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Gao, Shan; Hakanen, Esko; Rajala, Risto

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Digital Transformation: The Interplay of Explorative and Exploitative Capability Development

Shan Gao
Aalto University
shan.2.gao@aalto.fi

Esko Hakanen
Aalto University
esko.hakanen@aalto.fi

Risto Rajala
Aalto University
risto.rajala@aalto.fi

Abstract

This research focuses on the firms' capability development in the era of digital transformation. We empirically investigate how firms operating in heavy industry extend their capabilities through explorative and exploitative capability development. Our study uncovers that firms in the industry tend to begin with exploitation and gradually extend to exploration. Our findings highlight the importance and necessity of adopting network capabilities both for execution of transformation activities, and for developing internal capabilities. The empirical evidence indicates that inter-organizational ambidexterity is essential for unleashing the full potential of digital transformation, and that ambidexterity can be achieved through a combination of internal and external capabilities.

Keywords: digital transformation, ambidexterity, explorative capability, exploitative capability, knowledge search

1. Introduction

Emerging digital technologies affect the ways business is conducted across industries. We have seen how the introduction of digital technologies may disrupt industry value chains and trigger firm-specific responses to technology-driven changes, which entail finding, acquiring, and developing new, more relevant capabilities [15, 17, 41]. In the process, firms need to constantly balance between explorative and exploitative capability development [21, 40]. This study investigates digital transformation and, specifically, *how firms in a heavy technology sector have begun to extend their capabilities through both explorative and exploitative capability development.*

Digital transformation is understood here as the transformation of business processes and organizational resources related to leveraging the changes and opportunities that digital technologies provide, and seizing the impact of these technologies on the business models and operational activities of

firms in the industry. Instead of attempting to find a universal way of adoption, each industrial firm must define their targets and development paths. This has led to contradicting views and interests [8, 15, 47].

Thus, our research is rooted in the practitioners' constant, industry-wide struggle to grasp the emerging possibilities. The pervasive digital technologies have been reshaping the industry dynamics and ways of working during the past decade with an accelerating pace. This trend has posed new challenges and requirements for the firms' capability portfolios. Accordingly, a vast majority of the past studies have considered how a single firm could respond to these new demands [21, 26, 43]. However, considering the global scale and the economic significance of the ongoing change, we argue in favor of a broader perspective. We focus our study on the metals and mining (M&M) industry, due to its role as a traditional, asset-intensive industry, but as one that has seen a renaissance following the rise of electric vehicles and the surge in demand of battery materials.

This study aims to increase the current understanding of how firms in the metals and mining industry balance explorative and exploitative capability development at the intersection of the existing industrial processes and the heightened interest to adopt digital technologies in business. Due to the multifaceted nature of digital transformation, we follow the path suggested by Li et al. [32], to analyze the knowledge search both within and across different domains in the value chain. Such an approach allows us to consider both the type of capabilities that the firms search for and the domain this expertise is sought from.

We contribute to the discussions of ambidexterity and dynamic capabilities by empirically uncovering the emergence and evolution of firm's explorative and exploitative capability development based on leveraging internal and network capabilities.

2. Theoretical background

We first discuss the digital transformation as the interplay of explorative and exploitative capability development efforts. Then, we elaborate on our views on the two knowledge search types, exploration, and exploitation. Last, we present an integrative framework, which helps to explain the different changes –whether incremental or radical– that organizations conduct along with their digital transformation efforts.

2.1. Digital transformation as an ambidextrous capability development

The rapid evolution of digital technology brings both new opportunities and threats. For example, in the metals and mining industry, digital technologies are expected to facilitate autonomous, remote operation, but only a few companies have managed to integrate the new tools due to poor applicability to current processes and persistent technological concerns, such as cyber-security [14, 46, 47]. Several industrial firms have decided to strategically embrace these opportunities among the front-runners with an expectation to differentiate from the competition by disruptive business models and to address the issue of declining productivity with digital transformation [12, 14]. Congruently, the discussion has progressed from whether to take part in the digital transformation to rather on how it should be implemented [14, 46]. This trend has posed a stark contrast to the traditional approaches in the metals and mining industry. Thus, digital transformation requires firms to reconsider their business models and capability bases.

