Received: 3 August 2019 | Revised: 27 November 2019 | Accepted: 2 December 2019

DOI: 10.1002/gsj.1370

GLOBAL STRATEGY JOURNAL WILEY

RESEARCH ARTICLE

Shared digital identity and rich knowledge ties in global 3D printing—A drizzle in the clouds?

Ricarda Bouncken | **Roman Barwinski**

Faculty of Law and Economics, Chair of Strategic Management and Organization, University of Bayreuth, Bayreuth, Germany

Correspondence
Ricarda Bouncken, Faculty of Law and Economics, Chair of Strategic Management and Organization, University of Bayreuth, Prieserstraße 2, 95444 Bayreuth, Germany.
Email: bouncken@uni-bayreuth.de

Abstract

Research Summary: Modern audio-visual digital technology enables the immediate exchange of explicit, but also of tacit knowledge worldwide. Still, when not embedded in strong ties, the international exchange of tacit and proprietary knowledge becomes risky. Our flexible pattern matching qualitative research approach develops new theory and finds that in the nascent 3D printing industry firms exchange explicit and tacit knowledge globally, even in weak ties. The exchanges seem to be grounded in identification processes with digital technology forming a shared digital identity. We conceptualize the shared digital identity as the collective self-concept(s) of an in-group towards the creation, emergence, application, and development of digital technology built on a sense of community, enthusiasm, being part of something special as well as common values and norms.

Managerial Summary: Firms in the nascent digital industry of 3D printing share knowledge worldwide. Potentials of transferring tacit and proprietary knowledge by modern audio-visual digital technologies increase constantly. However, so do the dangers of knowledge leakage and competitive risks. A resolution of this tension comes from a new phenomenon, the shared digital identity. A shared digital identity within and among firms enables and informally guards the sharing of tacit and proprietary knowledge via digital technologies. We conceptualize the shared digital identity by a sense of community, enthusiasm, being part of something special as well as common values and norms. The knowledge exchanges assisted by digital technology occur under the aegis of the shared digital identity and accelerate the emergence of digital technologies and so facilitate global business.

KEYWORDS

3D printing, digital identity, digitalization, flexible pattern matching, knowledge ties

1 | INTRODUCTION

The present study examines and contextualizes local and global knowledge ties in the digitalization context. Digitalization describes the stronger implementation of digital technologies, the progressive transformation of firm's traditional processes to digitized versions, the increasing use of digitalized business models, and/or the increasing use of digital platforms (Bouncken, Kraus, & Roig-Tierno, 2019; Claggett & Karahanna, 2018; Clauss, Bouncken, Laudien, & Kraus, 2019; Fichman, Dos Santos, & Zheng, 2014; Legner et al., 2017; Tallman, Luo, & Buckley, 2018).

Global business of regionally dispersed activities and firms might flourish through digitally supported exchanges (Bharadwaj, El Sawy, Pavlou, & Venkatraman, 2013; Fitzgerald, Kruschwitz, Bonnet, & Welch, 2014; Tallman et al., 2018), that are not limited by spatial boundaries (Kohli & Melville, 2019). Firms in industries that are at the forefront of digital technology integration, for example, 3D printing or artificial intelligence, will be prone to digital knowledge exchanges and merits of digital technologies in global business. However, the digitalization might bear an overestimation of the knowledge exchange potentials and an underestimation of the knowledge spill-over risks. Furthermore, digital exchanges might limit the understanding among international partners (targets, backgrounds, and expertise) resulting in inaccurate generalizations (Yamin & Sinkovics, 2006).

The overestimation of the digital knowledge exchange potentials might be based on the tacit components of knowledge. Such sticky and often rich, complex, operationally embedded, or hidden knowledge is much more difficult to transfer than explicit knowledge, which is easy to express, codify, and exchange (Carlile, 2002; Simonin, 1999; Szulanski, 2000). Tacit knowledge, especially the operationally embedded components (Carlile, 2002), largely demands personal experiences, and it is non-verbalized and intuitive making it hard to express and transfer (Polanyi, 1967). The transfer of tacit knowledge requires direct personal interaction, typically by co-location of individuals and becomes more difficult when international and inter-cultural differences exist so that spatial influences persists (Bouncken & Winkler, 2010; Kumar & Nti, 1998; Mudambi et al., 2018; Pesch & Bouncken, 2018). An overestimation of potentials becomes prospective when (a) digital technologies need localized knowledge, (b) they integrate physical technology, and/or (c) using and advancing digital technology demands co-located knowledge transfers including tacit knowledge. An underestimation of risks occurs when high and multiplex unintended knowledge spill-overs are present, which become more severe with the easy duplication ease and further transmission of digitalized knowledge. Hence, the increasing use of digital technologies and digitalized processes demands exploring and contextualizing the underlying knowledge exchanges. The research gap is particularly insistent in global business, where digitalization might improve boundary spanning (Schotter, Mudambi, Doz, & Gaur, 2017), reduce spatial boundaries, but simultaneously bears challenges of spatially bound knowledge and spill-overs.

Hence, our study aims at exploring and contextualizing the knowledge ties in global digital business, paying specific attention to the social context that facilitates tacit knowledge transfers and that might reduce risks of unintended knowledge spill-overs. We expect particularly significant, nuanced, and observable empirical insights, when digital technology integrates physical technology and demands human operations resulting in tacit knowledge demands and the prevailing spatial influences. The 3D printing industry is such a case in point that it also represents a "nascent" and global digital industry.

3D printing is about designing solutions in a socio-technical system that captures operative software, digital designs but also human operations, for example, set-up activities and post-printing practices. It transfers digital designs into physical goods of polymers, metal, or proteins (Rindfleisch, O'Hern, & Sachdev, 2017). Products can be printed at any location in the world (Bogue, 2013; Kietzmann, Pitt, & Berthon, 2015; Rayna & Striukova, 2016). Suppliers, clients, or service firms in the 3D printing industry can be internationally dispersed. The 3D printing industry is not restricted to a local network. It is a born-digital industry following global business models from its beginning (Conner et al., 2014). 3D printing is amenable to global business aligning manufacturers of printers, suppliers of physical inputs (e.g., polymers, metal, and proteins), and service firms that offer software and personal operations. The final production step is typically local to save on logistic costs. In sum, the global, but also local setting of the born-digital 3D printing industry allows us to study different knowledge ties and global boundary-spanning activities.

We chose a qualitative flexible (stepwise) pattern matching design approach suggested by Sinkovics, Sinkovics, and Yamin (2014) and Sinkovics (2018). It enables a nuanced understanding of social and knowledge exchanges, mindsets, meanings, and social identities on the basis of a theoretic background that is stepwise altered towards new theory (Eisenhardt & Graebner, 2007; Larson, 1992; Pla-Barber, Villar, & Madhok, 2018; Yin, 2014). We employed a multiple case-study approach. Initially, we analyzed six 3D printing firms for initial insights. Later, we conducted a detailed analysis of 10 cases of 3D printing firms with cooperative ties in different locations of the world. We use interviews with the case firms and their cooperation/network partners, integrating secondary data sources on industry data, platforms, and firms.

The main contribution of our research lies in introducing the concept of a shared digital identity. We define the shared digital identity as the collective self-concept(s) of an in-group towards the creation, application, development, and emergence of digital technology built on a sense of community, enthusiasm, being part of something special and common values and norms. The digital technology influences social identification with an in-group and the separation from out-groups. Individuals might share their fondness, enthusiasm, and proclivity towards digital technology and identify with the related group prototype. Connecting with others serves as an act of boundary spanning (Schotter et al., 2017). The group prototype can emerge within firms but also stretch beyond firm boundaries to collaborative arrangements, communities, and industries. The shared digital identity includes shared norms/values, cognitions, and behaviors among individuals that are not limited by national borders. It thus can exist in global exchanges and allows smoothing the exchanges.

The secondary contribution of our research is the duality of digital and direct knowledge ties for global digital business. It drives global digital technology emergence and markets. Our study supports the importance of knowledge in global linkages (Awate & Mudambi, 2018; Cuervo-Cazurra, Mudambi, & Pedersen, 2018; Lorenzen & Mudambi, 2013; Mudambi, 2008; Turkina, Van Assche, & Kali, 2016). In finding "rich" international knowledge exchanges, we challenge the understanding that codified knowledge exchange is the focus of global ties argued on the basis of international differences and distance (Parkhe, 1991, 1998; Tallman & Phene, 2007).

2 | CONCEPTUAL BACKGROUND

By building on previous research about digitalization, knowledge ties, and exchange processes, we develop a conceptual model on digital and co-located exchanges of explicit and tacit knowledge in this section. We theorize how knowledge exchange assists the emergence of digital technologies, boundary spanning and the globalization of business. In Figure 1 we illustrate our model. Digital exchange mechanisms are primarily used for explicit knowledge exchanges while tacit knowledge demands co-location. Only very strong ties allow exchanging tacit knowledge digitally. Given the importance of knowledge exchanges in our conceptual model, we explain specific characteristics of explicit and tacit knowledge as well as the effects of digital technologies on their exchange processes in the following.

2.1 | Initial conceptual model

Knowledge exchanges and boundary spanning is important to global business (Awate & Mudambi, 2018; Cuervo-Cazurra et al., 2018; Lorenzen & Mudambi, 2013; Mudambi, 2008; Pesch & Bouncken, 2017; Turkina et al., 2016). Global business can take advantage of the digital ties that face no spatial limits and allow network-economies (Chu & Manchanda, 2016; Gawer & Phillips, 2013; Sawhney & Zabin, 2002). Firms can use various digital technologies for personal and organizational exchanges both domestically and globally (Manyika et al., 2016).

