Technological Diversification: A Systematic Review of Antecedents, Outcomes and Moderating Effects

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Technological diversification has been linked to a wide range of phenomena, including financial performance, innovation, product diversification and inter-organizational relationships. This is the first systematic review of this literature and provides an overview of its historical development and conceptual foundations. It finds that the role of contingency factors impacting the positive relationship between technological diversification and financial performance needs further exploration. Also, it finds that the research on the links between technological diversification and inter-organizational relationships requires consolidation. This paper suggests three avenues for further research. First, it sets out an agenda for identifying the antecedents of technological diversification. Second, it identifies contextual factors that could shape the relationship between technological diversification and performance. Third, it argues that technological diversification research must engage with contemporary technological and organizational developments such as digital organizations, open boundaries and networks.

Introduction

A firm’s technological resources and capabilities are central to its competitive success (Barney 2001; Nason and Wiklund 2015; Peteraf 1993; Ray et al. 2004). Consequently, many firms have expanded their technology base by becoming active in multiple technological fields (Breschi et al. 2003; Fai 2003; Kim et al. 2016; Krammer 2016; Mendonca 2009). They differ, though, in the level of this technological diversification. Some focus their technological resources and capabilities, whereas others diversify across many fields (Ardito et al. 2018; Dosu et al. 2017; Lee et al. 2017; Marhold and Kang 2017; Pan et al. 2018).

Firm-level technological diversification was established as an area of research in the 1990s by studies such as those of Granstrand and Sjölander (1990) and Patel and Pavitt (1997). Two factors in particular underpinned the emergence of the field. The first was an interest in the role of technology and fast-changing technological paradigms in economic development and restructuring (Dosu 1982, 1997; Kodama 1986a, 1986b; Pavitt et al. 1989; Zahra 1996). The second was the development of resource-, capabilities- and competency-based theories of the firm which informed the theoretical foundations of research on technological diversification (Barney 1991; Foss 1993; Nelson and Winter 1982; Teece et al. 1997; Wernerfelt 1984).

There is now a broad literature on technological diversification. Research has considered the evolving patterns of technological diversification (Cantwell 2004; Granstrand and Oskarsson 1994; Mendonca 2006) and established its importance for financial performance (Chen et al. 2013; Gambardella and Torrisi 1998; Kim et al. 2009; Pan et al. 2018). Research has also shown that technological diversification impacts...
on innovation (Garcia-Vega 2006; Leten et al. 2007; Quintana-Garcia and Benavides-Velasco 2008), firm growth (Kim et al. 2016), product diversification (Cantwell and Piscitello 2000; Miller 2006; Piscitello 2004; Silverman 1999) and inter-organizational relationships (Cantwell and Santangelo 2006; Hohberger et al. 2015; Krammer 2016).

This paper offers the first systematic review of this diverse body of research and complements earlier reviews of product and international diversification (Hitt et al. 2006; Hoskisson and Hitt 1990; Palich et al. 2000). It specifically considers three research questions: (1) What is the current status of the literature on the antecedents, outcomes and moderating effects of firm-level technological diversification? (2) What is the trajectory of its thematic development? (3) What are the implications for future research suggested by our findings?

First, we found that the literature on firm-level technological diversification remains unbalanced, and lacks consolidation and integration. Some issues, such as the link between technological diversification and performance outcomes, have been studied extensively. In contrast, other topics, such as the antecedents of technological diversification, have received relatively little attention. Research into the effects of moderating factors is also at an early stage of development. We nevertheless identified a number of emerging themes considered throughout the literature. These include the role of organizational complexity, which is caused by fragmented but interdependent tasks, functions and units (Berry et al. 2006; Kostova and Zaheer 1999; Larsen et al. 2013), and the relationship between technological diversification and inter-organizational relationships.

Second, we identified four overlapping temporal phases of research on technological diversification. The first phase involved the early exploration of the phenomenon and established theoretical and conceptual foundations of the field (Granstrand 1998; Granstrand and Oskarsson 1994). The second phase focused primarily on the implications of technological diversification for financial performance outcomes (Gambardella and Torrisi 1998; Miller 2004, 2006). The third phase broadened the scope of the field beyond financial performance to explore other outcomes, mainly innovation (Leten et al. 2007; Quintana-Garcia and Benavides-Velasco 2008). In the fourth and most recent phase, research has focused on moderating effects (Eggers and Kaul 2018; Kim et al. 2016).

Third, we identify opportunities for future research in three particularly important and promising areas. First, we discuss how the relatively limited work on the antecedents of technological diversification can be moved forward. Second, we propose how research on the relationship between technological diversification and performance can be strengthened by considering key contextual factors. Third, we suggest that research needs to take into account technological and organizational changes. Specifically, we argue that research must acknowledge that firm boundaries are increasingly permeable. In this context we point to the opportunities offered by a network perspective on technological diversification. We also suggest that in order to address the implications of current digital technological developments such as the Internet of Things (IoT), artificial intelligence and robotics (Schwab 2017), research needs to move beyond its established way of thinking of technology-as-knowledge. Studies should explore how the use of technology (Orlikowski 2000) and its sociomateriality (Orlikowski and Scott 2008) relate to technological diversification.

