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Digital pioneers in the periphery? Toward a typology of rural Hidden Champions in times of digitalization

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ABSTRACT

We unravel dimensions, conditions, and outcomes of digitalization for Hidden Champions (HCs) in rural areas in Germany. As highly innovative small- and medium-sized market leaders, HCs are challenged to maintain their niche dominance but are endowed with significant resources. However, firms in rural areas face resource constraints related to digitalization and innovation. Based on qualitative interviews with 28 companies, we develop a typology of HCs with four firm types differing in their handling of digitalization: Digital HCs, HCs of Digitalization, Traditional HCs, and Digitalization-Skeptical HCs. Their digitalization-related potential and risk assessment, resource availability, strategy, and innovation types are portrayed. We provide evidence that innovative market leaders in rural areas are not necessarily also digitalization front-runners. We contribute to a deeper understanding of the nexus of digitalization, SMEs, and rural areas. Our findings have managerial and policy implications. Less innovative SME can emulate HCs' handling of digitalization. Regional policymakers should expand firm type-specific digitalization policy formulation.

RÉSUMÉ

Nous révélons les dimensions, les conditions et les résultats de la numérisation pour les champions cachés (CC) dans les zones rurales en Allemagne. En tant que leaders de marché de petite et moyenne taille hautement innovateurs, les CC doivent relever le défi de maintenir leur domination de niche mais sont dotés de ressources importantes. Cependant, les entreprises des zones rurales sont confrontées à des contraintes de ressources liées à la numérisation et à l'innovation. Sur la base d'entretiens qualitatifs avec 28 entreprises, nous développons une typologie des CC à partir de quatre types d'entreprises qui diffèrent dans leur traitement de la numérisation: les champions cachés du numérique, les champions cachés de la numérisation, les champions cachés traditionnels et les champions cachés sceptiques de la numérisation. Leur potentiel et l'évaluation de leurs risques, liés à la numérisation, la disponibilité des ressources, la stratégie et les types d'innovation sont décrits. Nous apportons la preuve que les leaders du marché dans les zones rurales ne sont pas nécessairement aussi des précurseurs de la numérisation. Nous contribuons à une

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meilleure compréhension du lien entre la numérisation, les PME et les zones rurales. Nos résultats ont des implications managériales et politiques. Les PME moins innovantes peuvent s'inspirer de la façon dont les CC gèrent la numérisation. Les responsables politiques régionaux devraient élaborer la formulation de politiques de numérisation spécifiques à chaque entreprise.

1. Introduction

Digitalization involves fundamental changes to products and business models and processes, both internally and with external stakeholders. Following Clerck (2017), we understand digitalization as “the use of digital technologies and of data to create revenue, improve business, replace/transform business processes and create an environment for digital business, whereby digital information is at the core.” Digitalization also affects Hidden Champions (HCs) as highly innovative but little-known small- and medium-sized companies possessing market or technology leadership for specialized products. HCs have significant export shares in their niche segments and are required to cooperate with customers globally (Rammer and Spielkamp 2019). HCs are mainly active in manufacturing industries and have concentrated their innovation activities on incremental continuous process improvement, which deviates from digital modes of innovation (Simon 2009; 2020). Hosting a vast majority of HCs in Germany, rural areas face special conditions and external resource constraints, both concerning digitalization and innovation (Eder and Trippel 2019). HCs are understood as the backbone of the German *Mittelstand* of export-oriented small- and medium-sized enterprises (SME). So, their continued business success in times of digitalization is crucial for the prosperity of the larger economy (Wittenstein 2020). This situation is even amplified for rural areas, facing substantial challenges related to digitalization.

We contribute to the literature by addressing a research gap in the nexus of digitalization, SMEs, and rural areas, which will be further described in Section 2. Facing scant research, this study adds additional analytical depth and differentiation in understanding HCs' digitalization behavior by considering contextual factors and focusing on key conditions and outcomes of digitalization. Most of the HC literature neglects the spatial context by not distinguishing between rural and agglomeration areas and not considering differences in location conditions and requirements. The geographical focus of this study on rural areas shines a light on a regional context associated with increased challenges and resource constraints concerning digitalization (Eder and Trippel 2019). Moreover, managerial context such as ownership structure (and hence managerial agency) is largely ignored in the HC literature, and thus, for example, private equity-owned firms and family businesses are not analyzed in distinct ways. Research frequently does not distinguish between HCs and other SMEs (Schenkenhofer 2020). This article provides a perspective on a segment of SMEs that systematically deviates from other SMEs due to market and technology leadership and abundant internal resources, and different managerial context (Witt and Carr 2013). Further, in academic and political discourses and beyond, digitalization has

suffered from a lack of analytical precision (Bloomberg 2018). Using semi-structured interviews has so far not been employed in research on the digitalization of HCs.

These identified voids have recently motivated scholars to ask for a more differentiated understanding of digitalization (Attaran and Woods 2019) and for building bridges from management research to related disciplines (Beckmann, Garkisch, and Zeyen 2021), such as economic geography.

This study hence investigates two key research questions: What are the dimensions and conditions of digitalization for HCs in rural areas? How do these dimensions and conditions shape outcomes of digitalization for these firms?

Therefore, we develop a typology of HCs concerning the dimensions, conditions, and outcomes of digitalization. It emphasizes the key role of context to address this interface of digitalization with this special firm type, which is highly relevant for the overall economy, and a distinct spatial situation, facing increased challenges globally. The typology helps to better understand important dimensions of digitalization, key characteristics of HCs, and the combination thereof.

This study is structured as follows. Section 2 presents the state of research about HCs in rural areas in times of digitalization and develops relevant research questions. Section 3 describes the qualitative methodology employed for this study. Section 4 introduces a typology of HCs and portrays the identified types. Section 5 concludes with a discussion and summary.