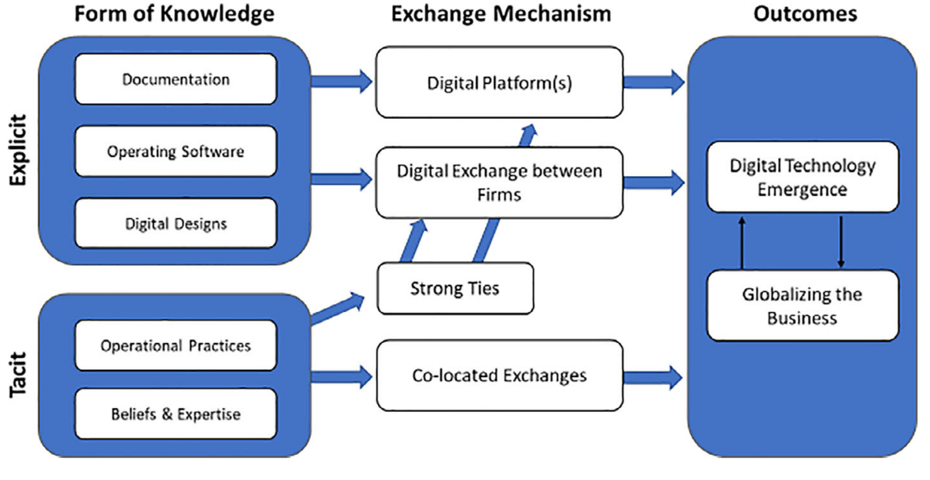

FIGURE 1 Initial framework

Digitalization can reduce spatial boundaries, align geographically dispersed actors and expedite global business models because the pure digital exchanges are not limited by spatial boundaries (Bharadwaj et al., 2013; Bouncken & Fredrich, 2016a; Fitzgerald et al., 2014; Kohli & Melville, 2019; Legner et al., 2017; Tallman et al., 2018). Digitalization demands expertise and adaptations from diverse actors across organizational boundaries in local, regional, or global ties (Nambisan, Lyytinen, Majchrzak, & Song, 2017). Digitalization requires heterogeneous, tacit knowledge, constant changes in socio-technical systems, and ongoing learning of dispersed experts who are often not sufficiently available within the firm (Lenka, Parida, & Wincent, 2017). Thus, digitalization not only enables, but also requires firms to share, combine, and generate knowledge using diverse and dispersed organizational sources from different locations.

Digital exchanges, digitally substituted or enhanced physical resources (data-sets, pictures, videos, etc.), digitalized operations, and platforms (Gawer & Cusumano, 2014) all facilitate exchanges among dispersed locations around the world (Lee & Berente, 2012; Lyytinen, Yoo, & Boland Jr, 2016; Tallman et al., 2018). Digital media allow the immediate transfer of knowledge. It connects individuals and organizational entities, and thus might reduce cultural, institutional, and organizational boundaries. For example, digital designs in the 3D printing technology can be digitally transferred and altered in dispersed and globally distributed locations. Digitalization supports and relates to boundary-spanning activities that individuals within and among organizations perform to draw connections among multiple cultural, institutional, and organizational contexts (Schotter et al., 2017). We argue that explicit knowledge is relatively easily transferred by digital technology while tacit knowledge exchanges demand co-location. Only when firms have strong ties, characterized by long term, trustful and intense relationships (Bouncken & Fredrich, 2016c; Hughes, Rigtering, Covin, Bouncken, & Kraus, 2018), they might use digital media supported by audio-visual digital technology to exchange tacit knowledge. Digital exchanges in the form of bi-directional or multi-actor models, for example, platforms, support reciprocal exchanges and might especially reduce boundaries and therefore enable the emergence of the technology and increases in innovation capabilities (Schotter et al., 2017). Audio-visual solutions (i.e., augmented reality and video) might digitalize some of the tacit knowledge components and improve rich knowledge exchanges beyond spatial boundaries. We explain the reasons in the following.

The set-up of the technological and digital system in 3D printing (similar: Industry 4.0) might require significant tacit and operational knowledge, which relates to embedded practical knowledge (Carlile, 2002). The knowledge exists on the interface of technology, methods and individuals' accumulated conscious or unconscious rules of thumb (Carlile, 2002). Pre- and post-production of 3D printing processes, as well as maintenance processes, demand tacit operational knowledge. The programming and the development of the digital objects and sequences requires constantly changing heterogeneous digital expertise. For example, geometries of 3D objects demand high engineering and programming expertise. Accordingly, firms in industries with strong digital technology integration need not only the exchange of digital(ized) knowledge but also tacit knowledge and the embedded practical knowledge. The exchange of tacit knowledge, including practical knowledge, flourishes by bi- or multi-directional exchanges. They can occur as person-based global linkages and/or organization-based linkages, the latter referred to as pipelines (Lorenzen & Mudambi, 2013). While the digital and tacit knowledge needs to be integrated and contextualized it needs organizational commonality at both ends (Awate & Mudambi, 2018; Cuervo-Cazurra et al., 2018; Lorenzen & Mudambi, 2013; Mudambi, 2008; Turkina et al., 2016). Previous research assumes that individuals have a tendency to stick to their accumulated tacit, especially practical knowledge and that change becomes less likely when crossing physical or psychological boundaries (Carlile, 2002). Accordingly, digital media that facilitate the exchange of a wide range of explicit and tacit knowledge might improve boundary-spanning activities but is also limited to within-boundaries and identification processes (Carlile, 2002; Schotter et al., 2017).

Knowledge exchanges, particularly in international ties and when they relate to proprietary knowledge face risks of unintended knowledge spill-overs (Fredrich, Bouncken, & Kraus, 2019; Kale, Singh, & Perlmutter, 2000). The rich proprietary knowledge exchanges, supported by rich media or by platforms suffer from low protection mechanisms that are even less effective when international distance and differences are present (Ring & Ven, 1994; Tsang, 1999). Thus, firms might hesitate to transfer spatially bound tacit knowledge in international ties.

In essence (see model in Figure 1), digitalization can facilitate global knowledge exchanges but is less suited for the transfer of all the tacit knowledge components. The tacit components including the operational-practical knowledge might stick to within-boundaries and strong ties that have identificational potential (Carlile, 2002; Schotter et al., 2017). Figure 1 shows on the left side the explicit (upper part) and the tacit forms of knowledge (lower part). The knowledge exchanges improve the global business and the emergence of the 3D printing technology (right side). The middle part shows the different exchange mechanisms, platforms as multi-side transfers and bi-directional digital exchange between firms. Tacit knowledge might be exchanged by co-location among firms, but will only be digitalized and exchanged within strong and local ties (Bouncken & Reuschl, 2018). We explain the relationships in more detail in the following.

The socio-technology digital systems require digital and perceptive, responsive, and recursive knowledge transfers of diverse and dispersed firms in local, regional, or global ties within personal ties and pipelines. The transfer will be especially limited when the tacit knowledge is bound to (different) interpretation systems of the actors at the ends of the pipeline. Simultaneously, a digital exchange might not be feasible because of the low protection mechanisms and the easy exchange of digitalized knowledge. Thus, not all of the knowledge that can be digitalized also will be transferred digitally. Co-located and locally bound exchanges remain and they provide better social mechanisms for the protection of proprietary knowledge (Cesinger et al., 2016). Firms will prefer to share tacit knowledge locally while changing the explicit digitalized knowledge digitally in pipelines and through platforms. Thus, global business and the emergence of the 3D printing technology can take advantage of the digital exchange of knowledge.

Besides the different alternatives, some firms might concentrate on either digital exchanges or personal co-located exchanges, while others could use diverse forms of exchanges. Firms might also focus on certain ties, scope, and intensity of tacit knowledge transfers. Considering the rich literature on strong ties, repeated ties, and social capital, firms might consider specific strong and long-term ties as better suited for the exchange of tacit knowledge (Nelson, 1989; Tiwana, 2008; Tortoriello, Reagans, & McEvily, 2012). Thus, high tie strength might increase firms' tendency to digitalize rich, and proprietary knowledge and share it internationally even through digital channels.

3 | METHODOLOGY

3.1 | Research setting and design

We apply an explorative research design to uncover the multiple facets of knowledge ties in the global 3D printing industry. The 3D printing industry consists of manufacturers of 3D printing devices (e.g., for 3D printing using plastic, metal, proteins), industrial clients (e.g., for rapid prototyping, rapid tooling, and digital manufacturing), suppliers of materials, scientists and labs, software developers, designers of the printed objects, and end-customers (Berman, 2012). 3D printing products and services are expected to reach a worldwide revenue of $15.8 billion in 2020 and $35.6 billion in 2024. The number of producers of industrial 3D printer systems has risen from 135 in 2017 to 177 in 2018 equaling a 31% increase on a year to year basis (Wohlers, 2019). Big industry players such as ThyssenKrupp and IBM collaborate on 3D printing platforms (Stumpfe, 2019).

An exploratory research design is well suited to uncover causalities, allows for contextualization, and helps to communicate theory (Welch, Piekkari, Plakoyiannaki, & Paavilainen-Mäntymäki, 2011). We chose a multiple case study approach with nested pattern matching logic as we are interested in the dynamics within the setting of a single industry (Eisenhardt, 1989; Sinkovics, 2018). We employed a flexible-pattern-matching approach (Sinkovics et al. (2014), which builds on a deductive theory-driven research paradigm while simultaneously allowing for new patterns and theory to emerge from the empirical data. The flexible-pattern-matching approach builds on an initial analytical framework (King, 2012).