Our paper is structured as follows. In the next section we clarify key definitions and conceptual matters. We then present our review method and sampling process. We continue by discussing the theoretical foundations and temporal evolution of the literature. Next, we explore existing empirical research. The discussion is organized around the focal thematic categories: antecedents, outcomes and moderating effects. Finally, we make suggestions for future research.

Definitions and concepts of technological diversification

Conceptualizing technology

Technology has been defined in many ways (Mitchell and Singh 1996; Orlikowski and Scott 2008; Sahal 1981; Weick 1990). For example, technology has been defined very broadly as the ‘means to fulfil a human purpose’ (Arthur 2007, p. 276) or as involving the ‘transformation of organizational inputs into organizational outputs’ (Burkhardt and Brass 1990, p. 104). These varying definitions reflect disciplinary and theoretical points of departure and different empirical interests (Burkhardt and Brass 1990; Layton 1974).

Due to the range of definitions offered by the wider literature, we did not restrict our review by using a predetermined definition of technology. Although few studies provide an explicit definition, we found that the literature on technological diversification has
consistently conceptualized technology ‘as a special kind of knowledge’ (Granstrand 1998, p. 480). Following an earlier definition of technology as ‘a set of pieces of knowledge’ (Dosi 1982, p. 151), one of the foundational papers of the field (Granstrand and Sjölander 1990, p. 59) defined technology as ‘an area of specialized technical expert knowledge (e.g. electronic hard-ware) or the practical application of knowledge in a scientific area (e.g. thermodynamics)’. As reflected in the widespread reliance on patent-based measures, the literature sees technology as ‘a body of knowledge ( . . . ) that falls in areas containing in principle patentable knowledge’, the operationalization of which ‘is immensely aided by the international patent system’ (Granstrand 1998, p. 466). This conceptualization is in line with Pavitt (1998, p. 436) and Nelson’s (1998) notion of technology as a ‘body of understanding’ that is based ‘on competencies in specific technological fields, and reflected in the qualifications of corporate technical personnel, and in the fields in which they patent and publish’ (Pavitt 1998, p. 436).

This focus on technology as knowledge and the associated use of patent-based measures has had important consequences for the reach and development of the literature. It has meant that research on technological diversification has not engaged with technology as a physical device (Dosi 1982), its materiality (Leonardi and Barley 2010) or its actual ‘use’ (Orlikowski 2000). Empirically, technology-based applications and processes such as process management, customer relationship management (CRM), supply chain management (SCM) or enterprise resource planning (ERP) technologies (Hendricks et al. 2007) have not been explored systematically. The role of technology in service firms, particularly those in which patenting plays a limited role (Agarwal et al. 2003; Carman and Langeard 1980), has also typically not been considered.

The ability to distinguish technologies is critical when we consider technological diversification. Although the literature has largely avoided dealing with this issue directly due to its reliance on the patent system, we need to note some fundamental challenges. The number of distinct technologies that can be identified depends on both the level of abstraction and technological change (Granstrand and Sjölander 1990). As an example: the development of mechatronics has involved the fusion of previously separate areas of technology (Kodama 1992; Leten et al. 2007). Also, ‘higher-order families of technologies’ (Bodrožić and Adler 2018, p. 87) can be seen as a single general purpose technology (GPT), characterized by its applicability to a wide range of product-market settings (Bresnanhan and Trajtenberg 1995; Crafts 2004; Gambardella and McGahan 2010). The development of GPTs, most recently in the form of information communication technology (ICT), may, as firms move to new technological paradigms, play a role in technological diversification and its relationship with product diversification (Mendonca 2006, 2009).

**Technological diversification and the multi-technology corporation**

At the firm level, early work introduced the notion of technological diversification as distinct from product diversification (Granstrand and Sjölander 1990), which is the expansion of the firm across product-market domains (Chandler 1962; Rumelt 1982). Research has consequently distinguished between ‘what a firm knows’ (technological diversification) and ‘what a firm makes or does’ (product diversification) (Brusoni et al. 2001; Dosi et al. 2017; Miller 2006; Patel and Pavitt 1997). For firms, technological diversification has been defined ‘as the expansion of the corporation’s technological competence’ captured in terms of the ‘diversity, or the breadth (or width) of the corporation’s technology base’ (Granstrand and Oskarsson 1994, p. 355). Technological diversification thus reflects the range ‘of the firm’s technological competencies’ (Piscitello 2000, p. 296), the ‘diversity in the knowledge system’ (Quintana-García and Benavides-Velasco 2008, p. 492) and ‘the extent to which technology is spread across a range of different areas’ (Lai and Weng 2014, p. 81).