Ambidextrous development of the capability base, i.e., a successful combination of explorative and exploitative capability development, is needed to support the new value creation opportunities of digital transformation. To capture the opportunities, a firm needs to discover, develop, and utilize resources and capabilities that they have not been exploring and exploiting previously. Ambidexterity is difficult to attain for many reasons. One of them is that the changes induced by digital transformation affect both the operational and dynamic capabilities of the firms.

Operational capabilities are capabilities that enable a firm to perform an activity on an on-going basis using more or less the same techniques on the same scale in order to support existing products and services for the same customer population [20]. In turn, dynamic capabilities are capabilities that enable a firm to alter how it currently makes its living [39].

Ambidexterity itself can be considered a dynamic capability. Competing firms differ in their dynamic capabilities, and these differences have a significant and enduring effect on their competitive advantage

[38]. By developing, replacing, and reconfiguring existing resources and capabilities, dynamic capabilities seek to create an improved match between a firm's resource and capability portfolios, and environmental conditions [19]. In the process, the firms change their ability to perform explorative and exploitative activities. Ambidextrous performance may be attained by successfully combining explorative and exploitative capability development [34].

2.2. Exploration

Exploration is defined as “the pursuit of knowledge, of things that might come to be known,” and it involves uncovering previously unknown knowledge, searching and utilizing unfamiliar technologies, creating new products and services, and approaching new markets [31]. As a concept that is often linked with emerging customer needs, untapped markets and technologies, and path-creating [1], exploration is referred to as “search, variation, risk taking, experimentation, play, flexibility, discovery, and innovation” [33].

Firms adopt explorative learning to prepare for future market demand [25]. Another objective is to differentiate from the competition by creating novel products and services, which are unique from the existing portfolio, for the current market situation [48]. The novelty of a solution can be classified as new to the firm, new to the industry, and new to the world [2].

Inter-organizational learning is important for exploration alliances [37]. Explorative activities are associated with alliances that include new partners from different technology domains [10], searching for distant knowledge [2], and broadening of the capability portfolio [4].

2.3. Exploitation

Exploitative capability development is defined as “the use and development of things already known,” which strengthens the present competitive advantage by using and improving knowledge, technologies, products, and markets that currently exist [31]. Exploitation is often linked with stable markets and technologies, path dependencies, routines and mechanistic structures [3], and it is referred to as “refinement, choice, production, efficiency, selection, implementation, and execution in resource capturing” [33]. As an approach that aims to fulfill the current market demand [25], exploitation aims to improve existing operational processes and products in current markets [48], in search for better customer satisfaction, increases in revenue and profits, and ultimately better firm competitiveness [7].

Exploitative activities are associated with utilizing firm’s currently available resources and partner networks [32], search for knowledge within relatively short distance [2], and cultivation of the existing capabilities [4]. For exploitation, alliances are vital for different partners to learn from each other [37].

2.4. Ambiguity of exploration and exploitation – an integrated framework

Although definitions do exist, interpreting exploration and exploitation remains a challenging task due to the inconsistencies and ambiguity among the different definitions. Li et al. [32] proposed a framework to consolidate the different perspectives of exploration and exploitation (see Figure 1) by applying the function domain and the knowledge distance domain. The “function” refers to science, technology, and product or market specific knowledge. The exploration and exploitation shall be interpreted as comparative attributes of different activities across the value chain. In turn, “knowledge distance” domain categorizes the exploration and exploitation based on whether it is a local knowledge search (exploitation) or a distant knowledge search (exploration). Knowledge distance can be further decomposed and measured via cognitive vectors, temporal vectors, and spatial vectors.