We developed the analytical framework from the conceptual background. Following this step, we conducted open interviews with the aim of gaining more in-depth insights into the mechanisms driving knowledge exchange processes and contextualizing global knowledge ties in the 3D printing industry. The interviews covered the topics of the firm's business model, the relevance of different forms of 3D printing technology as well as the value of partners and knowledge for the firm. These interviews were carried out between June and November 2017. The broad initial sample allowed us to refine our model and capture the ideas about the relevance of knowledge and partners as well as the importance of knowledge exchange in the 3D printing industry. We further learned about differing motivations and strategies for knowledge exchange. We included these ideas enriching the theory-based analytical framework with a practice-driven approach (Brooks & King, 2014). See Table 1 for an overview of the main characteristics of the initial interview sample.

Table 2 provides an overview containing the theoretical patterns and patterns developed from the first set of initial interviews. We also provide information on the expected observational patterns and the expected implications for global knowledge ties. The first column indicates the area of study. The second column indicates whether the pattern stems from theoretical deduction or the initial interviews. The third column shows the specific dimension. Column four specifies the expected observational pattern while the fifth column provides information on expected implications.

3.2 | Data collection

After building our analytical framework, we used purposeful sampling to identify 10 firms operating at different positions in the 3D printing value chain. We selected these firms to generate a sample that represents different cases of 3D printing use and intensity to cover our areas of interest (Seawright & Gerring, 2008). Purposeful sampling further enabled us to seek a maximum of variation in our cases (Lincoln & Guba, 1985; Patton, 1980), resulting in a sample consisting of similar and contrasting cases (Lincoln & Guba, 1985). The selection criteria included (a) the firm's position in the value chain, (b) the number of global and local ties and, (c) the importance of 3D printing for their own business model.

TABLE 1 Overview of initial interview sample

Interview	Business model	Industry	Employees	Revenue	Profit	Material	Location	Founded
1	Electronics	Electronics	171	—	$1.9 M	Plastic	Germany	1945
2	Full service 3D printing provider	3D printing	19	$3.4 M	—	Plastic	Germany	2006
3	Industrial machinery and equipment	3D printing	5,000	$754 M	$153 M	Metal	United Kingdom	1973
4	License 3D printer sales agency	3D printing	24	—	$135 K	Metal and plastic	Germany	2016
5	3D printer manufacturer	3D printing	300	$75 M.	$8.3 M	Metal	Germany	2000
6	Software information management	Software	180	$13.8 M	$8.5 M	Metal and plastic	United States	1994

TABLE 2 Initial analytical framework

	Underlying analytical framework	Dimension	Expected pattern	Expected implication for global knowledge ties
Forms and modes of global knowledge exchange	Conceptual framework	Documentation	Digital	Explicit knowledge is available in a documented form and therefore can easily be exchanged using digital channels
				Digital exchanges facilitate explicit knowledge, save time and money compared to co-located exchanges
				The digital exchanges enable firms to work with global experts and resources
		Operating software	Digital	Software sales and services are conducted via downloads on platforms or are made available online, therefore solutions from global players are available to all
		Digital designs	Digital	Digital 3D printing designs are exchanged in digital form
				The digital transfer of designs enables collaboration with global players
		Operational practices	Co-located	Setting up technological and digital system requires significant tacit operational knowledge, which cannot be transferred using digital technology
				The required sticky knowledge can only be transferred face to face, therefore global partners need to be co-located
		Beliefs and expertise	Co-located	Beliefs and expertise can only be transferred face to face between people and organizations. This requires temporary co-location of (global) partners
				Digital exchanges have low protection mechanisms and are therefore risky. Expert knowledge demands co-location for protection
				Co-located and locally bound exchanges which provide better social mechanisms for the protection of intuitive tacit knowledge

(Continues)

TABLE 2 (Continued)

	Underlying analytical framework	Dimension	Expected pattern	Expected implication for global knowledge ties
Factors/motives influencing sharing/exchange of tacit knowledge via digital channels				
Factor (multi-directional)	Conceptual framework	Tie strength	High	High tie strength might increase firm's tendency to digitalize rich, and proprietary knowledge and share it internationally even through digital channels
Motives (downstream)	Initial interviews	Inspire	High	Firms are motivated to use digital exchanges of information to inspire customers
				Motivate broad and global audience to use the technology
		Enable	High	Platform-based information is provided to enable broad usage of technology
				Educating the customer
				Provide information to work with a global customer market

At the beginning of the data collection process, we developed a list of firms that fulfill our criteria. We then started contacting those firms and inquired about their availability to participate in our study. After scrutinizing the profiles of the firms from websites, newspapers, industry platforms, and blogs, we shortlisted 10 firms for our study. Following Eisenhardt (1989), 10 or even fewer cases are optimal for in-depth case study analysis. Table 3 gives an overview of the case firm profiles.

Following the identification of our case firms, we collected qualitative data through interviews with CEOs and managers of case firms and their partners. We only interviewed individuals who were in charge of the 3D printing-related operations, knowledgeable about the case firms, and the topic of global and local knowledge ties. In total, we conducted 35 interviews between December 2017 and February 2018. The interviews were complemented with secondary data from firm websites, press releases, industry platforms, and newspapers. The interview questions started with the firms' stance on the 3D printing technology and future potentials from their point of view. These questions were followed by more sensitive questions on the firm's collaborations, knowledge exchanges, and global and regional factors. Interviewees were asked to give examples of important instances or categorize the importance of specific collaborations. Two researchers conducted the interviews, one leading the interview and the other staying in the background taking notes.

3.3 | Data analysis

We applied two stages of analysis. We started with a flexible pattern-matching approach analyzing the case data according to our analytical framework. Flexible pattern matching allows to further develop an initial analytical template and enables the researcher to develop new theory (Sinkovics, 2018; Sinkovics & Alfoldi, 2012; Sinkovics, Choksy, Sinkovics, & Mudambi, 2019). It allows for the development of new and unexpected dimensions, thereby enabling the revision of prior expected relationships. Building theory with flexible pattern matching starts by using matches and mismatches between theoretically expected and empirically observed patterns. These matches and mismatches are used as an aid to theory development (Alvesson & Kärreman, 2007).

In the first stage of the analysis, we conducted two pattern matches. The first was conducted for different forms of knowledge and the exchange methods. In a second pattern match, we limited the sample to only those cases, which were a mismatch to the theoretically expected pattern. Specifically, we analyzed the firms using digital technologies to exchange tacit knowledge. We aimed to identify how exactly these cases were different and what lead to the mismatch. In the second pattern match, we found confirmation for tie strength as a relevant factor driving the use of digital technologies. We further identified a strategy of *inspiring*, *enabling*, *leveraging* and *stretching* to grow global business. In addition, we identified the new dimensions *sense of community*, *enthusiasm*, *specialty*, and *common values and norms*.

As these dimensions were of high relevance in the deviating cases and clearly related to the open digital exchange of tacit knowledge we decided to follow up on these findings in more detail. In the second stage of our analysis, we explored the cases independently, looking for the mechanisms behind the dimensions and discovered the underlying concept of shared digital identity.

TABLE 3 Case sample description

Case	Business model	Industry	Employees	Revenue	Profit	Material	Location	Founded	Suppliers	Customers
A	Design and 3D print, design products and sell them	3D printing	6	$900	—	Plastic	Germany	2015	Global	Global
B	Biomechanical research and development	Biomechanics and sports	8	$800 K	—	Plastic	Germany	1987	Global	Global
C	Engineering services	Engineering	150	$11 M	$1.5 M	Metal and plastic	Germany	2011	Global	Local
D	3D printing service	3D printing	10	$1.5 M	$200 K	Plastic and biological degradeable	Germany	2011	Global	Local
E	Logistics services	Logistics	72,000	$18,700 M	$550 M	Metal and plastic	Germany	2007	Global	Global
F	3D printing software solutions	3D printing	1800	$185 M	$3,3 M	Metal and plastic	Belgium	1990	Global	Global
G	Additive manufacturing service	3D printing	15	$2.6 M	$100 K	Metal and plastic	Germany	2006	Local	Local
H	Manufacturer of forming technology and technological ceramics	3D printing	30	$2.5 M	$80 K	Ceramic	Austria	2011	Global	Global
I	Additive manufacturing service/workspace provider	Office sharing	53	$3.6 M	50 K	Metal and plastic	Germany	2015	Global	Local
J	3D printing service	3D printing	2	—	—	Metal, plastic, and paper	Germany	2013	Global	Local

4 | FINDINGS

4.1 | Dual use of co-located and digital knowledge exchange

The first two pattern matches were conducted to understand the knowledge exchange of firms in a highly digitalized industry. The first pattern match enabled us to identify which knowledge is exchanged between partners and how the transfer takes place. Table 4 provides an overview of each case and which knowledge was exchanged, also indicating which method was used for the exchange. This pattern match informs that both digital and co-located knowledge exchange takes place, but their purpose is different. Explicit knowledge, such as documented knowledge, knowledge about software and digital designs, is exchanged on a mainly digital basis when partners are globally dispersed. Platforms have high importance for these exchanges. Case G signposts that explicit knowledge can be exchanged in co-location but appears to be dependent on close proximity of the partners. Further information from the case data indicates that knowledge exchange about operational practices as well as beliefs and expertise takes place in co-location for all case firms. Simultaneously we can show that in six of our 10 cases firms use digital exchange mechanisms to exchange tacit forms of knowledge (knowledge about operational practices and beliefs and expertise). This contradicts our expectations and prior literature.

