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Published in:
IOP Conference Series: Earth and Environmental Science

DOI:
10.1088/1755-1315/1389/1/012013

Published: 01/01/2024

Document Version
Publisher's PDF, also known as Version of record

IOP Conference Series: Earth and Environmental Science

PAPER • OPEN ACCESS

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To cite this article: A Ainamo and A Peltokorpi 2024 *IOP Conf. Ser.: Earth Environ. Sci.* **1389** 012013

 doi:10.1088/1755-1315/1389/1/012013

Innovation meets institutions: AI and the Finnish construction ecosystem

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Abstract. Artificial intelligence (AI), machine learning (ML), and deep learning (DL) are technologies that have recently transformed many industries. The construction industry has traditionally been a laggard industry in terms of digital-technology adoption. When leading firms in this industry have experimented with these technologies, many of these experiments have met resistance. In this paper we take an institutional lens to study why and particular social structures appears to have contributed to the resistance and paucity of success stories. Within institutional research, we focus on research with traces to cognitive science and psychology. We have carried out a qualitative embedded multiple-case study on resistance to new technologies and how to overcome such resistance. The study involves four use cases in the Finnish construction industry: (1) automation of a material-product subcontractor's production planning; (2) business-model innovation by contractor on how to best work across multiple construction sites at once; (3) machine learning and automation of documentation by a software firm; and (4) promotion of a vision of information sharing across organizations by the above software firm. Based on within and cross-case analyses, preliminary empirical findings are that AI, ML and DL have in the Finnish construction industry challenged institutionalized forms of organizing and workflow established long since in the industry and, until about the time of this piece of research, taken for granted. Resistance was nonetheless beginning to be overcome at the time of writing this piece of research with small-group interaction across firms – such as those in this study -- in the industry ecosystem. Human-human mediation and face-to-face encounters were building trust in and across the organizations. The implication for practice and policy is that business transformation will not quickly and autonomously transform into "impersonal" or machine-machine exchange but, before that, requires human-human mediation. *" In the long-term, AI and analytics have boundless potential use cases in E&C* [i.e. engineering and construction]*. Machine learning is gaining some momentum as an overarching use case (that is, one applicable to the entire construction life cycle, from preconstruction through O&M 8i.e.* operations and management*), particularly in reality capture (for example, in conjunction with computer vision) as well as for comparison of in situ field conditions with plans (for example, supporting twin models). Indeed, by applying machine learning to an ongoing project, schedules could be optimized to sequence tasks and hit target deadlines, and divergences*

IOP Conf. Series: Earth and Environmental Science **1389** (2024) 012013 doi:10.1088/1755-1315/1389/1/012013

> *from blueprints could be caught closer to real time and corrected using a variety of predetermined potential scenarios."* [1]

1. Introduction

Many industries such as advertising and architecture have employed artificial intelligence (AI), machine learning (ML), and deep learning (DL) to transform their industry [2].[1] AI means that computer systems capable of performing many complex tasks that historically only a human could do, such as reasoning, making decisions, and problem solving. ML is a branch of AI and computer science that focuses on the using data and algorithms to enable AI to imitate the way that humans learn, gradually improving its accuracy. DL is a method within AI and ML to teach computers to process data in a way that is inspired by the human brain. Deep learning models can recognize complex patterns in pictures, text, sounds, and other data to produce accurate insights and predictions.

In contrast to many other industries, the construction industry has been a laggard in transforming modeling how create, deliver, and capture business value [2][3] [4], cf.[5]. Whereas there are many success stories by leading firms in the nearby field of architectural design, for example (e.g. [6]), leading firms in the construction industry have been far less successful in how they have planned for, organized, and executed deployment any new digital technology [2]. Sure, there may have been a few successful experiments, having to do with "virtual design teams" [7] [8] [9], "federated learning" [12] [13] [14] [15], and "integrated projects" [16]. Yet, the exceptions have been few and far between in the West, at least, a fact strengthened in countless studies, e.g. [17]; cf. [2] [18] [19][20]. The words of McKinsey [1] have continued to hold true:

> "*AI's proliferation in the E&C sector remains modest. Few leaders have [had] the processes, resources, and existing data strategies in place to power the necessary algorithms and meaningfully implement this technology*".