2.5. Ambidextrous performance

Previous research suggests that exploration and exploitation are key learning concepts which represent a firm’s dynamic capability in innovation and transformation [5, 48]. Capability development is a complex phenomenon, in which the firms’ success is ultimately revealed over time [19]. Hence, exploitation and exploration are not completely separate approaches to capability development, but they often coexist in the organization [37]. Previous studies have

shown that exploitation without exploration will eventually lead to inefficiency [30, 33]. Furthermore, positive performance on the exploitation side also provides the essential foundation and financial support for firms to conduct exploration, which is associated with higher uncertainties [48]. Existing literature also argues that combining exploitative and explorative capability development contributes to a firm’s long-term survival, enhances financial performance, and improves innovation [9, 37].

Organizational ambidexterity refers to exhibiting exploitation and exploration simultaneously [45]. Studies have indicated that structural separation of explorative and exploitative activities is laden with challenges [44]. When considering the complexity and the nature of the needed changes, firms that approach exploitation and exploration utilizing distinct subunits, business models, incentives, and processes risk to jeopardize their overall alignment of capability development [34]. Research of contextual ambidexterity has suggested that firms operating in turbulent and competitive markets try to create conditions in which innovations can be created [16]. However, the diversity of abilities within the organization and experiences among the senior team [6] and process design [23] affect firm’s ambidextrous performance.

Ambidexterity is seen as a valuable dynamic capability that facilitates the configuration of resources and capabilities, which in turns generates competitive advantages [13]. Organizations without such a capability may stagnate when confronting market and technology changes because of path dependence and organization inertia.

Achieving and maintaining ambidextrous performance has proven to be a tough challenge [34]. Exploitation and exploration may create self-reinforcing cycles within the organization, leading to competition for the scarce operant resources, such as embedded knowledge, needed in innovation [33].

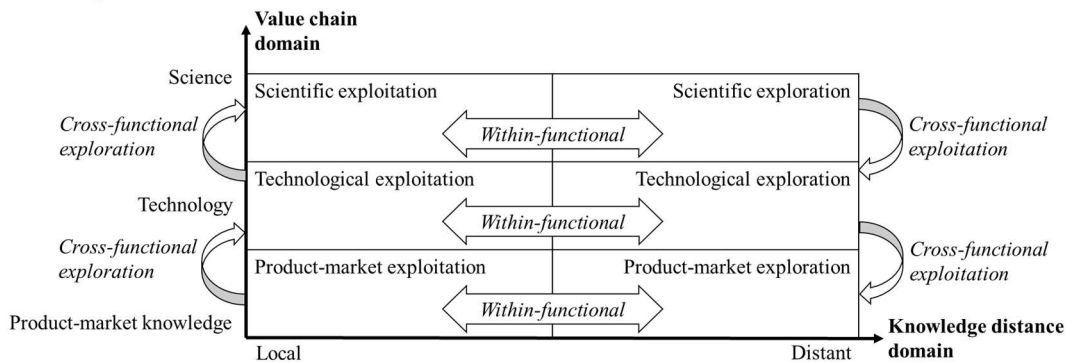


Figure 1. Typology of exploitation and exploration based on function and knowledge distance. Adapted from Li et al. [32]

Hence, ambidexterity requires justification on the firm's vision, complex design on strategy intent and execution with needed resources [36]. Since organizations have few means to manage conflicts between exploitation and exploration, researchers have introduced the concept of partner perspective in ambidexterity discussions [27, 28]. Existing studies reveal that alliances play a key complementary role in firm's exploitation and exploration [18, 22, 28].

For firms operating in the metals and mining market, which has stayed relatively stable for the past decades, intra-organizational ambidexterity can be a scarce capability. However, digital technologies have significantly improved the efficiency of leveraging and integrating complementary resources and capabilities from external partners. Extending from existing literature, this empirical study illustrates how firms approach inter-organizational ambidexterity by leveraging internal and external capabilities.

3. Research Methodology

Our case study research investigates how firms have extended their capabilities for pursuing digital transformation. Our aim is to gain in-depth understanding of the firms' search for explorative and exploitative capabilities for implementing the change. Following the suggestion by Li et al. [32], we focus on the different domains of knowledge through which these capabilities are derived in a cross-functional manner concurrently across firms. Put differently, we are interested in both the type and the origin of the capabilities that the firms search for.