In the second pattern match, we examined in greater detail why firms engage in the digital exchange of tacit knowledge. Following our analytical framework, we focused on the importance of tie strength, motivation, and strategic aspects. For this pattern match, we reduced the sample, excluding cases B, C, E, and I, where there was no indication of digital exchanges of tacit knowledge. As there was no variation in the cases regarding the use of digital exchange mechanisms, we have summarized the results in a single table. Table 5 provides an overview of the second pattern match.

The results confirm that tie strength has a positive effect on the exchange of tacit knowledge via digital channels. High tie strength leads to the digital exchange of tacit knowledge. The manager of case firm F, a provider of 3D printing and software solutions, clearly mentioned this:

> "A lot happens with old contacts. With us, at least there are a lot of old grown contacts. It is about the assessments of the market. So much knowledge in terms of technology and assessments is very much based on the fact that you have contacts in a variety of companies that are also active in the industry and you exchange knowledge."

In addition to the confirmation with respect to the importance of tie strength, we found evidence for strategic and motivational factors leading to knowledge exchange and knowledge sharing. We identify that firms use platforms and digital technologies for a strategy of *inspiring*, *enabling*, *leveraging*, and *stretching*. This finding goes beyond the expected patterns of *inspiring* and *enabling* which were discovered in the initial interviews.

Surprisingly, we also discovered a new factor increasing and fostering the digital exchange of tacit knowledge. We label this factor as a *shared digital identity* that relates to a *sense of community*, *enthusiasm*, *specialty*, and *common norms and values*.

TABLE 4 Pattern match: Knowledge form and exchange mode

		Cases									
Form of knowledge	**Mode of exchange**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
Documentation		x	x	x	x	x	x	x	x	x	x
	Digital	x	x	x	x	x	x	x	x		x
	Platforms	x		x		x	x		x		
	Co-located		x					x		x	
Operating software		x	x	x	x	x	x	x	x	x	x
	Digital	x	x	x	x	x	x	x	x	x	x
	Platforms	x				x	x		x		
	Co-located				x			x		x	
Digital designs		x	x	x	x	x	x	x	x	x	x
	Digital	x	x	x	x	x	x	x	x		x
	Platforms	x	x		x	x	x		x		x
	Co-located							x			
Operational practices		x	x	x	x	x	x	x	x	x	x
	Digital	x			x		x	x			x
	Platforms	x									
	Co-located	x	x	x	x	x	x	x	x	x	x
Beliefs and Expertise		x	x	x	x	x	x	x	x	x	x
	Digital	x			x		x	x	x		x
	Platforms	x					x		x		x
	Co-located	x	x	x	x	x	x	x	x	x	x

4.2 | Multiple purposes of digital knowledge exchange and sharing via platforms

As first outset in our initial framework, the exchanges between firms can be supported by digital transfers via digital technologies in pipelines and/or on platforms that bundle several actors. Yet, our second pattern match shows that the usage of digital exchange mechanisms, and especially platforms, goes far beyond the simple exchange of explicit knowledge.

Our initial interviews had portrayed that platforms help to inspire and educate customers. We now find convincing case evidence for the existence and transfer of digital knowledge "packages" that are meant to deliver assistance, information, and training to current customers. Additionally, the digitalized knowledge on the platforms provides informational, co-creational, and marketing benefits. The platform shows the firm's process expertise, stimulating the use of 3D printing, and thus increasing sales. 3D printing service firms are focal firms of digital platforms. The manager of case firm A describes the situation: "These platforms are important for service companies because they can generate their orders for smaller or individual pieces." Case firm J, a small 3D printing service operating with regional customers, confirms and elaborates on the benefits of using platforms:

TABLE 5 Factors driving tacit knowledge exchange using digital technologies

Factors influencing sharing of tacit knowledge via digital channels	Expected pattern		Observed pattern	
Relational				
Tie strength	High	Firms trust each other	High	Trust between firms leads to the use of digital channels although they are less safe
Growing business strategically				
Inspire	High	Firms inspire customers by showing potentials of the technology	High	Firms were eager to share knowledge with as many customers as possible to educate them on possible uses of the technology
				Spreading "use cases" of the technology on Youtube and other video platforms
				Platforms are used to distribute knowledge of different forms
Enable	Medium to high	Platform-based information is provided to enable usage of technology	High	Providing extensive knowledge on platforms to help customers with problems
				Technology wiki on the homepage
				Online tutorials/packages of knowledge are made available
				Platforms play a key role for knowledge distribution
Leverage			High	Using digital technology and platforms to approach bigger markets
				Using platforms saves on human resources
				Automation of processes (calculations and offers)
Stretch			High	Goal: Market share increases and entering new markets making the technology available and usable by everybody
				Wanting to become the number one technology
				First, enable the customer and then make them use and distribute the technology

(Continues)

TABLE 5 (Continued)

Factors influencing sharing of tacit knowledge via digital channels	Expected pattern	Observed pattern	
Shared digital identity			
Sense of community		High	Open and constructive communication with competitors Innovative community All push the topic together Competition is not a primary focus Global networks and communication- one community despite competition
Enthusiasm		High	Feels like a goldrush Feeling of contributing and developing something important There is recognizable enthusiasm 3D printing is a hot topic
Specialty		High	Feeling like pioneers Being part of something new and important Developing a new technology Changing how business is done Being part of something special and exciting
Common values and norms		Medium to high	There are recognizable values and norms in the industry Same ideas about how things need to be done Shared understanding

> "There are many new 3D printing service providers. Many have only online platforms, where you upload a file and then you have the price and then everything is great, so it seems to be enough. But eventually, there will be a market shift again. The need for our personal services is currently too high. We do not have the time to talk about each request with a customer on the phone or face to face. That is why such automatic price calculations on platforms are already important."

Customers (often manufacturers) also establish themselves or use public knowledge platforms that store knowledge, making their expertise available to others. 3D printer manufacturers often provide solutions for printer problems on platforms. Platforms also enable exchanges with other users who share their knowledge. We found rich evidence for the existence of a community. For example, a customer of case firm A described the 3D printing industry as “a community, a network - or 3D printing scene. People are already exchanging ideas about materials, what's cool and which printers are good, etc.”

Our data indicates that the firms not only use the sharing and exchange of knowledge to inspire and enable customers but also for a strategy of leveraging and stretching. Table 5 shows case firms that share knowledge via digital exchange mechanisms to strategically leverage limited resources. Rich digitalized knowledge is made available to approach bigger markets, make better use of limited capacities and increase the automation of sales processes. Especially the smaller case firms (A, D, and J) were extensively following this strategy. It allowed them to follow their stretched goals of growing their market share and entering new markets even becoming the market leader for a new technology.

4.3 | New differentiation: Technology potential and operational process knowledge

A deeper analysis of the individual cases uncovered a clear differentiation between two categories of knowledge specifically related to digital technologies: *technology potential knowledge* and *operational process knowledge*.

Technology potential knowledge is complex and requires complementarities between the actors. Surprisingly, the exchange of this proprietary knowledge often takes place locally and/or globally. The exchange occurs via informal channels but often with well-known partners. Accordingly, the tie strength is a key mediator for tacit knowledge transfer and the level to which it is digitalized and exchanged globally.

Operational process knowledge includes instructions on how to use 3D printers, including the pre- and post-production processes. Accordingly, it covers explicit and tacit knowledge, which requires personal interaction and co-location. Interestingly, it does not only occur locally but also globally. A printer supplier of case firm A revealed: “We deliver the machines and software plus all the training (to our customers) and we do it all the time. We always support the customer because they have to learn a lot.” However, operational process knowledge is also about future uses. It enables suppliers to qualify their customers in a one-directional knowledge exchange process. A printer supplier of case firm J made this very clear in the following statement:

> “We also offer training for our software. So, for example, our 3D express software, you have to do a week of training to understand it. (…) Training is important because we can pass on our knowledge within a short time and focus on incremental innovations along the process line.”

4.4 | A new factor facilitating local and global knowledge exchange: Shared digital identity

Our key finding on the shared digital identity as a new factor driving the digital exchange of rich and tacit knowledge was discovered in the second pattern match. The cases clearly show that the exchange of knowledge in general, but especially tacit knowledge, is driven by social identification of individuals working in the 3D printing industry. Identification processes base on a strong *sense of community* or *connectedness*. We observed a second reappearing pattern of *enthusiasm*. In case H a supplier of printers even described the situation surrounding 3D printing as a *gold rush*. Further examples were that managers and employees were feeling like they were contributing to something bigger. In case H a customer even mentioned that this enthusiasm made a significant difference in the war for talent. As a small firm, many qualified people were willing to work for lower wages, just to be part of the 3D printing industry. In all cases, the interviewed CEOs and managers mentioned that they share enthusiasm. Enthusiasm is closely related to the third dimension which we labeled *specialty*. *Specialty* refers to being part of something special and changing how things are done by using digital technology. Many firms consider establishing new technology (3D printing) to be more important than short term firm success. Case firm F even referred to the existence of shared values and norms, which is the fourth and final dimension: *common values and norms*.