There have been surprisingly few empirical studies of the reasons behind the foregoing lack of adoption or take-up of AI, ML and DL in the construction industry. In this paper, we focus on the Finnish construction industry, an interesting empirical setting in that Finland has been recognized as generally being a leader in digital knowledge ecosystems and innovation ecosystems but a laggard in terms in her construction industry [17]. We focus in this paoer on four uses cases in the Finnish construction industry: (1) automation of production planning of a sub-contracted material product; (2) machine learning in documentation automation; (3) business-model innovation in how to plan across construction sites; and (4) AI-supported information sharing in the industrial ecosystem.

In our within- and cross-case analysis of these four use cases, we focused on answering two research questions: a) what have been reasons behind the paucity of success stories in the construction industry in taking up AI, ML, and DL; and b) what possibilities construction firms have in transforming their business so as to take up and make more productive use of AI, ML, and DL than so far? We took an institutional lens in our seeking of answers to the above two research questions, focusing on a research stream within it whereby resistance sometimes can

[1] Other digital technologies than AI, of which there is much excitement in the construction industry, include machine learning, digital twins, drone-enabled yard inspection, digital modularization, supply chain optimization, digital marketplaces, laser scanning, 3-D printing, robotics, and virtual learning and design simulation [9] [10] [11].

be circumvented by "scaffolding" between what is old and taken for granted and what new one desires to have adopted [22] [23], cf. [24] [25].

We next briefly review institutionalist theory generally. We then translate to the reader why and how scaffolding can play out as a successful process of business transformation. We relate our review to our focal empirical context of the construction industry to spell out our data and within- and across-case analysis methodology to answer our research questions and draw implications.

2. Institutional stability: Three "pillars"

By institutions, we refer here to sets of socio-economic elements such as legal code, knowledge, symbols, and culture [27] [28]. The standard definition of institutions is that institutions are forces in the economy and society that explain why organizations and industries can succeed to function and maintain a sense of homeostasis or relatively stable existence even in a dynamic environment [29] [30]. There are three main "pillars" or kinds of institutions: a regulative pillar, a normative pillar, and a cultural-cognitive pillar. These pillars are not exclusive to each other, but loosely coupled. Each represents a relatively integrated set of established and taken-for-granted assumptions as relates to how the economy and society, as well as organisations embedded therein, function and should function [29] [30].

2.1. Regulative pillar

The "regulative" pillar is the least complex of the three pillars. The regulative pillar defines what organizations are forbidden to do within rules and laws that exist. The regulative pillar is a codified legal framework, including statutes, that govern public bureaucracies and their standard operating procedures. This pillar establishes a platform of security and trust in the social contract underlying society and the economy operating in tandem with that society. It is the laws governing technical solutions and labor practices, and a frame for private contracting. This pillar is the source of authority that stipulates what forms of agency in or across organizations are legal and legitimate.

Taking inspiration from the interstices of institutional theory, cognitive science, and complexity science [22] [23], we construe the regulative pillar as a foundation for satisfying of physiological and safety and security needs at the bottom of a hierarchy of needs of human beings and organizations, relating to coping with real or imagined risks and threats to existence.

In the construction industry, what is real is that there are real sanctions for violating a building code or another such regulatory rule. On the flip side, some scholars have argued that new technologies in the construction industry will be adopted and diffuse only as long as these technologies are beyond doubt effective, efficient, reliable, and safe to use -- such new technologies fit pre-existing "schemata" [24] [26]. Adoption and diffusion can then well happen in distinct phases: i) automation, ii) transformation of data into information, and iii) the transformation of the industry as a whole [30]. In this view, when and only when such schemata are in place to favour transformation, two or three kinds of equally valid strategies are available for technology adoption: a) controlled experimentation phase-by-phase; b) going for wholesale transformation at once [31], which two strategies make it possible that there is also a c) hybrid of "a)" and "b)".