2. Literature review

Several streams of literature relate to this study sitting at the nexus of digitalization, HCs, and rural areas. These include research on digitalization in SMEs, HC-related digitalization, and conditions of digitalization in terms of spatial and managerial context. These micro- and meso-level perspectives are being coalesced into research questions, which this article investigates.

2.1. Digitalization in SMEs

Digitalization has an enormous potential to transform products, business models, and processes, both internally and with external stakeholders (Geissdoerfer et al. 2018). Theoretical perspectives on organizational digitalization can be identified in the literature on resource-based views, dynamic capabilities, transition theory, transaction cost theory, and platform theory (Parida, Sjödin, and Reim 2019).

The understanding of digitalization in SMEs is heterogeneous. Over the past decades, substantial research on business-related digitalization, digital transformation, and Industry 4.0 has been published, mainly focusing on its necessary resources and capabilities, enablers, and processes (Li et al. 2018). We follow Clerck (2017) in understanding digitalization as “the use of digital technologies and of data in order to create revenue, improve business, replace/transform business processes and create an environment for digital business, whereby digital information is at the core.” Regarding components and dimensions of digitalization, scholars have developed various frameworks of digitalization in the economy. Examples include Mayer’s

(2018) main technologies of digitized manufacturing processes and Ciffolilli and Muscio's (2018) taxonomy of Industry 4.0-enabling technologies based on the European Union's Seventh Framework Program key enabling technologies. As an example, the latter include advanced manufacturing solutions, additive manufacturing, augmented reality, simulation, horizontal and vertical integration, industrial internet and cloud, cyber-security, big data, and analytics. The literature is unanimous in emphasizing the importance of internal and external resources such as digital infrastructure and workforce with digital capabilities (Salemink, Strijker, and Bosworth 2017). Digitalization has additionally been investigated about its potential and risk for SMEs. Frequently mentioned potential includes increased revenue, cost savings, and increased organizational agility, while risks and challenges highlight technological complexity, uncertain benefits and business cases, and lack of adequate resources (Matt, Modrák, and Zsifkovits 2020). However, there is no differentiation of firms occurring in virtually all research, except for a few industry- and firm size-specific studies (Peillon and Dubruc 2019).

The vast majority of studies on digitalization in SME in Germany was designed with standardized questionnaires and then analyzed quantitatively (e.g. Freimark et al. 2018). Further, many studies have anchored opinion polling as a central method. These are often guided by interests – e.g. by private sector firms – and contain suggestive questions and operationalize key concepts insufficiently. A sizeable share of these surveys focuses on measuring digitalization in SME (e.g. Schuh et al. 2017). Becker, Ulrich, and Botzkowski (2017) attest such studies a lack of depth in the analysis of digitalization components or Industry 4.0 – especially about the strategic dimension and adjustments and extensions of existing business models. Only a few studies employ a qualitative research design to better understand the complexity of digitalization's dimensions and conditions (e.g. Müller-Seitz and Weiss 2018).

2.2. Digitalization of HCs

HCs are little-known small- and medium-sized global or continental market leaders. Due to their incessant strong firm performance, they have been examined widely and have been shown as significantly contributing to the strength of the German *Mittelstand* and its export orientation. With a substantial part of the research literature coming from Germany due to the global HC concentration there, we refer to Simon's foundational efforts (e.g. 2009) and to Schenkenhofer (2020) for an extensive literature review of research on HCs.

Three key features of HCs are especially relevant for this study, and most serve as differentiators from other SMEs. First, HCs possess market or technology leadership, or both, mainly in manufacturing-related business-to-business niche markets, enabled by abundant internal and external resources (Simon 2009). However, literature on resource availability has so far neglected digitalization-specific resources. Second, HCs have significant R&D capacity and activity to maintain this market position and use innovation as a long-term business success strategy, supported by strong research cooperation with universities (Venohr and Meyer 2007). Third, innovation is mainly conducted incrementally, emphasizing continuous improvement processes in close

interaction with customers (Rammer and Spielkamp 2019). However, there is a research gap on digitalization-related R&D activity and innovation of HCs. In particular, it remains open whether capabilities in manufacturing R&D are equally suited for digitalization-related innovation. This question has important implications for the prospective business success of HCs.

Very few studies have so far examined the digitalization of HCs, although several analyses focus on SMEs without specifying company size, market position, and levels of public awareness. Further, conditions of digitalization such as spatial (e.g. rural areas) and managerial (e.g. ownership structure) context have not yet been acknowledged concerning HCs. Freimark et al.'s (2018) survey of digital transformation initiatives are focused on distinguishing HCs from other SMEs and large corporations. Müller-Seitz and Weiss's (2018) case study of digitalization efforts of a German artificial intelligence HC is limited to a software firm whose digital products deviate from the vast majority of manufacturing-focused HCs. Kamp's (2018) analysis of offerings for smart services of manufacturing HCs is focused on a particular type of business model innovation. Wittenstein's (2020) dynamic capabilities approach emphasizes the resources of HCs but does not consider digitalization-related innovation as an outcome of the utilization of these resources. Simon's (2020) assessment of digitalization success factors is selective about marketing and opens up research avenues for other corporate functions.

2.3. Conditions of digitalization: spatial and managerial context

The conditions of spatial and managerial context play an increasingly important role in management research, particularly concerning innovation and decision making (Autio et al. 2014) and are hence also relevant for digitalization.