These four patterns have obvious effects on the sharing of knowledge as this statement by the manager of case firm F shows:

> "There are the same values, norms, so in any case, the enthusiasm of all is recognizable. This is always a beautiful thing. We can also talk with competitors in the best way. And anyone who deals with the topic itself is simply in a very innovative and exciting industry. And that's always great! You notice the enthusiasm in any case, usually with all involved. And that's always nice, so there's no real hate-loving in the industry, that's interesting, yes."

Our cases portray that the shared digital identity explains the broad range of knowledge transfers that occur locally and globally and via direct and digital transfers.

5 | DISCUSSION

Our study reached out to examine and contextualize knowledge ties assuming that digitalization facilitates global business because it reduces physical boundaries (Lee & Berente, 2012; Lyytinen et al., 2016; Tallman et al., 2018) via virtual information transfers, digital operations, and digitally aided physical resources (Kraus, Roig-Tierno, & Bouncken, 2019; Lee & Berente, 2012; Lyytinen et al., 2016; Tallman et al., 2018). Yet, digitalization also enables tacit knowledge exchanges. Further, it demands the transfer of tacit knowledge. We find a duality of digital and rich knowledge ties that we discuss in the following section. A shared digital identity can explain some of the tacit knowledge exchanges and the boundary spanning among international firms (Schotter et al., 2017). A shared digital identity is based on a shared sense of community and shared enthusiasm about the digital technology and its uses. We discuss the concept of shared digital identity later.

5.1 | Duality of digital and rich knowledge ties

Global digital business benefits from digital ties that face no spatial limits, for example, by using platforms (Kwak, Kim, & Park, 2018) and from network-economies (Chu & Manchanda, 2016;

Gawer & Phillips, 2013; Sawhney & Zabin, 2002). Digital exchanges can facilitate exchanges while connecting physical technology and human operations with digital technology (McIntyre & Srinivasan, 2017; Zhu & Iansiti, 2012). Digital media does not only transfer explicit knowledge but also allows richer and contextualized exchanges, for example, by augmented reality/virtual reality devices, video calls, and sensors. Transferring programming sequences, tutorials, designs and/or organizing might leverage or stretch existing physical technology, operating software, designs, novel materials, and altered practices.

Firms exchange two core forms of knowledge: technology potential knowledge and operational process knowledge. Both occur locally and globally and have the potential to span boundaries (Schotter et al., 2017) and contain not only explicit but also tacit knowledge. The operational process knowledge relates more strongly to knowledge that is embedded in practice (Carlile, 2002). Using, leveraging, and stretching digital solutions and knowledge is not without social and local contextualization, for example, of physical technology, of operating software, of available input material, and of human or organizational practices. Richer social relations can make better use of the global diversity of knowledge, resources, and users (Bouncken & Winkler, 2010; Pesch & Bouncken, 2018; Tallman & Pedersen, 2015). Hence, we contribute that digital exchanges allow but also need to transport more richer components than mere explicit knowledge. Previous research considered that inter-firm international knowledge exchanges are strongly limited to codified and protectable knowledge (Ring & Ven, 1994; Tsang, 1999). Our finding on the risky rich knowledge exchanges extends and somewhat contrasts previous literature that assumes tacit knowledge exchanges without formal protection as particularly risky under the conditions of international distance and differences (Bouncken & Fredrich, 2016b; Kale et al., 2000; Ring & Ven, 1994; Tsang, 1999). Knowledge exchanges over distance via digital technologies might even require intense co-located exchanges, for example, in frequent meetings for understanding and applying digital technology. Face to face meetings improve the exchange, align the cooperation, define future goals, drive technology development, or analyze and optimize a process. We highlight that global transfers in the digital field allow and cause rich knowledge exchanges and at least temporary co-location for knowledge exchange in various situations. This points to a duality of digitalization and rich knowledge transfers. We theorize this duality by the existence of an identity mechanism. Shared identity of an in-group stimulates tacit knowledge exchanges in general and in particular across international and spatial borders without the need for strong ties (Schotter et al., 2017). The community, enthusiasm, and being part of something special requires boundary spanning but also creates an identification processes among individuals who might belong to different units in diverse locations and thus allows boundary spanning (Schotter et al., 2017).

5.2 | Shared digital identity: Development of a new concept

As the discussion of digital natives shows (Margaryan, Littlejohn, & Vojt, 2011), using and developing digital technology separates in- and out-groups. Individuals who see themselves as in-groups consider others as outsiders. The process of self-categorization describes the depersonalization of an individual's perception, feelings, and behavior with respect to a context-specific in-group prototype (Ashforth & Mael, 1989). It builds on the idea of a taken-for-granted reality among persons (Ashforth & Mael, 1989). The in-group prototype might refer to their fondness of digital technology, expertise, constantly working on improvements, sharing of proprietary knowledge, and working on the emergence and global expansion of the digital technology.

The shared digital identity addresses the existence of a long-lasting, while not necessarily permanent, inter-subjective digital-self(s). Individuals might have a strong identification with digital technology and share the meaning of the technology or of their industry (Anthony, Nelson, & Tripsas, 2016), even when they are located in different firms and in dispersed international locations. Open exchanges and making sense of other's contributions are more likely when individuals consider themselves in a social group that they identify with. Thus, the shared digital identity can explain the open and risky exchanges of explicit and tacit knowledge among individuals and firms via digital media and platforms (e.g., designs and tutorials on platforms). It can also explain the rich international knowledge transfers among dispersed firms and actors who might only be temporarily co-located. Digital technology emergence and globalization becomes easier by a shared digital identity. The fondness of individuals towards digital technologies, shared proclivity, shared enthusiasm, and shared general mindsets towards working and pushing digital technologies improves exchange.

We define shared digital identity as the collective self-concept(s) of an in-group towards the creation, application, development, and emergence of digital technology building on a sense of community, enthusiasm, being part of something special, and common values and norms. It is not elusive to local contexts and can exist beyond national borders and spatial distance. It might connect individuals in firms that collaborate and possibly even compete (see coopetition) in national and international value chains (Bouncken, Fredrich, & Kraus, 2019; Bouncken, Fredrich, Kraus, & Ritala, 2019; Bouncken, Fredrich, Ritala, & Kraus, 2018).

5.3 | Theoretic foundations of the shared digital identity

Identities can be created as an intersubjective reality that transcends the individual occurring as a collective identity, for example, on the group and organizational level (Ashforth, Rogers, & Corley, 2011; Ashforth & Mael, 1989; Ashforth & Johnson, 2001). The process of self-categorization describes the depersonalization of an individual's perceptions, feelings, and behavior with respect to a context-specific in-group prototype (Ashforth & Mael, 1989). The in-group prototype refers to a shared concept among individuals, which is partly conscious. Social construction and shared meaning might develop an in-group-prototype that covers a normative level associated with proclivity, sympathy, fondness, and enthusiasm towards digital technology and a behavioral level associated with constant work on improvements, the sharing of proprietary knowledge, and the ongoing searches for digital technology advancements and expansion.

The shared digital identity concept refers to shared behavior and behavioral expectations among individuals but also shared values and norms related to digital technology. Similar to an orientation concept (e.g., EO, Covin & Lumpkin, 2011), the identity concept includes proclivity as a behavioral element. Yet, identity has a stronger normative connotation than an orientation concept.

Hence, the stronger use of digital technologies automatically includes a positive valuation, confidence in, attachment to, and even excitement towards digital technologies as a fundament. Shared digital identity means that digitalization has a positive connotation to those of an in-group. Some of the positive attainment is tacit or subconscious to individuals and relates to their norms and valuation. Other elements are more conscious and explicit in choices, technology, and documents. The digital identity of a group of individuals relates specific expectations and behavioral patterns, influences by specifics of digital technology in general or to certain technologies (operating software, digital designs, etc.). Accordingly, a shared digital identity has normative, cognitive, and behavioral elements that operate at individual as well as collective levels.

The identity set of an individual is built on varying memberships that fluctuate in importance (Hogg, Terry, & White, 1995; Tajfel, 1974; Tajfel & Turner, 1986). Particular (e.g., digital) contexts request a specific social identity to become a salient basis for stereotypical behavior of the in-group and evaluations of the out-group (Tajfel, 1974; Tajfel & Turner, 1986). The identity prototype provides a collectively constructed standard against which members distinguish in-groups and out-groups in organizations (e.g., entrepreneur vs. non-entrepreneurs, Powell & Baker, 2017).

For example, a family firm identity emerges from role identities consistent with group norms and can exist where the family agenda and identity become visible in articulated points of view, needs, values of members and their emotional ties (Miller, Breton-Miller, & Lester, 2011). Accordingly, the firm might provide a micro-level anchorage for social identification. The digital identity might be influenced by certain centralized individuals, for example, the founder of the firm, the engineer/designer of digital solutions, or a well-known digital expert. Some individuals might be more in the center (e.g., leaders with technology affinity) while others might only be tangential (e.g., IT-experts). In addition, digital identity might develop from using specific technology (operating software, physical technology, digital designs) and concentrate on this one.

Digital identification processes respectively the shared digital identity is also influenced by the communities around a specific technology, for example, the peers that share their knowledge on the internet especially on platforms. Individuals have mutual interest and enthusiasm. Using and contributing to internet forums, open-source platforms, membership to associations, etc. will drive identification processes, even without the need for direct personal exchanges. Central industry players and celebrities deliver speeches and narratives in which they espouse their values and further inspire identification processes. Digital industries, especially nascent ones such as 3D printing might thus inspire certain shared values, beliefs, and behaviors. Hence, we assume identification processes of macro-anchorage for the digital identity.