We posit this study as a qualitative, single-case study. Although the study sample consists of a total of 28 firms, we consider them as a single case because the firms in our sample belong to the same contextual setting [35]. Such an approach allows us to explore the knowledge search within and across different knowledge domains in this context.

We analyze the data with an abductive approach [11], aiming to elaborate the existing theoretical insights [29]. The empirical data is based on 45 semi-structured interviews, conducted with industry practitioners, spanning between years 2015-2018.

3.1. Metals and mining industry as the context of the study

The context of our study is defined as the digital transformation in the metals and mining industry. This context provides a suitable frame for investigating a complex change in an industry that has been shaped by long periods of stability. Yet, the rise of digital technologies has begun to lay its mark also on such

traditional, asset-intensive industries [14, 15, 26]. Our study positions on this time period, during which the firms in the industry have begun to identify the potential of digital transformation. Moreover, the growing popularity of electric vehicles has created a new demand for materials suited for battery manufacture.

We define our single case study against this distinctive contextual setting that the firms in our sample share [35, 49]. As illustrated in Table 1, our sample included both metals and mining industry firms (M) and technology and equipment suppliers (E), with a diverse geographical distribution. The primary data collection relied on interviewees among a broad range of firms. Our purpose was to collect insights of the operational level activities of single firms, and to contrast our findings on the individual firms against the other firms in the sample. The essence of our case [35] is to explore the concurrent and cross-functional knowledge search by which the firms increase their capabilities for digital transformation. Thus, we analyze all the firms as a part of the same case, which aims to study the capability development within and across knowledge domains.

3.2. Data collection and analysis

This study was conducted via 45 in-depth interviews from 28 companies operating in the metals and mining sector. The interviews were conducted between the years 2015-2018. All the interviews were audio recorded and transcribed verbatim. The length of the interviews varied from 45 to 100 minutes. Informants were chosen based their position and expertise in the field, with the focus on people with current or previous experience on planning and execution of digital transformation in the field. Majority of the global firms were chosen and contacted by the researchers, whereas the local firms were accumulated in a snowball sampling through both academic and business contacts. Full details regarding the empirical material are shown in Table 1.

The aim of our abductive data analysis process [11] was theory elaboration [29]. Abductive data analysis is based on the continuous reflection of the data and theory, as the findings from the practical research context is fitted against the chosen theoretical constructs [11]. In this study, we wanted to understand how the mining industry firms pursue digital transformation by analyzing their actions as cross-functional knowledge search across different knowledge domains [32]. In the process, we hope to clarify the practical embodiment of such processes and, thus, to elaborate theory [29].

We analyze the firms' knowledge search in their explorative and exploitative learning activities. We follow Jansen et al. [24] to differentiate between these two types of capability development. In addition, we consider whether the needed capabilities are local or distant to the focal firms knowledge domain [32]. To summarize, as we analyze the firms' knowledge search, we try to understand whether the capabilities for learning and new insights reside *internally* or in a *network*, and if the learning activities are *explorative* or *exploitative*.

In our analysis, explorative activities include:

- Searching for new technology opportunities across different functions/industries (M & E)
- Inventing novel technical applications (M)
- Utilizing the solutions which are completely new to the organization (M)
- Inventing novel digital technologies (E)
- Searching for new business models, products and services in new market domain (E)
- Providing completely new product and services for existing markets (E)

Exploitative activities include:

- Adopting or improving existing technical solutions within the industry (M & E)
- Small adaptations to operational processes to improve efficiency (M)
- Improving the efficiency for existing product/service delivery (E)
- Refining/upgrading/expanding the existing products and services for existing markets (E)

4. Empirical Findings

Our findings illustrate the interplay between explorative and exploitative capability development among the firms in the metals and mining industry. In particular, we explored the domain of the knowledge search process by examining whether the needed capabilities are brought internally or exerted through the network. Following Helfat and Winter [20], we considered that if a firm performs a certain type of activity, they must have access to the needed capabilities for using the digital technologies. The findings are summarized in Figure 2, which reflects the extent of digital transformation activities of the interviewed firms. We differentiate between exploration and exploitation, and whether the firms rely on internal or network capabilities.