Regarding spatial context, rural regions are an important spatial category for HCs as their headquarters are frequently located outside agglomeration centers. In Germany, which hosts most HCs globally, about two-thirds of HCs are in rural areas (Simon 2009; Schenkenhofer 2020), compared to 39% of all companies in Germany (Stiftung Familienunternehmen 2020). In this study, we define rural areas according to the Eurostat (2020) NUTS3-based definition as regions with a density of fewer than 300 inhabitants per km². Rural areas face various challenges and could not fully reap the benefits of the digital revolution, underlining a digital divide (Malecki 2003). The reasons are manifold and lie in complex interactions between infrastructural, supply-related and usage-/demand-based factors (Salemink et al. 2017). The literature on digitalization in rural areas often neglects the conditions of digitalization for enterprises and the specific impact of enterprises on the digitalization of these regions in terms of externalities (Colombo, Croce, and Grilli 2013). In rural areas, the conditions for innovation are different from urban areas, and innovation capacities and types should be interpreted in a regional context: There is a broad consensus in the research literature that peripheral spaces offer comparably difficult conditions for innovative activities (Eder and Trippl 2019).

Besides spatial conditions, managerial context such as ownership structure plays an important role in decision-making and innovation (Cucculelli, Dileo, and Pini 2021).

Mostly, HCs are owner-managed and in cross-generational family ownership (Venohr and Meyer 2007). Family firms are distinct in their long-term orientation (Lumpkin and Brigham 2011), home-region focus and secrecy (Banalieva and Eddleston 2011), and relevance of noneconomic goals and bounded rationality (Chrisman, Memili, and Misra 2014). These have significant implications for the digitalization of family businesses, such as more conservative approaches to new technologies, and the threats to home-region orientation through the transaction-cost reducing effect of digitalization and to secrecy due to digital traces and data interfaces with other actors (Cravotta and Grottko 2019).

2.4. Research questions and objectives

Addressing the context and research gap outlined above, the following research questions are approached in this article: What are the dimensions and conditions of digitalization for HCs in rural areas? How do these dimensions and conditions shape outcomes of digitalization for these firms?

3. Methods

3.1. Data collection and sampling

To better understand the dimensions, conditions, and outcomes of digitalization for HCs in rural areas, we designed and implemented a qualitative research approach. The method was deliberately chosen to address the research gap outlined above. Therefore, we decided on conducting semi-structured interviews with HCs in rural areas in Germany. The method of interview guide-led semi-structured interviews has been chosen deliberately to cater to the explorative nature of this study (Gioia, Corley, and Hamilton 2013). Hence, this study differs from the questionnaire-based approach pursued by most studies on digitalization in SMEs. This method seemed appropriate for a widely discussed topic such as digitalization.

We limit the sample to Germany, hosting more than half of all HCs (Simon 2018), to standardize macro-conditions. To better understand regional characteristics, we selected four rural regions to cover a large spectrum of demographic, economic, and infrastructural indicators, based on Oberst, Kempermann, and Schröder (2019): two regions with a strong and two with a weak profile of indicators, and of each group one in West and one in East Germany. The regions selected were Central Hesse and Leine-Weser in West Germany, and Lower and Upper Lausitz, and northeastern Harz foreland in East Germany. We based the definition of rural regions on the Eurostat (2020) NUTS3-based definition. For firm sampling, the Global Market Leader Index by Müller (2018) and interviews with Chambers of Commerce and Industry representatives in the respective regions were used to identify potentially relevant firms. All firms were afterwards evaluated regarding their fit with Simon's (2018) definition of HCs.¹ Only firms that matched this definition and were located in these four regions were contacted with interview requests.

¹(1) Part of the top three companies in their market segment globally or are number 1 on their continent, (2) annual turnover below 5 bn. €, and (3) low level of firm familiarity among the general public or outside their industry.

Based on the theoretical and empirical starting situation described above, an interview guide was developed and used in the interview. This semi-structured approach supported orientation during the interview and ensured comparability in the evaluation. We distributed the interview guide with open questions in advance, and personal focal points were encouraged. Between September and December 2020, 28 interviews were conducted with representatives of the HCs. The interview partners were exclusively members of the management, in particular CEO/CIO/CTO/CDO. We focused on those roles as they are knowledgeable about the respective company's digitalization strategy and pursuits and have the authority to disclose details. Further, they are acquainted with the firm's history and regional context due to the long tenure typical for leadership of HCs (Venohr and Meyer 2007). One representative per firm has been interviewed.

In our sample, the share of HCs mainly active in manufacturing is 89%, the remainder being HCs that exclusively produce software. This distribution is proportionate to the proportions among all German HCs. The average turnover of 195 mn.€ per year is lower than the overall average of all HCs with 325 mn.€ (Simon 2018). The average share of exports was 52%, and the share of family-owned firms was 54%. Details of the sample are provided in Table 1. Due to the ongoing COVID-19 pandemic, all interviews were conducted remotely: most via video-conferencing and the remainder via telephone. The interviews on average lasted 57 min were audio-recorded after permission was granted, and then transcribed. All relevant statements by interviewees used in this article were translated into English. Considering that digitalization strategies and innovation activities are sensitive matters, we guaranteed confidentiality and anonymity to the interviewees to ensure openness and to increase the response rate.

3.2. Data analysis and evaluation

The interviews were subsequently coded to develop a data structure with first-order concepts, second-order themes and aggregate dimensions, based on Gioia et al. (2013). The software *f4* was used for this purpose. One researcher coded the interviews, while research assistants transcribed the interviews. First, we coded the HC interview material into 323 first-order concepts derived from the data and proximate to the interviewees' terminology. Examples are statements on "data standardization," "bandwidth requirements," and "step-fixed costs." Investigating the similarities and differentiations between these concepts, we aggregated them into 27 second-order themes such as "infrastructure" and "process innovation." Four aggregate dimensions of digitalization were derived from the further aggregation of second-order themes: "potential and risk assessment," "resource availability," "digitalization strategy," and "innovation types." Additionally, the interviewees' statements were selectively triangulated and validated with secondary data sources such as annual reports, firm websites, and magazine articles (Graebner, Martin, and Roundy 2012).