In addition, we propose that digital identification as for rich knowledge exchanges are facilitated by stronger ties between firms. Ties might follow economic considerations, but also include social–emotional factors, for example, the sharing of visions and enthusiasm about digital technology. Enabling others or being enabled, exchanging ideas, experiencing joint inspiration, and leveraging and stretching uses can further stimulate in-group processes and identification. Thus, the digital identity allows boundary spanning as it pushes borders, units, and individual's mindsets and behaviors, and thus facilitates the change and exchange of knowledge (Schotter et al., 2017).

Inter-firm ties can allow permanent and/or temporary direct social processes of identification. Other exchanges might be only virtual but still might contribute to the development of in-group prototypes for identification because of intense digital exchanges, joint values/norms, and overlapping behaviors. Thus, we assume different firm, inter-firm, and industry anchors of the taken-for-granted reality related to a digital identity that each take advantage of each other.

Figure 2 shows how the shared digital identity resides on the specifics of digital technology, its mediating technologies, and the micro-, meso-, and macro-anchorage. At the bottom of the figure are the different digital technology demands, derived from the literature on digitalization. These technology demands differently coin individual values, cognitions and behaviors, which

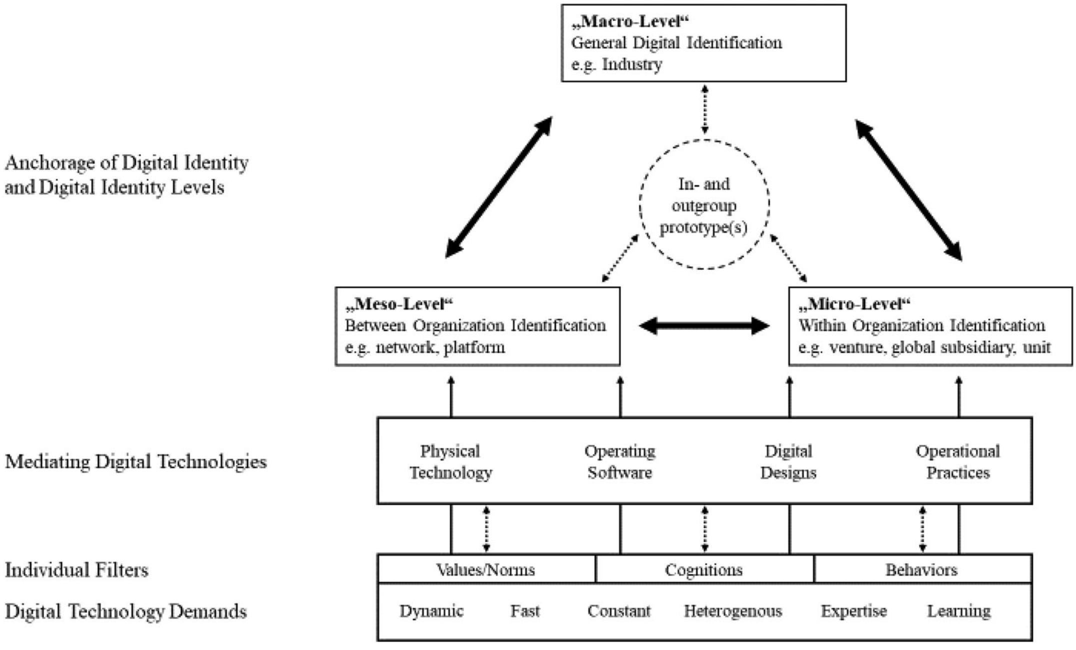

FIGURE 2 Digital identity in the context

are also influenced by the specific digital technologies. All these three layers determine the creation of the in-group prototype of a shared digital identity, respectively the out-group prototype. The in-group prototype can become salient and shared within firms (micro-level), among firms (meso-level), and within a specific field, for example, an industry.

5.4 | Digital identity and global digital emergence

As outset before, the shared digital identity is based on mutual values, norms, meanings, cognitions, and behaviors related to greater fondness, proactivity, and in-group's inclination towards digital technology. Shared digital identity includes meaning (Anthony et al., 2016) that can facilitate category development, technology emergence, and expansion in the national and global business contexts (see Figure 3). Digital technology evolves by ongoing reciprocal alterations of digital technologies, changes by physical technology, and of human operations. Accordingly, we assume that the shared digital identity relates to intense exchanges but also will have positive indirect and direct effects on boundary spanning which supports technology emergence and expansion in national and global business. These positive influences will be in a complementary relationship with the rich knowledge exchanges and the identification processes. The knowledge exchanges drive boundary spanning and as such technology emergence and international expansion (Schotter et al., 2017). We propose that rich knowledge exchanges occur in local, regional, and global ties. They occur in personal and organizational ties. Digital and personal exchanges will inspire uses, enable uses, and allow leveraging and stretching the socio-technical system of digital technology.

Figure 3 shows how the shared digital identity builds the fundament of the digital and co-located ties and the different strategies for digital technology emergence and global business.

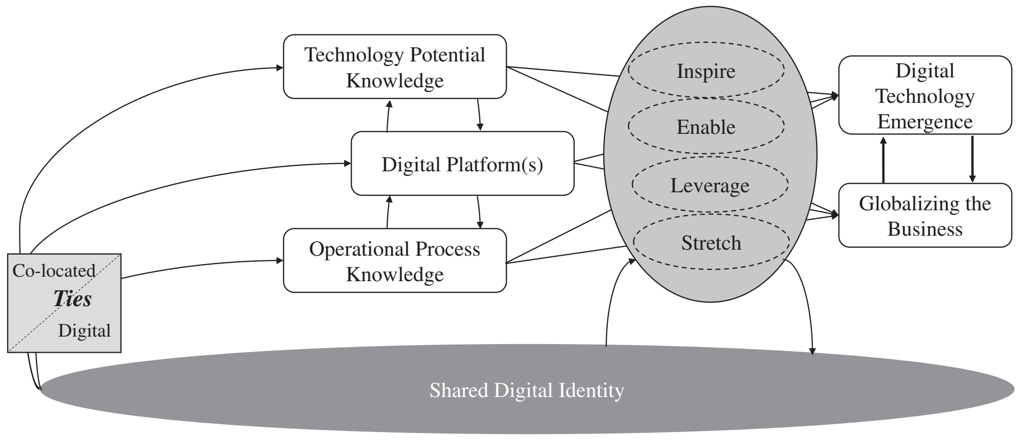

FIGURE 3 Digital identity influencing ties, emergence, and globalization

Direct ties but also platforms transport the technology potential knowledge and the operational process knowledge that include rich knowledge. With the greater knowledge exchange firms inspire and enable uses in other firms. Firms can stretch and leverage their technology towards other contexts and uses as well as business models when they ally or internationalize (Bouncken & Fredrich, 2016a). This advances the field and global business.

6 | CONCLUSION

Our qualitative study supports previous research in that digitalization eases global business. It finds that various digital and non-digital knowledge ties are important for global business. Our study portrays two forms of knowledge exchanged in local and global ties, the *technology potential knowledge* and *operational process knowledge*. Surprisingly, both include rich knowledge. Digitalization facilitates but also demands rich knowledge exchanges indicating a duality of digitalization. In particular, we find mutual values and behavior (e.g., sense of community and enthusiasm) that explain the digital exchange of tacit knowledge. From this, we derive our key theory contribution, the shared digital identity that can occur on micro, meso, and macro levels. We develop the concept of the shared digital identity as the collective self-concept(s) of an in-group towards the creation, application, development, and emergence of digital technology building on a sense of community, enthusiasm, being part of something special, and common values and norms.

6.1 | Limitations and future research

As a general limitation, our model relies on qualitative data so that insights might not be generalizable. Furthermore, our findings might have boundary conditions related to the 3D printing industry. Global digital business in 3D printing requires digital, physical, and human changes that include programming, physical technology, input resources, human operations, and digital designs for 3D printed objects. Global digital business in this so-called mid-range technology relies upon digital exchanges and co-located rich knowledge exchanges to allow inspiration, enabling, leveraging, and stretching the technology. Accordingly, findings on technology potential and the operational process knowledge might only relate to a mid-range digitalization technology, which integrates physical technology and human operations. Future studies might analyze other technology fields for personal knowledge exchanges.

Still, all digitalization advancement benefits from an individual's proclivity, sympathy, fondness, mindsets, and enthusiasm towards digital technologies and being open to exchanges. These characteristics form an in-group and a boundary. Yet, the boundary shifts by communication, coordination, and the perception that others also identify with the digital technology. Thus, digitalization will be facilitated by the shared digital identity regardless of the classification of the digital technology. Future research might analyze precisely how a shared digital identity develops in social interactions. Leadership within a firm might influence a shared digital identity. Some narratives of leaders might be more or less useful in shaping a shared digital identity or organizational digital identity. Researchers might explore how leadership in local or global networks can shape a shared digital identity between firms on a meso-level. Event studies might clarify how shared digital identity developes in digital industries. For global business models, diversity might exist for the antecedents and outcomes of a shared digital identity. Moreover, studies might explore on what bases in-groups identify with others, especially in international ties.

REFERENCES

Alvesson, M., & Kärreman, D. (2007). Constructing mystery: Empirical matters in theory development. *Academy of Management Review*, *32*(4), 1265–1281.

Anthony, C., Nelson, A. J., & Tripsas, M. (2016). “Who are you?...I really wanna know”: Product meaning and competitive positioning in the nascent synthesizer industry. *Strategy Science*, *1*(3), 163–183. https://doi.org/10.1287/stsc.2016.0015

Ashforth, B. E., & Johnson, S. A. (2001). Which hat to wear? The relative salience of multiple identities in organizational contexts. In M. A. Hogg, and D. J. Terry (Eds.), *Social identity processes in organizational contexts* (pp. 31–48). Philadelphia: Psychology.