2.2. Normative pillar

The second institutional pillar is a "normative" one. The normative pillar guides the behavior and values of an organization or community. This pillar relates to unwritten rules: norms of

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opposition or compliance, as well as guiding principles, as to how things have been done in the past, how are done in the present, and how they ought to be done in the future. Members to a community identify themselves as members according to those norms that create and attach meaning to their affiliation and to the symbols of the organization or community. This pillar includes norms for compliance in terms of what is in the local system generally referred to as "common sense" (Swidler in [26]).

Ideas and roles in the normative pillar fit with needs schemata of belonging, social comfort, and love – schemata higher in the psycho-social hierarchy of human and social needs. Belonging, social comfort and love are needs more developed needs than are safety and security.[2] The stance is not coopting with change as an avoidance response to threat or risk as in the regulative pillar; rather the stance is about coalescing with others based common values and norms, whether such coalescing be temporary or permanent. Normative motivations and needs can be said to build not only on addressing safety and security needs that can be said to exist 'lower down', but only on motivations and needs 'higher up'.

2.3. Cultural-cognitive pillar

The "cultural-cognitive" pillar is the pillar that gives life to ideas and roles that stem from the normative pillar and, by extension, the regulative pillar. The cultural-cognitive pillar is essentially local culture [25]. It is the pillar that meets and enables the social-recognition and esteem needs of the individual. Yes, human individuals in this view, true enough, as suggested by the normative pillar, have needs as to how they pay attention to how their group sees them. But, if and when that the needs related to the normative pillar are accomplished, they also need to see themselves having a role in shaping the identity of their group or groups. Most individuals and most groupings of individual human beings make deliberate or emergent choices in how they may differentiate themselves from others, and not only how they comply with group consensus. The cultural-cognitive pillar relates to how an individual, or any grouping of individuals, establishes one's self a distinct image and reputation.

In the hierarchy of human and social needs, the cultural-cognitive pillars relate to needs for esteem and self-actualization -- motivations more developed than to the normative ones of belonging, social conformance, and love. [2] One individual and another contract with one another with a view of future commitments, rather than with the view of the here and now or of the past. Rather than compliance, one creatively challenges rules and norms and exist within one's grouping; one is biased towards independent searching and finding of new alternatives without feeling of peer pressure. While the regulative and normative pillars may have defined "the where", "the what", the "why" and "the how", this pillar is the one that self-creates the "who", cf. [32] [33]. When an innovation or what is new is in the above ways solidly and comfortably contained within the above three-pillar institutional schemata, it is likely to be met with a favourable, rationalized response on the part of those who would have been in a position to resist it.

3. Institutional resistance, how to overcome it, and how to change and transform

When an innovation calls for change across more than one pillar, the innovation is likely to trigger "off-loading" [22]. This is a term that refers to the human tendency to avoid peer pressure, shaming, and having to feel guilty. Any innovation that appears to involve systemic transformation in the form of change across more than one pillar is likely to be considered by many participants as radical, suspect, and perhaps warranting resistance action [23] [24]).

In most industries, those who are best in off-loading often move up the career ladder, the average stay in their positions, and the worst may be found guilty, be shamed, even thrown off the ladder. Rules and common sense of 'the best' and the average agglomerate and accumulate into organizational-level rules and norms. Collective action in and across organizations carries to future generations the wisdom that one should avoid all chances that one might be breaking rules and chances that one be seen as too keen on what is new.

Few things would ever get accomplished in any industry if one has always to consider every possible way to follow every building code or other rule. Most human beings sort out data available to him or her by making make quick, intuitive commonsense determinations about the best course of action to adhere. Most of these determinations will conform to the norms and expectations of one's working or other such immediate environment.