In response to digital transformation, metals and mining firms had mainly taken exploitative activities with network capabilities. Among them, some firms preferred to "purchase ready-made digital solutions" (M13) and fully rely on the technology suppliers'

capabilities. For example, M6 claimed that they "expect our suppliers to come up with fit-for-purpose solution for us to truly address the challenges in operation" (M6). Conversely, other firms were looking for partnerships and joint development of solutions to improve their existing business operations. For example, M5 was "close of finalizing a partnership with a major player in the digital world and we are talking about architecture, a platform of having those data operating and creating analytics" (M5). With such partnerships, the firms were able to exert network capabilities, providing them an opportunity to acquire, develop, and leverage also their internal capabilities during exploitation. Illustrating such events, informant from M18 described how "we are setting up a delegated team to implement information platform together with subcontractors".

Some firms had decided to search beyond the metals and mining market domain, and to explore the applications which can be potentially empowered by digital technologies. As metals and mining firms are traditionally "not good at working with data in a creative way" (M3), such cross-domain explorative activities often involve or even depend on external capabilities which originate from the digital technology domain. Because of this, companies had decided that "we would, go seek the assistance from partners to do the design and potentially fabrication" (M2). Although "the novel idea may typically derive in-house" (M2), many firms still tried to "discover new ideas by cooperating with companies and research centers" (M10). Few firms exhibited internal capabilities needed for digital transformation, such as "mathematical modelling and data center hosting capabilities" (M3). Only one firm, M3, had achieved a complete integration of exploration and exploitation activities with network and internal capabilities. The firm had a long tradition as the pioneer, bringing in new technologies to the industry, a characteristic which might be associated with its large business scale and "marvelous business network" (M3). In summary, the largest case firms exhibited most operant resources for digital transformation.

On the other hand, the interviewed technology and equipment suppliers drove digital transformation in their own way. These firms sought for ambidexterity through their own capability development for exploration and exploitation, using both internal and network capabilities. Most often, these firms utilized both internal and network capabilities for exploration, through which novel business models and digital solutions were created. These activities had been preceded by considerable investments: "we invested hundreds of millions of dollars and built a brand-new data center for IoT delivery through distributors" (E1).

Table 1. Interview details

Firm	Introduction	Informant(s)	Date of interview
Firms that operate within the metals and mining industry (M)			
M1	Operates in multi-continent, produces multiple metals and minerals	Head of Automation	Feb 2016
M2	Multi-continent, produces multiple natural resources	Operation Manager; Operation Manager (former); IT manager	Mar-May 2016
M3	Multi-continent, metal producer	Superintendent; Principle Advisor; Global Director; Head of Innovation (2 interviews)	Apr-Jun 2016
M4	Multi-continent, gold producer	Former employee with various management positions	May 2016
M5	Multi-continent, precious metal producer	Senior Director	Jun 2016
M6	China, produces mineral concentrate	Head of Operation; Head of Technology	Mar 2016
M7	Russia	Head of Automation	Jun 2016
M8	Multi-continent, gold producer	Chief Metallurgist	Apr 2016
M9	Mexico, produces multiple metals	Automation Manager; Process Engineer; Head of Technology	Apr 2016
M10	South America, copper producer	ICT Director	May 2016
M11	India, steel producer	Former CIO	Apr 2016
M12	North America, produces iron concentrate	Technical Service Manager	May 2016
M13	Russia, precious metal producer	Director of Development	Jun 2016
M14	Multi-continent, produces industrial minerals	Head of Instrumentation	May 2016
M15	Americas, copper producer	General Manager; Metallurgist	Jun-Jul 2016
M16	Mexico, produces precious metal	Lead Metallurgist	Jun 2016
M17	China, steel producer	Operation Manager	Jun 2016
M18	China, produces multiple metals	Director of Technology; Vice General Manager	Mar 2016
M19	Multi-continent, mining and metal production	R&D Director; Head of Technical Analysis; Managing Director	May 2018
M20	Multi-continent, produces multiple metals	R&D Manager; Business Director	Jun 2018
M21	Europe, mining and metal production	R&D Manager; Business Development Manager	Jun 2018
M22	Finland, mining and basic refining	Process Engineer	Aug 2018
Technology and equipment suppliers that have a close connection to metals and mining industry (E)			
E1	Global firm, supplies mining machinery	Former CIO	Mar 2016
E2	Global firm, supplies automation equipment and systems to metals and mining companies	Former General Manager	Apr 2016
E3	Global firm, supplies equipment and platform solutions to metals and mining companies	Chief Data Scientist; Marketing Director	Apr 2016
E4	Global firm, supplies mining and materials processing machinery	Mining Technology Director; Global Division President	Jan 2015 & Jun 2018
E5	European-based vehicle manufacturer and supplier of drivetrains	R&D Director	May 2015
E6	Technology provider for mining and metals processing companies	R&D Director	Jun 2018