A cross-case analysis revealed commonalities and differences between the interviewed HCs (Yin 2011). Based on this coding scheme, we identified two key type dimensions, which are outlined below. Thus, empirically grounded firm types were

Table 1. Description of interview sample.

ID	Industry	Firm foundation	Firm revenue (mn. €)	Employees (#)	Interview duration (min.)
HC1	Extension spindles and poles	1990s	~5	~50	85
HC2	Wireless controls	1990s	~50	~180	64
HC3	Lithium-ion batteries	2000s	~90	~1600	51
HC4	Water ultrafiltration	2000s	n/a	~140	59
HC5	Ladder systems	1940s	~150	~500	59
HC6	Slicing systems	1980s	~250	~1400	56
HC7	Bowden cables	2000s	n/a	n/a	30
HC8	Steel construction	1990s	~30	~200	35
HC9	Extraction and filtration	1990s	~30	~130	55
HC10	Electrical safety	1940s	~150	~900	50
HC11	Buffet solutions	1980s	~5	~20	51
HC12	Festive decoration	1890s	~10	~150	45
HC13	Fine chemistry and fragrance components	1990s	~15	~50	44
HC14	Marine gearboxes	1870s	~80	~500	63
HC15	Digital radio systems	1980s	~90	~50	92
HC16	Specialized textiles	1990s	~40	~150	40
HC17	Confectionery process lines	1920s	~50	~250	49
HC18	Foundry technology	1990s	n/a	~30	54
HC19	Welding machines	1910s	~120	~500	57
HC20	Office furniture	1900s	~80	~600	57
HC21	Spark extinguishers	1910s	~90	~650	74
HC22	Central heating products	1920s	~600	~3700	60
HC23	Welding torches	1940s	~300	~2200	62
HC24	Powertrain technology	1940s	~800	~4000	63
HC25	Software engineering	1990s	~10	~80	69
HC26	Switchgear	1990s	~60	~200	46
HC27	Seed production	1850s	~1700	~5700	50
HC28	Float glass	2000s	~300	~250	65
Average:			195	890	57

Source for firm data: Bureau van Dijk (2020) and desk research; latest data available for revenue and employees.

constructed, based on Kluge (2000). The interviewed firms were clustered and assessed regarding regularities of responses. The subsequent construction of types was based on meaningful relationships between responses, focusing on heterogeneity between and homogeneity within types. The identified types were then characterized and further illustrated; they represented homogeneous characteristics as responses to one or more dimensions. However, the types described in the next section should be understood as generalized. Although individual firm cases may differ from these types in one or more characteristics, they are useful in understanding and explaining the dimensions and conditions of digitalization of HCs in rural areas.

4. Results

4.1. A typology with two key dimensions

Conducting a cross-case analysis, it became evident that the responses of HCs toward the dimensions and conditions of digitalization were too heterogeneous to treat them as uniform for all HCs. Based on the methodology described above, we developed a typology of two independent type dimensions – first, potential and risk assessment of digitalization and, second, availability of digitalization-relevant resources, both internally and externally. In the following, the typology serves as a basis to portray the dimensions, conditions, and outcomes of digitalization for HCs.

The first type dimension, potential, and risk assessment of digitalization, is represented on a spectrum from affirmative, balanced, and skeptical. An affirmative assessment emphasizes the potential related to digitalization for the business success of the HC, and weighs it significantly higher than related obstacles and challenges. Potential includes revenue growth through new products, business models, or sales channels and cost reduction, product quality and customer satisfaction.

The potential is large and very significant, but some of these opportunities are imperative to take as they would turn into risks, if not taken. [...] If we do not move fast, large corporations such as Bosch or Continental develop more sophisticated technologies and we will suddenly trail. (HC2)

A balanced assessment highlights the necessity to consider potential and challenges equally, and calls for taking the company tradition and the nature of the product into account.

How can I develop a digital business model, a digital product on the basis of our company history, its tradition? I think it is very important for me that we do not try throwing away our entire history and tradition and then do something completely new, but to harmonize them in this way. It is my strong belief that mastering this tightrope walk will distinguish us. (HC20)

A skeptical assessment significantly focuses on perceived risks of digitalization that outweigh any benefits, and hence displays a decreased risk preference. This perspective may be centered on the company itself or may be broader to include existing business networks or the rural region, in terms of loss of workforce through automation or relocation of firms.

I am absolutely convinced that fine chemicals, as we make them, will not live on generating data, but that our core business will continue to be to manufacture products, tangible products. (HC13)

The second type dimension, availability of digitalization-relevant internal and external resources, may range from limited to abundant. Internal resources entail factors such as firm IT infrastructure and qualification of HC employees. External resources include existing networks and cooperation with suppliers, universities, and other institutions with digitalization-relevant resources relevant to a firm's digital transformation and locational factors such as digital infrastructure such as fiber, broadband, 5G, and mobile networks and digital capabilities of the regional workforce. To some extent, a deficit in internal or external resources can be compensated by the abundance of others, relocating, or contracting. HCs that would rate both their digitalization-relevant internal and external resources as abundant face no resource constraints, while the scarcity of resources limits a firm's ability to realize its assessment of digitalization, and consequently, its strategy.