To fit a really or potentially radical innovation into the existing institutionalized schemata an innovation, some institutionalist studies have argued that what is needed is that is that the innovation is initially protected from competitive pressure, isolated in a protected "niche" or "patch" [35] [36]. A small niche or patch allows innovators within that niche or patch to develop themselves new informal norms. The requirements are that the niche or patch is sufficiently closed, the group is enough small, or both [27] (cf. Granovetter in [28]). Such a niche or patch has features in place to enable self-regulation. Parameters and rules external to the niche or patch can be relaxed. There is relatively little that might hinder co-creation of norms from the bottom up [36] [27] [37].

In a niche or patch, what is normed, rather than institutionalized schemata, are "scripts" – in part improvised, just-and-just acceptable local norms for exceptions to any rules that might otherwise exist [38] [25] [26]. Later, after the first lead users and others around them have put the innovation to use, still other "users [in growing numbers]… can be represented in digital formats and their performance and behavior understood in terms of data" [3]. The lead users help to gauge how to meet the requirements of still others in the field. Such norms build towards "objectification"[39], digitalization, diffusion, and institutionalization (cf. [3]. With voluminous data that can be analyzed, what can follow are "scaffolds" (Clark in [22]; [23]); that is, new social structures that function to bridge the innovation with the old social structures. Each scaffold, in other words, functions as a solid and appropriate "robust design" [25] that serves to fasten new structural layers [25] [26], including layers that are material, digital, or both.

An innovation (e.g. AI, ML, DL) sometimes appears to meet absolute resistance when its adoption overly challenges institutionalized rules and norms. The innovation can, for example, call for shaping of both the parameters of choice in the industry and the rules of how such parameters are applied, to an exceptional degree. Then again, at other times, an innovation meets only resistance in terms of persistence as time delay. Within the latter circumstance, in particular, Douglass C. North [23]; [24]; [22] has argued that there are advantages "personal exchange" or reciprocal interactions between but a few human-individual actors who trust each and cooperate even when – or just because -- there are shortcomings in or across the institutional pillars of the system [23].

Later, partners in the above kind of personal exchange that successfully improvise state-of-the-art cultural-cognitive ideas and best practices between one another, in fit with the new circumstances, sometimes develop followers, sell more than their colleagues, and end up being recognized as experts who receive promotions, awards, and/or citations. One innovation is compared with another, and lessons are agglomerated by somebody higher up in psychological, social, and institutional hierarchy.

Lower-level personal-exchange agents and higher-level agglomerators can both be considered “digital leaders” [40], agents of change or prime movers for business transformation of their industry. The best digital leaders will rise in career ladders and the scaffolds designed or built by them and their followers will contribute to the success of their innovation. Over time, voluminous collective action will contribute to regulators coopting with the agendas of these leaders and their followers. With regulative change, even more followers will coalesce around what once was new and overly radical. All this will happen in line with ideas institutional theory has taken from cognitive and complexity science [22]; [23]: across multiple levels of analysis from the bottom up. In sum, when a niche innovation receives traction, also the next set of social mechanisms are more likely than otherwise to have impact [27].

Applying the review to the construction industry, it may be that, at least in the past, digital technologies represented a language and particular institutions different from traditional technologies, language, and institution within the construction industry (cf. Scott in [34]). When someone in the construction industry used the language of digitalization and software, this decreased how any initiative of that someone was attended by colleagues in the construction industry.

4. Data and methodology

In 2022, we began systematically engaging in “participant observation” [41] to empirically explore the conundrum of the tortuous take-up of AI and other digital technologies in the Finnish construction industry. As we would do many times over the subsequent two-and-a-half years, we interviewed our main informants to understand how and why this or that informant had or would become a main “protagonist” within his or her case context [42]. Our interviewees were within or closely approximate to the Finnish construction industry and in the Finnish construction ecosystem.

The interviews were mostly face-to-face interviews with an original aim to reach 30 interviews, each lasting between 30 min to 3 hours. We did have also specific questions that we asked some of our interviewees, but we also let all interviewees know we had time for them until the writing of this paper to tell their stories freely, rather than guide them with very precise questions. We engaged with the interviewees and other sources of data in an inductive qualitative research project [42], an exploratory, embedded, and longitudinal single-case study [43] [44] [45] [46].