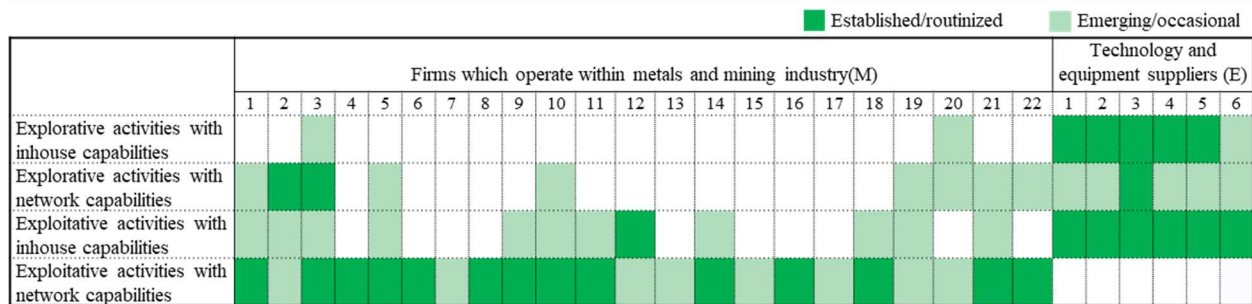


Figure 2. Digital transformation activities of industrial firms

Acquiring start-ups with digital competence was seen as another way of integrating network capabilities. In many cases, firms were looking for “ideas, capabilities and people, instead of ready-made concepts” (E4). At the same time, the suppliers had a clear vision of how to apply digital technologies to their existing products

and solutions. Especially for machinery products, sensors, network connectivity, and data collection tools were “already integrated as part of the asset before shipping” (E1). We did not find any supplier firm that would perform exploitative activities with network capabilities.

To summarize, the metals and mining industry firms and technology and equipment suppliers exemplified rather different activities. In general, the metals and mining industry firms seemed to prefer exploitative activities with network capabilities. We found that logical for an industry that is characterized by asset-intensiveness, small profit margins, a tendency for risk aversion, and a slow rate of change. In turn, the suppliers were considerably less reliant on the network capabilities, especially in exploitation. The suppliers had been developing their internal competences for a long time, resulting in plenty of internal capabilities for utilizing their products. Yet, while our data indicated the suppliers rely on internal capabilities for exploitation, we cannot exclude the possibility that some exploitation activities involve partners and subcontractors.

5. Discussion

This study aimed to uncover the evolution patterns of industrial firms' explorative and exploitative capability development in the context of digital transformation. Based on our findings from the metals and mining industry, we now discuss the firms' search for new knowledge and organizational capabilities. Following Jansen et al. [24], we analyzed whether the firms' knowledge search relies on internal or network capabilities, and whether their learning was focused on explorative or exploitative approaches. Herein, we further distill our findings into two discrete evolution paths that illustrate this cross-functional knowledge search between local (exploitation) and distant (exploration), and digital technologies and mining context.