So, if you want to continue walking in this direction about digitalization, and it definitely makes sense to do that, we must address the infrastructure. Digitalization by itself is without purpose if the required infrastructure is not available. (HC4)

4.2. Description of types

Our interview data allow for the identification of four types of HCs in rural areas regarding their approach toward digitalization: (1) Digital Hidden Champions

		Resource availability (internal and external)	
		<ul style="list-style-type: none"> • Digital infrastructure • Workforce with digital capabilities 	
		Abundant	Limited
Potential and risk assessment of digitalization • Firm-centered perspective	Affirmative	Digital Hidden Champions (DHC) n=2 HC18/25	Hidden Champions of Digitalization (HCD) n=10 HC2/3/4/5/6/10/19/22/23/27
	Balanced	Traditional Hidden Champions (THC) n=11 HC1/9/13/14/15/17/20/21/24/26/28	
	Skeptical		Digitalization-Skeptical Hidden Champions (SHC) n=5 HC7/8/11/12/16

Figure 1. Typology of HCs regarding digitalization.

Source: Own elaboration, based on interviews with $n = 28$ interviewed HCs.

(DHC), (2) Hidden Champions of Digitalization (HCD), (3) Traditional Hidden Champions (THC), and (4) Digitalization-Skeptical Hidden Champions (SHC). **Figure 1** positions them in relation to the developed type dimensions. The type dimensions of potential and risk assessment and resource availability – expressed both as condition and requirement – and the outcomes in terms of digitalization strategy and innovation types will be used to portray the identified types. **Figure 2** presents a framework of these aggregate dimensions, while **Table 2** summarizes the portrayal of these identified types.

4.2.1. Digital Hidden Champions

Firm profile: DHC exclusively produce niche digital products and services. They are small- to medium-sized firms, predominantly owner-managed or start-ups.

Potential and risk assessment: Owing to the purely digital nature of their products, DHCs rate digitalization-related potential significantly higher than challenges and obstacles. Commonly highlighted potential includes both revenue increases through new business models, product innovations and digital sales channels, cost reductions through additional digitalization and automation of processes. Moreover, a regionally specific argument includes the remote market access potential for these firms being located in rural areas. Mentioned challenges focus on technological complexity, the difficulty in attracting labor with digital capabilities to rural areas, the lack of political support for digital infrastructure and internal digitalization, and the difficulty in establishing cooperation with public research institutions.

Resource availability: DHCs put a strong emphasis on the availability of digital infrastructure and highly qualified employees. Besides high bandwidth and latency demands, DHCs have stressed the importance of redundancy in Internet connections. In extreme cases of initial resource scarcity, some firms report having undertaken significant efforts to ensure sufficient connectivity, including local political involvement

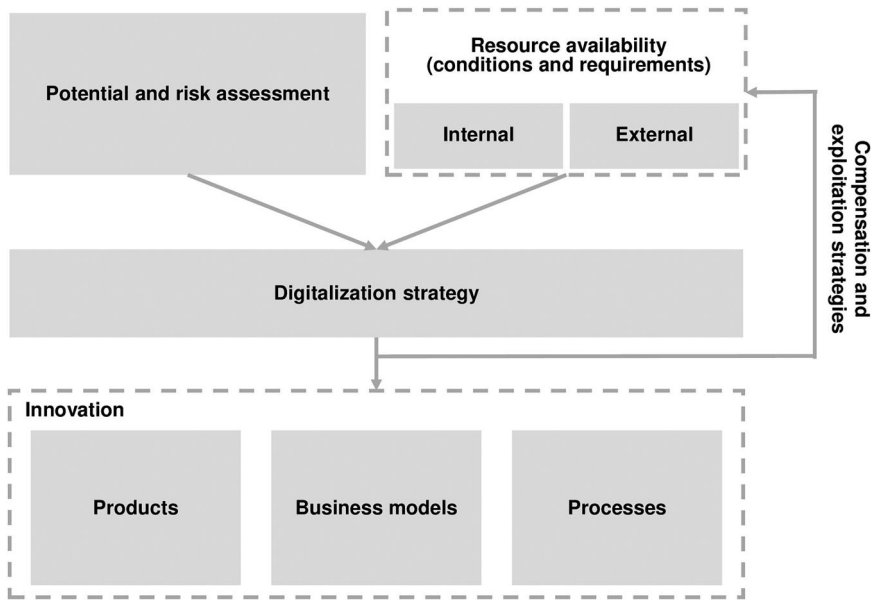


Figure 2. Dimensions of HC digitalization.

Source: Own elaboration.

and pressuring regional grid operators to accelerate construction and dedicated lines with costly contracts with telecommunications providers or even own construction.

It took us seven years of application, and then we finally got it here. However, we drilled it ourselves: We drilled the 2 km to the distributor ourselves with a deep drilling machine. Otherwise, it would have taken another two years, [...] and there we said “enough is enough”. (HC18)

The interviewed HCs occasionally emphasized the importance of 5G, but to an extent smaller than broadband and fiber internet. It has exclusively been cited as a future locational requirement by DHCs and HCDs.

A commonly mentioned instrument to attract local labor and to retain employees is corporate social/regional responsibility. DHCs have also emphasized the need for urban amenities, traffic connectivity, and other initiatives to cater for the lifestyle preferences of the young, digitally qualified workforce.

Digitalization strategy: Due to the overwhelmingly optimistic attitude toward digitalization and the abundant availability of resources, DHCs have detailed their relevant strategies to a large extent. Due to their product, DHCs perceive digitalization as an integral part of their overall firm strategy. Further, the agency of management plays an important role here as an impetus for these strategies.

Well, we do not have a strategy in itself. Our strategy is to digitize and automate everything possible. First, because you have no employees, and second, because the machines, if they run around the clock, are much cheaper than if people are used. (HC18)

Innovation types: DHCs have strongly advanced and implemented digitalization-related innovation, including adjusted digital business models. They further report

Table 2. Dimensions and outcomes of digitalization for HC types.