By the time of writing this interview, we have discussed our four cases with a good number of informants. On the other hand, all our informants have not been interviewees. We also engaged also in participant observation that took forms of engaging in field events related to established construction companies, construction-industry startups, as well as software for use in this ecosystem (e.g., Slush—Northern Europe's largest start-up and tech-event founded in 2008 with 25,000 participants by 2019), and scientific and outreach events in and across leading universities in Europe. We followed up action research that our colleagues had done in our ML use case or use case 3. We reviewed empirical studies on the construction industry in Finland and elsewhere. We consulted practitioner books, official websites, specialized magazines, books, and scientific collaborations to triangulate these data and evidence.

In line with our methodology of not only interviewing but ethnographically observing talk and behavior in workshops (having to do with our state- or Business Finland funded “co-innovation" project with our focal three firms, we did not shy away from a diversity of perspectives or roles among interviewees [47]. Our focus was on understanding *in toto* the "cultural system" [48] to which each of our many informants belonged.

In codifying, analyzing, and interpreting the interview data and other data that we collected, we took inspiration from ethnographical "thick description" [49]. That is, our data collection followed the principles of description focusing more on the phenomenon itself than on any existing body of literature or methodology; our collection of data was more driven by the "substantive domain" of the Finnish construction industry than by any "conceptual domain" or "methodological domain" [50].

As our research process progressed, our analysis of the statements and their iteration with other data began to reveal to us temporal narratives of events at play, flavoured by the cultural biases of our informants, yet collectively neutral in approaching the original sequences of events [51]. We increasingly came to understand and learned to streamline our originally somewhat unfocused topic of scientific inquiry with established qualitative research procedures and protocols created visionary innovations of how to 'change the world' and not only the immediate situation. Following [52], we began to build our dataset on the many verbatim statements and compiled these into first-order codes (Table 1, next page).

As is often the case in qualitative research, more than once we came across something even more interesting than what we had learned earlier. We revisited, revised and, in a few instances, even changed our original theoretical ideas [53] [54] [55]. In chase of internal consistency. In chase of credibility, validity, and increased reliability [50] ([50] [46], we repeatedly triangulated our data in the process of developing Table 1's "first-order codes" [50] towards a relevant innovation model and scientifically rigorous findings ([56][57]. We did not as much "manipulate the data" [58] as we (1) categorized interview data into the first-order codes in line with conventional innovation-management language; (2) contextualized these first-order codes into second-order themes to identify the more general context, factors and relationships; and (3) documented and captured the variables of interest in aggregate dimensions for our preliminary findings and conceptual framework [56]; [52]; [46]).

Table 1. Data table (selected excerpts from data compiled 2022 to 2023) and first-order codes (April 2024 version).

Direct quotes	***First-order codes***
"Question of legal responsibility"… "What is most difficult i to change an existing model [of work]… traditional ways of thinking… and civil-servant structures…" [Such traditional structures] hinder…" "Contemporary positions have long remained unchanged" "With public innovation funding" "we work to find a breakthrough somewhere" "We try to get big picture of what goes well and what things are a cause of problems…" "Question of … other responsibilities' "Last millennium… transferring data in documents…" "[What has been done has been done] reactively backwarc rather than proactively frontwards…" "We still transfer [data but still] what is at the core is to do work… [is that, backwards and frontwards] everything is related to everything".	• Regulation as barrier or enabler • "John Wayne leadership" • Individual-level responsibility for one's own actions and thoughts

