 and 5.1 technology inside the company – demonstration case 2)
- 410 • The automatic transmission of tracking data within or outside the company (i.e. through Sigfox for GPS sensors
411 or Node-Red for BT5.0 and 5.1 sensors)

- 412 • The analysis and visualization of tracking data to provide information concerning the identity and location of the
413 tracked grates (i.e. Node-Red)

414 We presented these learnings to the involved stakeholders during a first workshop - to be validated - after presenting them
415 the “digital transformation focus shift” theoretical framework. The workshop participants discussed the potential
416 applications of the learnings in a brainstorming session, taking into consideration the different value categories included
417 in the framework and the related value applicability and temporality aspects.

418 The discussion initially concerned the use of the learnings to address additional issues (i.e. extended potential). On one
419 hand, these represent well-known issues indirectly affecting the performance objectives and that could have been
420 immediately addressed (i.e. in Figure 6: use of new domain knowledge, indirect value applicability and short-term
421 perspective):

- 422 • The automation of the (currently manual) check-in and check-out processes each transport grate has to go
423 through when transported. To equip delivery trucks with GPS sensors and grates with BT5.1 sensors would make
424 it possible to recognize when, where and which grates are delivered and taken-back. This would improve the
425 process speed and, indirectly, affect its cost;
- 426 • The optimization of the material flow within the warehouse. To equip a pool of grates with BT5.1 sensors would
427 make it possible to study their usual movements within the warehouse. This would improve the process speed
428 and, indirectly, affect its cost.

429 On the other hand, the discussion touched on novel issues – to be addressed in future applications or extending the
430 obtained learnings - that emerged during the project and that directly affected its performance objective (i.e. in Figure 6:
431 new efficiency opportunities, direct value applicability and long-term perspective):

- 432 • The elimination of the (currently manual) order labelling on the grates and the related need (and cost) for
433 dedicated resources (i.e. man-hours), as each grate would be identifiable by a BT5.1 tag: it would hence be
434 possible to build a more comprehensive IT system that digitally matches the grate to a specific customer order;

435 After that, according to the “digital transformation focus-shift” theoretical framework, the discussion was focused on how
436 these learnings and their additional applications (i.e. extended potential) could have supported further innovation projects,
437 part of the current company strategy (i.e. innovation). This discussion highlighted the following possibilities (Figure 6):

- 438 • The introduction of autonomous guided vehicles (AGVs) for automating internal logistics, due to the need for
439 precise tracking of the position of the grates, enabled by BT5.1 sensors;
- 440 • The introduction of an as-a-service business model to capitalize on the use of the transport grates by competitors,
441 catalyzed by the traceability of the grates at a national level enabled by GPS sensors.

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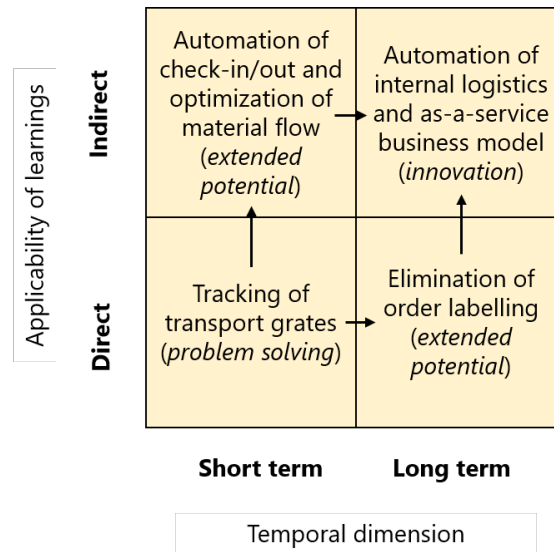