	DHC	HCD	THC	SHC
Industry/nature of product	Niche digital products and services	Mainly analog products in manufacturing and other industrial segments	Manufacturing of analog products, mostly in classic mechanical engineering	Solely analog products with company origins in manufacturing
Firm ownership	Predominantly owner-managed or start-ups	Publicly traded or private equity-owned firms; family businesses, often with junior management	Overwhelmingly family businesses, often with a long tradition	Family businesses with an extensive tradition
Firm size	Small- to medium-sized firms	Medium-sized to large HCs with a few thousand employees with ample internal resources	Small- to medium-sized firms	Mainly small-sized firms
Digitalization potential and risk assessment	Potential significantly higher than challenges and obstacles, including new business models, product innovations and digital sales channels, cost reductions	Digitalization considered necessary and imperative to maintain leadership position; potential (revenue gains, cost savings in production, sales, logistics and administration)	Balanced assessment between being affirmative and being skeptical; viewed as tightrope act to seize advantages and preserve tradition and identity; emphasis on limited flexibility of business model and significant risks associated with digital transformation	Risks by far outweigh potential benefits, such as high investment requirement, uncertain business cases, lack of necessity to maintain market leadership, loyalty with existing business networks, potential loss of employment for loyal employees
Resource availability	Abundant internal and external resources; strong emphasis on the availability of digital infrastructure (high bandwidth and latency, 5G) and highly qualified employees	Emphasized need for digital infrastructure and highly qualified professionals; varying availability of both internal and external resources, especially concerning digital skills	Both in combination with abundant and limited resources; skill compensation through contracting; digitalization seen as incentive for employees to make traditional manufacturers more attractive	Significant internal and external resource constraints, but assessed as less relevant as for other HC types

(continued)

Table 2. Continued.

	DHC	HCD	THC	SHC
Digitalization strategy	Integral part of their overall firm strategy; detailed to a great extent	Dedicated digitalization strategies to signal adequate importance; in family businesses strongly dependent on management agency	Formalized digitalization strategies, but selective and adjustable in nature, particularly in the medium and long term	Reluctance to develop a dedicated strategy
Innovation types	Inherently strong focus on digital innovations; mainly adjusted digital business models and overwhelmingly digitized corporate processes	Focus on process digitalization, mainly in production and administration; rapidly emerging digitalization of products and business models (data, value chain extension, platform)	Digitized sizeable processes in corporate support functions; however, often isolated and not integrated; more conservative approach for product and business model innovation	At most, select few projects, mainly to digitize administrative processes; skepticism toward digital business models; product innovations limited to considerations of use-based data gathering

Source: Own elaboration.

having digitized the vast majority of corporate processes. This naturally includes production due to purely digital products.

4.2.2. Hidden Champions of digitalization

Firm profile: HCD mainly produce analog products and have emerged mainly in manufacturing and other industrial segments. HCDs are the largest firms among HC types. They include large HCs with a few thousand employees with ample internal resources, publicly traded or private equity-owned firms with shareholder influence on corporate strategies, and family businesses with junior management. The latter are frequently the successors of company founders and tend to be more affirmative toward digitalization.

Potential and risk assessment: HCDs assess digitalization potential higher than challenges and risks, and consider it necessary to maintain and strengthen their market and technology leadership position. Cost-saving through digital and automated processes, predominantly in production, sales, logistics and administrative processes, as well as revenue gains through enhanced products, new business models related to servitization and disintermediation are frequently emphasized. Additional potential includes mastering technological complexity, using data analysis for various purposes, increasing customer satisfaction, stabilizing rural areas, and relieving COVID-19 pandemic obstacles. Digitalization considered imperative, with the risk of competitors taking over market shares being frequently emphasized.

Resource availability: HCDs strongly emphasize the need for digital infrastructure and highly qualified professionals. Many interviewees report having undertaken

significant efforts to ensure sufficient connectivity, including local political involvement. Firm size is a differentiating factor in terms of political support for the accelerated provision of high-speed Internet connections: HCs with more than a few thousand employees, predominantly classified as HCDs, have commended the swift political response. 5G was occasionally emphasized by the interviewed HCDs, with 5G campus and factory networks as relevant applications.

A frequently highlighted characteristic of HC is long tenure and low attrition of employees (Venohr and Meyer 2007). According to interviewed HCD leadership, this may prove to be an additional challenge under digitalization. In the past, HCs have succeeded due to continuous process improvement in mechanical engineering. The digital transformation constitutes a disruptive factor that may serve as an obstacle for potential inertia and lock-in. The long tenure and its consequential identification with the firm are still seen as a success factor for business, though increasingly threatened:

[...], which brings with it completely different challenges: How do I nevertheless establish a bond with the company? How do I get identification? We still need people identifying with the company, not just mercenaries who move from A to B. (HC6)

HCDs consistently emphasize that it is harder to attract qualified labor with more education and work experience due to increased competition by firms perceived as more attractive, such as software firms or large corporations in urban areas. As a consequence, many firms pursue strategies to attract potential employees as early as possible.

And since people are in high demand by the big companies, the competition is intense and as a small company you must get the people early on. (HC22)

An important advantage of digitalization frequently mentioned as a cause for substantial optimism and that proliferated in the pandemic conditions of 2020 is work from home, enabling HCDs in rural areas to expand their geographic reach in recruiting, without exacerbating the burden of commuting. Another compensatory strategy for resource constraints, both infrastructure- and workforce-related, is firm relocation or opening new firm locations in other regions. The launching of satellite offices, mostly for R&D, in agglomeration areas is an effective instrument. Larger HCs with a few thousand employees pursue a strategy of *tier 2* cities such as Bremen. These offer urban amenities and strong university and firm networks but are perceived as less “overcrowded” with new R&D offices of large corporations such as Berlin. This pattern corresponds to the image of “hiddenness” even in their locational choices. Relocation to other countries was mentioned less frequently.