" The task just done will help with the task you are doing now… then what is linked can also be used the other way for work-driven dataflow, rather than only data-driven workflow…" "[in case 1] they now have a digital twin, so that they can run simulation, that is why…" "Linked data is technology. More than one will share information… work will be connected to the data model… [There's] also other data, then dependencies between the data are formed… what is done, is litterated and linked… every designer gets a read-only model… "	• From dissatisfaction with fragmentation of information to sharing • From data transfer to information sharing
"Now take the [success story of] Turku shipyard, where they invited subcontractors into their own production premises, providing these with logistics for free… flow efficiency increased first by 106% , then 380 … Everybody has their granulation level…" "These are just personal opinions…" "Relations we have, they exist, having become accustomed to the other party or parties…" " In digital transformation what is most difficult is the human being…" " We take it [at first] at small scale…" " we have worked with some clients…" "a general model and we wait… little by little it will begin to diffuse…" "This… machine learning we could use it also at large scale… "	• Story telling • Human scale
"Application programming interfaces or APIs…" "In today's world… now we go in direct mediation, peer-to-peer, but in the future it will be accessible all the time..." "federated data structures are published, accessible, usable…" "demand pull... dynamic data, it is coming for sure… this has now become part of [our] strategy -- I hope…"	• Digitalization • Demand pull

5. Empirical data setting and the use cases

When looking at the long term of how new technological innovation have been adopted by firms in the Finnish construction industry over the years, top-down preferences alone have not sufficed to drive business transformation [19]; [59]. The reasons for this trace to times long-since past. In Finland, at the turn from the 19th Century to 20th Century included that there was an unprecedented economic boom. Many new buildings were constructed. There was much stylistic innovation in architecture. The construction of buildings slowed down during the global Great Depression in the late 1920s and early 1930s, during the Second World War and its after from 1939 to about 1950, and a severe economic depression in the Finnish economy in the early 1990s. Finally, in the 2020s came the international jolt of the war in Ukraine. In between the above events, technological and stylistic innovation in the Finnish construction industry was vibrant from the 1950s to about the late 1960s, for example. Technological innovation continued until about the 1990s but has been less after that.

As to the focal use cases in this study, the story begins in the 2020s, when a small circle of innovators at a Finnish software company (the one that has offered this multiple-case study use

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cases 2 and 4) assessed that their work on ML technologies was developed to a degree it could be used as a foundation on which to build AI capabilities within the Finnish construction industry and, in the future, also AI software products. They envisioned a "federated data ecosystem" with stakeholders within their company and with others in other firms in the Finnish construction including (including the firms with use cases 1 and 2). They had mutual interests: AI, ML and DL were a business case in and across their firms. Leveraging on definitions, rules, and protocols, such as "application programming interface" (API), the innovators in these three firms began to emerge with a consensus that there was a case for business transformation in the bringing about they might all participate – with a business case from the perspective of any one of the three firms. It was in their view also that such business cases and transformation in the Finnish construction industry extended also beyond their firms, and even beyond their Finland.

The three firms in our study we worked with were prime movers of business transformation with their industry, while many others in their firms and in still other firms in their industry were yet but passively reacting to technological change. The innovators across the three companies contacted us researchers (they knew many of us prior to this) at Aalto University, as well as at VTT. Across the three firms, we identified the four use cases to use cases. We got "co-innovation" funding for our project from Business Finland, the main Finnish government agency for technology and innovation.

The innovators in the software firm in use case 4 had a vision of a generic data ecosystem of federated information sharing and learning in the Finnish and global construction industries, as well as the innovators in use case 3 working on extending the scope of their use case of machine learning in documentation automation from firm-internal data to also customer data. The firm in use case 1 was more a passive follower of the firms in use cases 2, 3, and 4. In between the two extremes of use cases 1 and use case 4, use case 2 was jockeying for repositioning in terms of major intra-organizational restructuring of the Finnish construction industry.

We researchers began to work with the innovators in the three firms by facilitating them in translating their vision of a federated platform into a form that would be ever more ready in comparison to what was earlier. We researchers did our best to facilitate that inter-organizational experimentation and innovation would happen by pairs or other small groups of innovators as microelements within macro-level transformation. The innovators in the three firms and we researchers collaborated on their own in small-group interaction, as well as with us and within workshops organized by us, to plan further experimenting as concerns the use case. They and we learned from each other as to how they had already carried out various experiments, some of which had been at least partial successes and others less so. They and we worked to learn how to aggregate such lessons, to consider the context of each experiment, and to learn also from the experiments of others.