Figure 6 - Final digitalization initiative focus

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446 After the workshop participants had discussed these business opportunities linked to the additional application of the
 447 learnings obtained from the digital transformation project, their perception of the technology’s business case eventually
 448 changed. The company stakeholders organized a second workshop for discussion with the company’s top management
 449 as well as managers from another plant, which were suffering from the same issues. All the involved stakeholders agreed
 450 that, although the business case was perceived as negative when related to the initial problem only (i.e. problem solving,
 451 Figure 5), it became interesting once the focus was including the larger applicability spectrum of the developed solutions
 452 and of the consequential learnings (i.e. extended potential and innovation, Figure 5). In consequence, the company decided
 453 to immediately deploy the first solution (first demonstration case) on a temporary basis, to study the movements of a
 454 small batch of transport grates and identify patterns concerning their loss. In addition to that, they decided to further
 455 investigate the second solution (second demonstration case) in regards to its additional application cases, to provide
 456 additional support to the business case before discussing its potential scaling.

457 5.4. Validation of the artefact in context

458 The proposed theoretical framework satisfied both validation criteria (A, applicability and B, effectiveness). Regarding
 459 criterion A, the theoretical framework proved to be applicable in an industrial setting as, after the researchers presented
 460 it, the company stakeholders adopted it as a starting point for brainstorming the potential applications of the learnings
 461 from the digital transformation project. Moreover, they repetitively commented on its usefulness in widening the
 462 evaluation perspective when dealing with innovation projects, demonstrating their understanding of the concept behind
 463 it. Regarding criterion B, the framework enabled a shift of perception concerning the business case of the digital
 464 transformation project due to the consideration of the identified additional business opportunities - both short- and long-
 465 terms as well as direct and indirect. These had been included in the updated assessment of the digital transformation
 466 project’s business case and led to the eventual decision to proceed with the project.

467 6. DISCUSSION

468 The industrial case engaged for the testing of the proposed theoretical framework provided a tangible example of how the
469 presence of an unclear business case – and, more importantly, its perception as a negative one - acts as a barrier for the
470 adoption of digital technologies. Thus, the case provided three central findings. First, unexpected novel business
471 opportunities emerge over time in digital innovation projects. Second, these business opportunities can be identified and
472 articulated through learnings obtained from the innovation project itself - thus increasing the firm's sensing capabilities.
473 Third, these increased sensing capabilities change managers' perception of the technology's business case.

474 The testing of the “digital transformation focus shift” framework in the industrial case highlighted how the theoretical
475 framework facilitated the recognition of multiple business opportunities, thus increasing the firm's sensing capability.
476 While the hidden value potentially of innovation is widely documented in both the I4.0 literature (Cimini et al., 2020;
477 Demeter et al., 2020; Ghobakhloo, 2018) and general innovation literature (Paulson et al., 2007; Rice et al., 2001), the
478 successful use of a model to facilitate their recognition starting from the obtained learnings (i.e. the theoretical framework
479 we proposed in section 4) was only hypothetical. We showed that those learnings and their reflection in managerial
480 decision-making are key to increase the management's ability to sense and shape opportunities. Specifically, we showed
481 that our framework expanded managers' focus beyond a direct problem solving perspective, thus enabling them to scan
482 a broader temporal and locational horizon, and to articulate opportunities beyond immediate concerns – in line with
483 qualities that Teece (2007) posited as central to strong sensing capabilities. Thus, we contributed to the growing literature
484 on Industry 4.0 adoption as strategic process that relies on social and organizational aspects just as much as on
485 technological or structural considerations (Cimini et al., 2020; Frank et al., 2019).

486 For practice, the proposed “digital transformation focus shift” framework provides innovators – often technologists
487 without experience in recognizing business opportunities (Rice et al., 2001) – a tool to identify and communicate the
488 “hidden” potential of an innovation project to the firm's decision makers. Thus, instead of force-fitting digital innovations
489 into the tight corset of conventional business cases, we have provided a conversational tool building on the logic of
490 reframing (Raffaelli et al., 2019). We have shown that the framework expands the perceived innovation boundaries
491 widening the assessment horizon concerning innovation projects. Given the current collimation between innovation
492 projects and digital transformation ones, we could affirm that this theoretical framework is supporting companies in
493 succeeding in their digital transformation projects by supporting their business cases, addressing what was identified by
494 Schmitz et al. (2019) as one of their main barriers for the digital transformation of manufacturing companies. Illustrating
495 the potential, one of the authors has adopted the framework for his own consultancy practice to structure the dialog with
496 customers' in the early stages of technology innovation projects, thus successfully facilitating identifications of further
497 potential business opportunities. Moreover, he uses the framework as a communication tool to present the outcome of
498 such studies to customers' top management, responsible for allocating the funding for the innovation project.