Ashforth, B. E., & Mael, F. (1989). Social identity theory and the organization. *Academy of Management Review*, *14*(1), 20–39. https://doi.org/10.2307/258189

Ashforth, B. E., Rogers, K. M., & Corley, K. G. (2011). Identity in organizations: Exploring cross-level dynamics. *Organization Science*, *22*(5), 1144–1156.

Awate, S., & Mudambi, R. (2018). On the geography of emerging industry technological networks: The breadth and depth of patented innovations. *Journal of Economic Geography*, *18*(2), 391–419. https://doi.org/10.1093/jeg/lbx032

Berman, B. (2012). 3-D printing: The new industrial revolution. *Business Horizons*, *55*(2), 155–162.

Bharadwaj, A., El Sawy, O. A., Pavlou, P. A., & Venkatraman, N. (2013). Digital business strategy: Toward a next generation of insights. *MIS Quarterly*, *37*(2), 471–482.

Bogue, R. (2013). 3D printing: The dawn of a new era in manufacturing? *Assembly Automation*, *33*(4), 307–311.

Bouncken, R. B., Kraus, S., & Roig-Tierno, N. (2019). Knowledge- and innovation-based business models for future growth: Digitalized business models and portfolio considerations. *Review of Managerial Science*, 1–14. https://doi.org/10.1007/s11846-019-00366-z

Bouncken, R. B., & Fredrich, V. (2016a). Business model innovation in alliances: Successful configurations. *Journal of Business Research*, *69*(9), 3584–3590. https://doi.org/10.1016/j.jbusres.2016.01.004

Bouncken, R. B., & Fredrich, V. (2016b). Good fences make good neighbors? Directions and safeguards in alliances on business model innovation. *Journal of Business Research*, *69*(11), 5196–5202. https://doi.org/10.1016/j.jbusres.2016.04.112

Bouncken, R. B., & Fredrich, V. (2016c). Learning in coopetition: Alliance orientation, network size, and firm types. *Journal of Business Research*, *69*(5), 1753–1758. https://doi.org/10.1016/j.jbusres.2015.10.050

Bouncken, R. B., Fredrich, V., & Kraus, S. (2019). Configurations of firm-level value capture in coopetition. *Long Range Planning*. https://doi.org/10.1016/j.lrp.2019.02.002

Bouncken, R. B., Fredrich, V., Kraus, S., & Ritala, P. (2019). Innovation alliances: Balancing value creation dynamics, competitive intensity and market overlap. *Journal of Business Research*. https://doi.org/10.1016/j.jbusres.2019.10.004

Bouncken, R. B., Fredrich, V., Ritala, P., & Kraus, S. (2018). Coopetition in new product development alliances: Advantages and tensions for incremental and radical innovation. *British Journal of Management*, *29*, 391–410. https://doi.org/10.1111/1467-8551.12213

Bouncken, R. B., & Reuschl, A. J. (2018). Coworking-spaces: How a phenomenon of the sharing economy builds a novel trend for the workplace and for entrepreneurship. *Review of Managerial Science*, *12*(1), 317–334. https://doi.org/10.1007/s11846-016-0215-y

Bouncken, R. B., & Winkler, V. A. (2010). National and cultural diversity in transnational innovation teams. *Technology Analysis & Strategic Management*, *22*(2), 133–151.

Brooks, J., & King, N. (2014). Doing template analysis: Evaluating an end of life care service. In *Sage research methods cases*. Thousand Oaks, CA: Sage.

Carlile, P. R. (2002). A pragmatic view of knowledge and boundaries: Boundary objects in new product development. *Organization Science*, *13*(4), 442–455.

Cesinger, B., Hughes, M., Mensching, H., Bouncken, R., Fredrich, V., & Kraus, S. (2016). A socioemotional wealth perspective on how collaboration intensity, trust, and international market knowledge affect family firms' multinationality. *Journal of World Business*, *51*(4), 586–599. https://doi.org/10.1016/j.jwb.2016.02.004

Chu, J., & Manchanda, P. (2016). Quantifying cross and direct network effects in online consumer-to-consumer platforms. *Marketing Science*, *35*(6), 870–893. https://doi.org/10.1287/mksc.2016.0976

Claggett, J. L., & Karahanna, E. (2018). Unpacking the structure of coordination mechanisms and the role of relational coordination in an era of digitally mediated work processes. *Academy of Management Review*, *43*(4), 704–722. https://doi.org/10.5465/amr.2016.0325

Clauss, T., Bouncken, R. B., Laudien, S., & Kraus, S. (2019). Business model reconfiguration and innovation in SMEs: A mixed-methods analysis from the electronics industry. *International Journal of Innovation Management*. https://doi.org/10.1142/S1363919620500152

Conner, B. P., Manogharan, G. P., Martof, A. N., Rodomsky, L. M., Rodomsky, C. M., Jordan, D. C., & Limperos, J. W. (2014). Making sense of 3-D printing: Creating a map of additive manufacturing products and services. *Additive Manufacturing*, *1*, 64–76.

Covin, J. G., & Lumpkin, G. T. (2011). Entrepreneurial orientation theory and research: Reflections on a needed construct. *Entrepreneurship Theory and Practice*, *35*(5), 855–872.

Cuervo-Cazurra, A., Mudambi, R., & Pedersen, T. (2018). The boundaries of the firm in global strategy. *Global Strategy Journal*, *8*(2), 211–219. https://doi.org/10.1002/gsj.1208

Eisenhardt, K. M. (1989). Building theories from case study research. *Academy of Management Review*, *14*(4), 532–550. https://doi.org/10.5465/amr.1989.4308385

Eisenhardt, K. M., & Graebner, M. E. (2007). Theory building from cases: Opportunities and challenges. *Academy of Management Journal*, *50*(1), 25–32. https://doi.org/10.5465/amj.2007.24160888

Fichman, R. G., Dos Santos, B. L., & Zheng, Z. (2014). Digital innovation as a fundamental and powerful concept in the information systems curriculum. *MIS Quarterly*, *38*(2), 329–343.

Fitzgerald, M., Kruschwitz, N., Bonnet, D., & Welch, M. (2014). Embracing digital technology. *MIT Sloan Management Review*, *55*(2), 1–12.

Fredrich, V., Bouncken, R. B., & Kraus, S. (2019). The race is on: Configurations of absorptive capacity, interdependence and slack resources for interorganizational learning in coopetition alliances. *Journal of Business Research*, *101*, 862–868. https://doi.org/10.1016/j.jbusres.2018.11.038

Gawer, A., & Cusumano, M. A. (2014). Industry platforms and ecosystem innovation. *Journal of Product Innovation Management*, *31*(3), 417–433. https://doi.org/10.1111/jpim.12105

Gawer, A., & Phillips, N. (2013). Institutional work as logics shift: The case of Intel's transformation to platform leader. *Organization Studies*, *34*(8), 1035–1071.

Hogg, M. A., Terry, D. J., & White, K. M. (1995). A tale of two theories: A critical comparison of identity theory with social identity theory. *Social Psychology Quarterly*, *58*(4), 255–269.

Hughes, M., Rigtering, J. P. C., Covin, J. G., Bouncken, R. B., & Kraus, S. (2018). Innovative behaviour, trust and perceived workplace performance. *British Journal of Management*, *29*(4), 750–768. https://doi.org/10.1111/1467-8551.12305

Kale, P., Singh, H., & Perlmutter, H. (2000). Learning and protection of proprietary assets in strategic alliances: Building relational capital. *Strategic Management Journal*, *21*(3), 217–237.

Kietzmann, J., Pitt, L., & Berthon, P. (2015). Disruptions, decisions, and destinations: Enter the age of 3-D printing and additive manufacturing. *Business Horizons*, *58*(2), 209–215.

King, N. (2012). Doing template analysis. In G. Symon & E. Cassel (Eds.), *Qualitative organizational research: Core methods and current challenges* (pp. 426–450). London, England: Sage Publications.

Kohli, R., & Melville, N. P. (2019). Digital innovation: A review and synthesis. *Information Systems Journal*, *29*(1), 200–223. https://doi.org/10.1111/isj.12193

Kraus, S., Roig-Tierno, N., & Bouncken, R. B. (2019). Digital innovation and venturing: An introduction into the digitalization of entrepreneurship. *Review of Managerial Science*, *13*, 519–528. https://doi.org/10.1007/s11846-019-00333-8

Kumar, R., & Nti, K. O. (1998). Differential learning and interaction in alliance dynamics: A process and outcome discrepancy model. *Organization Science*, *9*(3), 356–367.

Kwak, K., Kim, W., & Park, K. (2018). Complementary multiplatforms in the growing innovation ecosystem: Evidence from 3D printing technology. *Technological Forecasting and Social Change*, *136*, 192–207. https://doi.org/10.1016/j.techfore.2017.06.022

Larson, A. (1992). Network dyads in entrepreneurial settings: A study of the governance of exchange relationships. *Administrative Science Quarterly*, *37*(1), 76–104.

Lee, J., & Berente, N. (2012). Digital innovation and the division of innovative labor: Digital controls in the automotive industry. *Organization Science*, *23*(5), 1428–1447.