Digitalization strategy: HCDs have developed dedicated digitalization strategies to endow it with adequate importance. Further, the agency of management plays an important role here as an impetus for these strategies.

We have separated digitalization into different areas: production, processes, sales and service. In these areas, we have numerous projects underway that we coordinate. [...] We have been doing this as a company since 2015. (HC22)

Innovation types: HCDs have digitized many processes in all firm units, including production and R&D, and state the ambition of digitizing additional processes.

Yes, it is definitely not easy for small companies, but we have the advantage that our investor insisted on [digitalizing most processes] and provided the necessary budget for the investment. (HC4)

For production, Mayer's (2018) key technologies industrial robots, additive manufacturing, big data and cloud computing, computer-aided manufacturing, artificial intelligence, and machine learning were all mentioned as already established digital processes. Most firms were realizing a manufacturing execution system, occasionally including digital twins of production. On a related note, a connected manufacturing environment related to Industry 4.0., frequently even with multiple plants involved, is a crucial goal of HCDs.

Generation and analysis of data are dominant motivations for digital product and business model innovation. Various purposes are stated: benchmarking to calibrate machines, better information about product lifecycles and wear out patterns, and predictive maintenance. Connectivity is also frequently mentioned concerning both inter-connectedness of product components and their connection to other machines and cloud connectivity. Connected devices have their main benefit in condition monitoring, remote control, and remote maintenance, often assisted by virtual and augmented reality technologies.

Some HCDs also state to be considering extending their value chain position and to transform toward platform providers. Various dimensions of a service business are motivations for HCDs that emerge from digitalization. These pertain to after-sales, particularly spare parts, to better understand the product's condition and increase replacement speed.

4.2.3. Traditional Hidden Champions

Firm profile: THCs manufacture analog products, mainly in classic mechanical engineering. They are overwhelmingly small- to medium-sized family businesses, often with a long tradition.

Potential and risk assessment: THC pursue a balanced assessment of digitalization between being affirmative and being skeptical. THCs view the task to seize digitalization advantages and conserve their tradition and identity as a tightrope walk. They embrace digitalization's potential and emphasize the limited flexibility of their business model and the significant risks associated with digital transformation. In contrast with HCDs, they have a more clouded perspective on the relevance of new business models. Additional challenges entail revenue loss through new competitors, the fast pace of digital transformation, the difficulty implementing digital innovation due to technological complexity, and data analysis, standardization, and security issues. The firm's size is frequently judged as too small to effectively engage in the digital transformation, partially due to the specific cost nature of many digitalization-related investments. Employees are an integral element in risk considerations, applying to the lack of acceptance for digitalization and digital skills. Moreover, a significant risk is seen in the chance of job losses – clashing with the perceived responsibility of THCs for their employees with long tenure and low attrition (Venohr and Meyer 2007).

Resource availability: THCs were identified both along with abundant and limited resources. For instance, the availability and reactions to limitedly available internet

varied significantly. All cases of scarce internet availability can be attributed to THCs and SHCs.

Our company is located in the middle of the forest, a bit far away from any village and of course you don't necessarily have a broadband connection for a single user here. (HC1)

To compensate for internal resource constraints by lack of expertise and to remain focused on their own technological specialization, HCs in rural areas report being contracting with external service providers such as software and consulting firms. Digitalization is further seen as an incentive for existing and potential employees to make traditional companies such as manufacturing HCs more attractive.

We can offer the young people something they like, something they are interested in. If I had remained solely a steel firm, things might have been different. (HC1)

From another perspective, digitalization and particularly automation and hence a decreased need for labor is perceived as an instrument to reduce recruiting difficulties in rural areas.

For me, that is a critical driving force to push and advance digitalization [...]: I do not know how it will be possible to find young talent here in five to six years. I want to have digital options to keep the business running smoothly with fewer people. (HC13)

Digitalization strategy: THCs report having formalized a digitalization strategy but aim at keeping it selective and adjustable, particularly in the medium and long term.

We have set ourselves a digital agenda: [...] Digitizing processes has top priority, simply to keep up with the costs. Digitized products are currently subject to a follow-up strategy. [...] That's simply not in our DNA, and we do not have people who can think and act like that. Our sector, by its very nature, is always behind. And you do not have to take a leading role here, you have to get used to it and saddle up a bit. (HC9)

The availability of policy programs to support the development of digitalization strategies is relevant. Additionally, agency of management in owner-managed firms plays an important role here:

There is no [digitalization] strategy written on paper. The strategy originates from my being. So I know what I want, where I want to develop the company and where I want to develop the employees, and I follow through on that. (HC1)

Innovation types: THCs have digitized sizeable process segments in corporate support functions such as finance, HR, and logistics. However, these frequently remain isolated and are not integrated into a connected IT infrastructure.

Oh, and we have also digitized the HR management: now we are digitizing our payroll system, fuel voucher and other fringe benefits. (HC9)

Additionally, THCs have only taken limited steps in digitizing production-related processes and often stated that a traditional continuous improvement process would yield the best results in optimizing production. THCs have consciously decided for a more conservative approach concerning digital product innovations compared to their advances in process innovations. They mainly focus on high-speed wireless sensors and actuators. Real-time analysis of sensor data is used to adjust the product operation, e.g. to change the heating system temperature, or to trigger the actual function

of a product, e.g. to eliminate sparks. Further, resource efficiency is frequently quoted as an additional benefit, such as optimizing gas input for welding machines. One interviewed HC, a manufacturer of specialized pipe components, uses sensors to locate grid leakages.