499 Our proposed theoretical framework provides a novel approach to support explorative innovation initiatives that are
500 challenged from the point of view of conventional business cases. However, for the frameworks successfully
501 operationalization, and to effectively increase the firm's sensing capability, two conditions must be met. First, the
502 involved stakeholders must understand the operations the innovation initiative is addressing, as well as the company's
503 strategy. This contextualization is necessary for the identification of additional applications of the obtained learnings for

504 either solving additional problems (i.e. extended potential) or supporting further innovation (i.e. innovation). Second, the
505 framework requires recurring consideration of potential innovation outcomes in context of newly gathered learnings and
506 insights. This requirement is mirrored in previous findings that found a positive influence of agile or lean organizational
507 structures – built on iterative and learning-oriented routines – on the success of I4.0 adoptions (e.g. Cimini et al., 2020;
508 Ghobakhloo and Fathi, 2019).

509 As a qualitative single case study, we need to be cautious regarding the generalization of our insights. Specifically, the
510 development of the artefact through repeated interaction with the company practitioners might have added to their learning
511 beyond the effect that the final artefact might have in context that had not contributed to its development. While one of
512 the authors has since successfully applied the framework in his consultancy practice, we have no systematic data on the
513 general applicability of the framework for I4.0 strategies in other firms. Specifically, we lack insight whether the success
514 of the framework may be contingent on certain characteristics of the firm, which could enable a more or less fruitful
515 conversation about “value potentialities”. Moreover, while in the present case the firm decided to pursue the identified
516 opportunities, we cannot conclude that this would be the case for any company. For example, companies with limited
517 resources might decide against seizing opportunities, even if the framework might enable them to see the long-term
518 potentiality of the opportunity. Thus, further research could address how interventions building on our framework affects
519 the development of sensing *and* seizing capabilities in different organizational contexts.

520 7. CONCLUSION

521 The industrial digital transformation agenda catalyzes a plethora of innovation projects, often concerning the introduction
522 of new technologies. One of the key, non-technical barriers for the implementation of digital innovations concerns the
523 translation of such activities into a clear - and positive - business case for the company. However, as we have shown, the
524 absence of a perceived clear business case may often be grounded in a firm’s limited sensing capability, blinding them to
525 perceive opportunities beyond the direct and short term benefits of a technology.

526 To address this need and support digital transformation projects succeeding, we proposed a theory-derived framework –
527 the “digital transformation focus-shift” framework. The framework structures and supports the identification of business
528 opportunities linked to (and enabled by) the learnings obtained from digital transformation projects. By guiding the
529 identification and formulation of the potential exploitative value of exploratory projects into specific project proposals, it
530 aims to support decision-makers in broadening their perspective when evaluating a business case. We tested the
531 framework in an industrial setting and observed both its applicability and its role in facilitating innovators and managers
532 in the identification of additional business opportunities linked to an innovation project. The case showed how continuous
533 reflection on learnings from an originally narrowly scoped technical projects enabled management and innovators to sense
534 novel opportunities for value creation. The inclusion of these business opportunities in the innovation’s initiative outcome
535 led the company’s stakeholders to change their perception concerning its business case, and convinced us of the validity
536 – and value – of the proposed theoretical framework.

537 The application of the theoretical framework in the presented case study gave a first glimpse of its usefulness for
538 broadening the value appraisal of digital innovation projects. We hope that through further application in other industrial
539 settings with further iterations the model can be refined regarding its wider and more generalizable application. Such, we

540 see its potential to be developed into a set of useful tools that enable manufacturers to confidently embark on the digital
541 journey and harvest the promised benefits of new technologies.

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