The innovators and we researchers developed the insight that the ways of cultural and institutional work as to innovation in the three firms could be interpreted as a part of a gradual transformation of personal exchange into large-scale change and business transformation in the Finnish construction industry (Table 2).

Table 2. Preliminary empirical findings and conceptual framework based on the four use cases.

First-order codes	*Second-order themes*	*Agglomerated dimensions*
Regulation as barrier or enabler "John Wayne leadership" Individual responsibility for one's own actions and thoughts	• Regulation • Norms about compliance and opposition • Cultural cognition as driver	Institutional stability and/or change
From data transfer to information sharing From dissatisfaction with fragmentation to a vision of sharing	• Fragmentation • Distributed ecosystem	Technological change
Story telling Human scale	• Scaffolding • Small-scale exchange	Personal exchange
Digitalization Demand pull	• Resistance to innovation • Diffusion of innovation • Scaled-up exchange	Business transformation

6. Conclusion

A gap has existed between the theory that artificial intelligence (AI), machine learning (ML), and deep learning (DL) are driving business transformation across industries and the practical fact that in an industry, such as the construction industry in Finland, there has been little evidence of this happening. By framing this paradox institutionally, we have sought insight into which factors hinder and which enable and accelerate adoption and diffusion of relatively new three technologies. Within this context, we had two research questions at the beginning of our paper. Now, at the end of this paper, we can answer them.

We find that the reasons behind the paucity of success stories in the Finnish construction industry in taking up AI, ML and DL include that the new technologies have challenged long-since-established institutions or traditions and legacy in this industry. AI, ML, an DL have been new technologies and innovations that have cut across the regulative, normative, and cultural-cognitive pillars of institutions, resulting in "off-loading" or refusal to take into consideration by many in 'the construction ecosystem'; that is, those in and around the industry.

We also find that there are possibilities in the construction firms to transform their business by taking up and making productive more use of AI, ML, and DL than so far. These possibilities include to experiment with also a limited amount of human and other resources involved: that way, lack of success can easily be ignored, and successes can be retold as stories perhaps more compelling than what objectively happened. Such dramatic silencing of failure and amplifying of success will produce scripts and processes for change and transformation, first at small "human" scale, then at scale as to what appears to work.

The time horizons and differing orientations within the use cases and firms we have studied, as reported in this paper, were different in their orientations to inner and outer environments of the firms during our study's time span. There was also commonality across these firms and their use cases. All informants held that AI, ML and DL were new technologies in tension with pre-existing institutions in the Finnish construction industry. Personal exchange was needed to mediate in and between firms and other organizations in the ecosystem.

Besides the above research findings, we also find that contributions of this study also include the specification of how even firms within the same industry can be doing business in circumstances different from another and have different time frames, different designs for their products or services, and different models of transformation, maybe also differing on other dimensions. Within this context, by the time of writing this paper, we have come to believe that personal exchange was a first step in successful business transformation in the industry we studied. New technologies recently transferred from the R&D labs, often R&D labs abroad, had not readily translated into autonomous business transformation without a phase of translation by personal exchange in between. In the short-term, experimentation in the form of simulation, DL or ML appeared good strategies of experimentation from the perspectives of both our focal innovators in one or the other of the three firms. In partial contrast, more long-term efforts towards business transformation based on AI, ML or DL appeared long-term rather than short-term business strategies in all four use cases 1, 2, 3, and 4. As a limitation of this paper, we underline here that this is but a conference paper delimited at this stage by not fully laying out our data and its analysis, something that is the obvious next step of our research. We have scheduled a business model workshop with our three firms but 10 days after this conference to explore how to co-create of a cross-firm-business model. Already at this point, however, we are sufficiently informed to be able to forecast that AI, ML and DL will eventually institutionalize even in the construction industry in Finland, and beyond. Business transformation to that effect appears already to have begun.

Acknowledgements.

Funding for this piece of research for AIXCON project from Business Finland is gratefully acknowledged.

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