4.2.4. Digitalization-Skeptical Hidden Champions

Firm profile: SHC solely produce analog products and have their company origins in manufacturing. They are mainly small-sized firms and are – equally to THCs – family businesses with an extensive tradition.

Potential and risk assessment: In the perspective of SHCs, risks and challenges of digitalization by far outweigh potential benefits. The obstacles include all the aforementioned aspects and additionally stress the high investment necessary, uncertain business cases, the lack of necessity to maintain one's market leadership position, particularly in manufacturing, the overwhelming speed of transformation, the loyalty with existing business networks that could erode through digitalization, the potential loss of employment for loyal employees, and negative social consequences of digitalization such as human isolation. Further, SHCs perceive no threat from digitalization to their market position due to the niche nature of their products.

Resource availability: SHCs face significant internal and external resource constraints relevant for digitalization. All cases of scarce internet availability can be attributed to THCs and SHCs. The requirement for infrastructure and labor with digital capabilities is limited, and the status quo is rated as sufficient. SHCs were the only group with strong reservations against working from home, citing the risk of inefficient collaboration, the physical distance to production sites, as well as individual effects such as the psychological consequences of isolation.

Digitalization strategy: SHC express their skepticism toward digitalization also in their reluctance to develop a dedicated strategy.

It is available only rudimentarily. We have a list of points that we want to modernize, digitize in the future. That is more of a bullet point list. [...] In the end, we can't work through this list systematically and with a time schedule. Furthermore, we always have to look at what our current possibilities are to improve something. (HC15)

Some SHCs also link their reluctance to regional resource constraints and scarce infrastructure. Moreover, the risk for existing sales networks is being related to developing a digitalization strategy.

We have not yet laid down a strategy for saying exactly how we want to do it. [...] Because every digital provider that we support makes things more difficult for our traditional specialist retailers. (HC11)

Innovation types: At most, SHCs pursue select few projects, mainly to digitize administrative processes such as document or leave management. SHCs refrain from digital business models and limit their product innovations to initial considerations of gathering data from product use. However, these have not yet been realized in the surveyed firms.

But actually we are not extremely innovative [concerning digitalization]. We employ product development to update user manuals and so on. (HC5)

5. Conclusion, discussion, and future work

5.1. Conclusion

This article examined dimensions, conditions, and outcomes of digitalization for HCs in rural areas in Germany. As highly innovative market and technology leaders, this segment of SME firms is fighting to maintain their niche dominance. Being in rural areas, the availability of digital infrastructure and a workforce with digital capabilities is frequently more onerous than in metropolitan areas.

We have identified four novel types of HCs that differ in their dimensions, conditions, and outcomes of digitalization: DHC, HCD, THC, and SHC. These types have distinct potential and risk assessments of digitalization – ranging from affirmative to skeptical – and availability of digitalization-relevant resources, ranging from abundant to scarce, differ in their digitalization strategies and outcomes of innovation.

Through these findings, the study contributes to the management, digitalization, and economic geography literature. We close the research gap to a deeper and more differentiated understanding of the digitalization behavior of HCs and have highlighted influencing contextual factors such as spatial and managerial. To comprehend the dimensions, conditions, and outcomes of digitalization, differentiation must account for the specific firm HC and its variations. Taking crucial dimensions such as the potential and risk assessment, resource availability, strategy, and innovation into account in a structured way allows for the explanation of diverging responses and occasional counterintuitive findings. This article provides evidence to the proposition that highly innovative market and technology leaders in rural areas are not necessarily also front-runners in digitalization but vary widely in their advances. This article focused on an under-researched situation of innovative firms with abundant internal resources in a regional environment linked to challenges and resource constraints concerning digitalization.

5.2. Discussion and future work

This study addresses a specific firm type. It needs to be discussed whether the digitalization typology also applies to other relevant firm types such as SMEs, or whether the distinctiveness of HCs in terms of niche position and market leadership is relevant for differences in digitalization-related corporate behavior. Hence, the transferability of results to other SMEs may be limited by fewer available internal resources and technological sophistication.

Key managerial implications of this research are threefold. First, the insights into digitalization of HCs can inform the leadership of other, less innovative firms and serve as orientation, depending on the specific contextual conditions of these firms. Second, firm leadership should pay increased attention to incorporate internal and external resource availability in their potential and risk assessment of digitalization, and subsequently in their digitalization strategies. Third, compensation and exploitation strategies for resource availability – particularly considering the regional context – should be actively pursued to realize the envisioned innovation outcomes of digitalization.

The findings are of relevance for policymakers at various spatial scales, too. A focused and differentiated regional policy approach to specific firm types can be

more effective in answering the distinct and specific requirements of these firms. A deeper understanding of the particular digitalization approaches of HCs provides an impetus for the formulation of differentiated policies for the four HC types, ranging from providing digital infrastructure to education programs for specialized digital capabilities and skills. Further, a better understanding of HC innovation systems and their institutional and spatial patterns helps incentivizing the development of adequate structures.

As an outlook for further research, quantitative statistical identification of digitalization types for more HCs relates to validating this qualitative study's findings. A comparative analysis with HCs in agglomeration areas, other SMEs, and family firms that do not fit the definition of HCs could add additional value. Regarding policies, more detail on digitalization type-specific support programs for HC may be beneficial. Last, it seems counterintuitive that HCs are highly innovative firms with technology leadership are frequently in rural areas. Research on enabling factors and regional embeddedness of HCs can contribute to a better understanding of spatial and managerial contexts and their impact.

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