Legner, C., Eymann, T., Hess, T., Matt, C., Böhmann, T., Drews, P., … Ahlemann, F. (2017). Digitalization: Opportunity and challenge for the business and information systems engineering community. *Business & Information Systems Engineering*, *59*(4), 301–308. https://doi.org/10.1007/s12599-017-0484-2

Lenka, S., Parida, V., & Wincent, J. (2017). Digitalization capabilities as enablers of value co-creation in servitizing firms. *Psychology & Marketing*, *34*(1), 92–100. https://doi.org/10.1002/mar.20975

Lincoln, Y. S., & Guba, E. G. (1985). *Effective evaluation*. New York, NY: Jassey-Bass.

Lorenzen, M., & Mudambi, R. (2013). Clusters, connectivity and catch-up: Bollywood and Bangalore in the global economy. *Journal of Economic Geography*, *13*(3), 501–534. https://doi.org/10.1093/jeg/lbs017

Lyytinen, K., Yoo, Y., & Boland, R. J., Jr. (2016). Digital product innovation within four classes of innovation networks. *Information Systems Journal*, *26*(1), 47–75.

Manyika, J., Lund, S., Bughin, J., Woetzel, J. R., Stamenov, K., & Dhingra, D. (2016). *Digital globalization: The new era of global flows* (Vol. 4). San Francisco, CA: McKinsey Global Institute.

Margaryan, A., Littlejohn, A., & Vojt, G. (2011). Are digital natives a myth or reality? University students' use of digital technologies. *Computers & Education*, *56*(2), 429–440.

McIntyre, D. P., & Srinivasan, A. (2017). Networks, platforms, and strategy: Emerging views and next steps. *Strategic Management Journal*, *38*(1), 141–160.

Miller, D., Breton-Miller, L., & Lester, R. H. (2011). Family and lone founder ownership and strategic behaviour: Social context, identity, and institutional logics. *Journal of Management Studies*, *48*(1), 1–25.

Mudambi, R. (2008). Location, control and innovation in knowledge-intensive industries. *Journal of Economic Geography*, *8*(5), 699–725. https://doi.org/10.1093/jeg/lbn024

Mudambi, R., Li, L., Ma, X., Makino, S., Qian, G., & Boschma, R. (2018). Zoom in, zoom out: Geographic scale and multinational activity. *Journal of International Business Studies*, *49*(8), 929–941. https://doi.org/10.1057/s41267-018-0158-4

Nambisan, S., Lyytinen, K., Majchrzak, A., & Song, M. (2017). Digital innovation management: Reinventing innovation management research in a digital world. *MIS Quarterly*, *41*(1), 223–238.

Nelson, R. E. (1989). The strength of strong ties: Social networks and intergroup conflict in organizations. *Academy of Management Journal*, *32*(2), 377–401.

Parkhe, A. (1991). Interfirm diversity, organizational learning, and longevity in global strategic alliances. *Journal of International Business Studies*, *22*(4), 579–601.

Parkhe, A. (1998). Building trust in international alliances. *Journal of World Business*, *33*(4), 417–437.

Patton, M. Q. (1980). *Qualitative evaluation methods*. Beverly Hills, CA: Sage.

Pesch, R., & Bouncken, R. B. (2017). The double-edged sword of cultural distance in international alliances—How perceived cultural distance influences trust and task discourse to drive new product development performance. *Cross Cultural & Strategic Management*, *24*(1), 33–54. https://doi.org/10.1108/CCSM-03-2016-0065

Pesch, R., & Bouncken, R. B. (2018). How to achieve benefits from diversity in international alliances: Mechanisms and cultural intelligence. *Global Strategy Journal*, *8*(2), 275–300.

Pla-Barber, J., Villar, C., & Madhok, A. (2018). Co-parenting through subsidiaries: A model of value creation in the multinational firm. *Global Strategy Journal*, *8*(4), 536–562. https://doi.org/10.1002/gsj.1180

Polanyi, M. (1967). *The tacit dimension*. New York, NY: Doubleday.

Powell, E. E., & Baker, T. (2017). In the beginning: Identity processes and organizing in multi-founder nascent ventures. *Academy of Management Journal*, *60*(6), 2381–2414.

Rayna, T., & Striukova, L. (2016). From rapid prototyping to home fabrication: How 3D printing is changing business model innovation. *Technological Forecasting and Social Change*, *102*, 214–224.

Rindfleisch, A., O'Hern, M., & Sachdev, V. (2017). The digital revolution, 3D printing, and innovation as data. *Journal of Product Innovation Management*, *34*(5), 681–690.

Ring, P. S., & Ven, A. H. V. D. (1994). Developmental processes of cooperative interorganizational relationships. *Academy of Management Review*, *19*(1), 90–118. https://doi.org/10.5465/AMR.1994.9410122009

Sawhney, M., & Zabin, J. (2002). Managing and measuring relational equity in the network economy. *Journal of the Academy of Marketing Science*, *30*(4), 313–332. https://doi.org/10.1177/009207002236908

Schotter, A. P., Mudambi, R., Doz, Y. L., & Gaur, A. (2017). Boundary spanning in global organizations. *Journal of Management Studies*, *54*(4), 403–421.

Seawright, J., & Gerring, J. (2008). Case selection techniques in case study research: A menu of qualitative and quantitative options. *Political Research Quarterly*, *61*(2), 294–308.

Simonin, B. L. (1999). Transfer of marketing know-how in international strategic alliances: An empirical investigation of the role and antecedents of knowledge ambiguity. *Journal of International Business Studies*, *30*(3), 463–490. https://doi.org/10.2307/155461

Sinkovics, N. (2018). Pattern matching in qualitative analysis. In C. Cassel, A. Cunliffe, & G. Grandy (Eds.), *The sage handbook of qualitative business and management research methods* (pp. 468–485). Thousand Oaks, CA: Sage Publications.

Sinkovics, N., Choksy, U. S., Sinkovics, R. R., & Mudambi, R. (2019). Knowledge connectivity in an adverse context: Global value chains and Pakistani offshore service providers. *Management International Review*, *59*(1), 131–170.

Sinkovics, N., Sinkovics, R. R., & Yamin, M. (2014). The role of social value creation in business model formulation at the bottom of the pyramid–implications for MNEs? *International Business Review*, *23*(4), 692–707.

Sinkovics, R. R., & Alfoldi, E. A. (2012). Progressive focusing and trustworthiness in qualitative research. *Management International Review*, *52*(6), 817–845.

Stumpfe, J. (2019). *Digital platform for industrial 3D printing*. Retrieved from https://www.ibm.com/blogs/blockchain/2019/04/digital-platform-for-industrial-3d-printing/

Szulanski, G. (2000). The process of knowledge transfer: A diachronic analysis of stickiness. *Organizational Behavior and Human Decision Processes*, *82*(1), 9–27.

Tajfel, H. (1974). Social identity and intergroup behaviour. *Social Science Information*, *13*(2), 65–93. https://doi.org/10.1177/053901847401300204

Tajfel, H., & Turner, J. C. (1986). The social identity theory of intergroup behavior. In W. G. Austin (Ed.), *Psychology of intergroup relations* (2nd ed., pp. 7–24). Chicago, IL: Nelson-Hall.

Tallman, S., Luo, Y., & Buckley, P. J. (2018). Business models in global competition. *Global Strategy Journal*, *8*(4), 517–535. https://doi.org/10.1002/gsj.1165

Tallman, S., & Pedersen, T. (2015). What is international strategy research and what is not? *Global Strategy Journal*, *5*(4), 273–277. https://doi.org/10.1002/gsj.1104

Tallman, S., & Phene, A. (2007). Leveraging knowledge across geographic boundaries. *Organization Science*, *18*(2), 252–260.

Tiwana, A. (2008). Do bridging ties complement strong ties? An empirical examination of alliance ambidexterity. *Strategic Management Journal*, *29*(3), 251–272.

Tortoriello, M., Reagans, R., & McEvily, B. (2012). Bridging the knowledge gap: The influence of strong ties, network cohesion, and network range on the transfer of knowledge between organizational units. *Organization Science*, *23*(4), 1024–1039. https://doi.org/10.1287/orsc.1110.0688

Tsang, E. W. K. (1999). A preliminary typology of learning in international strategic alliances. *Journal of World Business*, *34*(3), 211–229. https://doi.org/10.1016/S1090-9516(99)00016-4

Turkina, E., Van Assche, A., & Kali, R. (2016). Structure and evolution of global cluster networks: Evidence from the aerospace industry. *Journal of Economic Geography*, *16*(6), 1211–1234. https://doi.org/10.1093/jeg/lbw020

Welch, C., Piekkari, R., Plakoyiannaki, E., & Paavilainen-Mäntymäki, E. (2011). Theorising from case studies: Towards a pluralist future for international business research. *Journal of International Business Studies*, *42*(5), 740–762.

Wohlers, T. (2019). *Wohlers report 2019 3D printing and additive manufacturing state of the industry*. Retrieved from https://wohlersassociates.com/

Yamin, M., & Sinkovics, R. R. (2006). Online internationalisation, psychic distance reduction and the virtuality trap. *International Business Review*, *15*(4), 339–360.

Yin, R. K. (2014). *Case study research: Design and methods*. London, England: Sage.

Zhu, F., & Iansiti, M. (2012). Entry into platform-based markets. *Strategic Management Journal*, *33*(1), 88–106.

How to cite this article: Bouncken R, Barwinski R. Shared digital identity and rich knowledge ties in global 3D printing—A drizzle in the clouds? *Global Strategy Journal*. 2020;1–28. https://doi.org/10.1002/gsj.1370