Figure 3 illustrates our interpretation of capability development as a part of the digital transformation of metals and mining firms. For these firms, digital technologies have not been part of their operation, which is why they had to acquire new capabilities to facilitate the transformation. Most often the firms begun their digitalization journey by product-market exploitation relying on network capabilities. The 1st step indicates such activities, e.g., purchasing fit-for-purpose solutions or completely outsourcing to technical suppliers, with the focus on exploiting the products in the market. Gradually, firms adopted a partnership model in which internal capabilities were developed and leveraged throughout. The more innovative industrial firms later initiated cross-functional exploration (step 2), in which they sought for potentially novel applications with currently available digital technologies. Although with a high reliance on the network capabilities, a few front-running firms had been able to acquire new internal

capabilities, such as data analytics and digital application development. In the end, the firms adopted the novel outcomes into their existing business operations for performance improvements through cross-functional exploitation (step 3).

However, the full evolution path can be challenging to achieve in practice, since it "is a huge learning curve" and "takes a lot of time because it's almost hit-and-miss, trial-and-error" (M3). As illustrated in the empirical findings (see Figure 2), the majority of the firms had focused on within-function exploitations only. Some mining firms showed low commitment on internal digital capabilities development, potentially due to having limited financial resources or being uncompetitive in attracting the right talent [15]. Despite these differences, the firms seemed to illustrate characteristics that suited to different stages of the same evolution path.

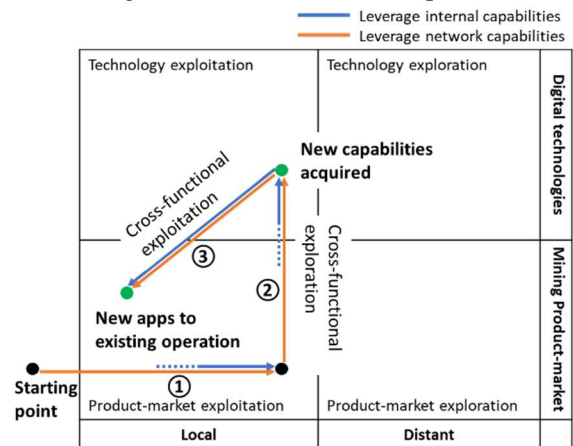


Figure 3. Evolution path of M&M firms

The technology suppliers' capability development path concerning digital transformation is illustrated in Figure 4. These companies relied more on their internal capabilities at the start of their journey. As the providers, they had begun to sense the market demands and to make adjustments on firms' existing products and business models (step 1) [38]. These activities helped the providers to gain on-hand experience of the practical demands in the industry. After that, the technology suppliers could combine internal and network capabilities to simultaneously extend their exploration within the metals and mining product-market domain (step 2), as well as cross-functional exploration toward digital technologies in other contexts (step 3). As a result, firms can better explore and develop novel digital technologies (step 4) with their industry partners.

Through such activities the firms will be able to acquire new internal capabilities, such as digital platforms and application development. Through step

2, new solutions were created by integrating existing digital technologies within the mining product-market domain. Alternatively, new solutions were generated via the cross-functional exploitation of novel technologies (step 5).

Ambidextrous performance is difficult to achieve, especially if only internal capabilities are utilized. Our study reveals that digitalization front-runners in the metals and mining industry (e.g., M3) chose to start with utilizing network capabilities from different sources (e.g., research institutes, start-ups and big corporations) in explorative activities and gradually developed internal capabilities throughout the process by talent acquisition and retraining employees. Such practices may be applicable for other firms which have not reached ambidexterity yet. Of note, firms' eventual success in acquiring new internal capabilities and their consequent role for digital transformation can be truly evaluated retrospectively [19].

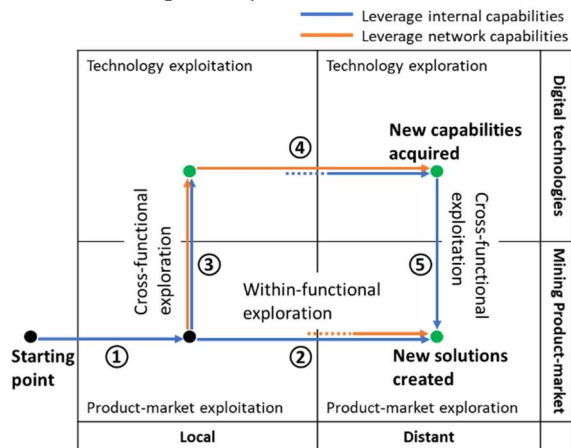


Figure 4. Evolvement path of technology suppliers

5.1. Research implications

This paper focused on the question of how firms can develop capabilities to support the new value creation opportunities of digital transformation. Thus, we contribute to literature on ambidexterity [33, 44] and dynamic capabilities [20, 34]. We add to the growing stream of research on digital transformation [15, 26, 42]. Our aim is to elaborate theory [29] by illustrating the different types of organizational learning activities and cross-functional knowledge search [32]. Thus, we connect the theoretical models of ambidextrous knowledge search to the practical context of digital transformation.

Our study supports the networked view of ambidexterity and the discussion that emphasizes partnerships and the capabilities external to the focal firm [27, 28]. We extend these perspectives by explicating the different types of learning and

knowledge search across domains [32] that is associated with digital transformation. We consider such cross-functional processes less guided by formal structures and thus allowing more dynamic capability development [34, 38] than, for instance, alliance portfolios [18, 22].

By building on the typology by Li et al. [32], we explicated the activities that are needed to facilitate digital transformation in a traditional, asset-intensive industry. Our findings suggested that firms develop ambidextrous performance by combining explorative and exploitative learning in a series of activities that balance their competences with their partners with complementing capabilities.

5.2. Managerial implications

This article elucidates the interplay of explorative and exploitative capability development. As digital transformation calls for and encourages ambidextrous capability development, firms shall first clarify the overall goal and determine their own spectrum of exploration and exploitation accordingly.

Considering a firm's digital transformation journey, we recommend the industry firms to **build mutual trust** with partners, especially in terms of data sharing. Although partnerships do offer complementary capabilities, firms with a high digital ambition shall **be active** in developing internal capabilities (e.g., M3 launched own innovation center several years ago for data analytics).

Achieving full ambidexterity can be time-consuming with heavy investments, and therefore firms should **be realistic** and focus on value-adding targets, e.g., adoption of autonomous trucks. Such clearly defined targets had resulted in considerable benefits among the studied mining firms.

Digital transformation is a continuing process with cyclical progress and unclear potential. Therefore, the firm should **be visionary** and set the program performance indicators which balance exploration vs. exploitation, short-term vs. long-term, and inhouse development vs. partnerships. Previous literature [15, 34, 42] has already pointed out how poor alignment between these aspects can lead to considerable tensions in the transformation process.

6. Limitations and Future Research

Our study is not without limitations. First and foremost, while we describe a snapshot of the realized and intended development paths for digital transformation for two types of firms, we use cross-sectional data to validate our view. Thus, the model should be regarded as an interpretation based on the

findings of our abductive data analysis. Second, we evaluated the firms' capabilities based on the activities they perform, due to the lack of more direct measures. Another limitation is that exploitation of network capabilities was not specifically brought up by the informants from technology suppliers. It may either indicate that the firms have not used network capabilities in exploitative activities, or the informants may not particularly consider the well-established stable partnerships in conventional solutions as an adoption of network capabilities. Therefore, we are not able to identify whether the exploitative activities involve partners for the technology suppliers. We did not control for the firm size in our analysis either—it is plausible that the different levels of maturity relate to the size and resources of firms, above anything else.

The impacts of digital transformation are twofold: on one hand it brings compelling opportunities to the business operations, while on the other hand, it erodes industry and market boundaries and forms a new set of rules for the game [47]. Therefore, future research should continue to investigate how could the firms manage digital transformation as well as acquire and sustain competitiveness in markets with growing turbulence.

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