Just as with product diversification (Rumelt 1974), work on technological diversification has differentiated between types of diversification by drawing on the notions of ‘relatedness’ and ‘unrelatedness’ (Kim et al. 2009, 2016). Diversification across broad categories of technology is described as broad-field or unrelated technological diversification. Diversification across, and within, narrow categories of technology is labelled as core-field or related diversification (Kim et al. 2009, 2016).

One of the field’s foundational concepts is the notion of the multi-technology corporation (MTC) (Granstrand and Sjölander 1990; Granstrand et al. 1997). MTCs are defined as corporations that operate in a minimum of three broad technologies (Granstrand and Oskarsson 1994; Granstrand and Sjölander 1990) and are set alongside multi-national
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Figure 1. The systematic search process

corporations (MNCs) and multi-product corporations (MPCs) (Cantwell and Piscitello 2000; Granstrand 1998). The concept of the MTC provided the foundation for the exploration of the causes and consequences of technological diversification. Initial work, however, did not adopt more precise measures of a company’s ‘degree of “multi-technologicalness”, or degree of technological diversification, due to its focus on qualitative issues’ (Granstrand and Sjölander 1990, p. 36).

Method

Following previous studies (Cacciotti and Hayton 2015; Wang and Chugh 2014), we adopted a systematic approach to the literature review (Denyer and Tranfield 2009; Tranfield et al. 2003) to make the results reliable, verifiable and reproducible (Booth et al. 2012; Macpherson and Jones 2010). Our research objectives and conceptual boundaries (see Figure 1) are captured in the three research questions: (1) What is the current status of empirical research on firm-level technological diversification? (2) What is the trajectory of its thematic development? (3) What are the implications for future research suggested by our findings?

First, we conducted an informal search to identify the most suitable search terms, which we then applied in a formal electronic database search. We used the EBSCO Host Business Source Premier database (Christoffersen 2013), which offers access to leading management journals such as AMJ, ASQ, AMR, MS, SMJ, JOM, JMS, OS and BJM, as well as specialized innovation and technology management journals including RP, Technovation and IEEE Transactions on Engineering Management (Kunisch et al. 2015; Niesten and Jolink 2015). We applied the filters ‘academic journals’, ‘peer-reviewed’ and ‘Language = English’, to limit the results to academically relevant content. We also searched the publisher databases of Wiley and Science Direct.

Following previous research (David and Han 2004; Newbert 2007), titles, abstracts and keywords were scanned to confirm the study fit with the review scope, and the Boolean operators and truncations described in Figure 1 were applied. We set no time restrictions.
To ensure the quality of the sample, we considered only peer-reviewed journal publications, except for highly cited work such as Cantwell et al. (2004) and Fai (2003). The papers in this initial step were read completely. Finally, backward and forward reference searches based on the identified studies were conducted (Cacciotti and Hayton 2015). This search identified 75 studies that both focused primarily on technological diversification and considered its antecedents, outcomes or associated moderating effects.

Our search also identified studies that considered technological diversification in conceptual terms or explored patterns of technological diversification but did not focus on the exploration of its antecedents, outcomes or moderating effects (Cantwell and Fai 1999; Granstrand 1998; Mendonca 2009). Although these studies did not correspond directly to our research questions, they included important foundational contributions (Granstrand 1998; Granstrand et al. 1997; Kodama 1986a, 1986b). We therefore refer to these studies in our discussion of the definitional and theoretical foundations of the field and when considering its trajectory over time.

In the following section, we discuss the theoretical foundations of the literature. We then explore its evolution. This sets the context for a discussion of the empirical findings of the literature on technological diversification in terms of antecedents, outcomes and moderating effects.

**Theoretical foundations**

Research on technological diversification has drawn primarily on the resource-based view of the firm (Barney 1991; Miller 2006; Ndofor et al. 2015; Penrose 1959; Wernerfelt 1984) as well as the related notions of capabilities, dynamic capabilities (Lee and Kang 2015; Teece et al. 1997) and the competence-based theory of the firm (Foss 1993; Lai et al. 2010b; Piscitello 2000). The resource-based view of the firm also informed the theory of the technology-based firm. This theory focuses on firms that are ‘reliant or based upon technology in exploiting business opportunities’ (Granstrand 1998, p. 466) and provided an early conceptualization of the relationship between a firm’s technological resource base and strategic characteristics such as product diversification. Specifically, the theory describes technological and product diversification as closely linked through a ‘complex pull–push relation’ (Granstrand 1998, p. 472). This means that, over time, products incorporate a higher number of technologies (Pavitt 1998), driving firms toward greater levels of technological diversification (Granstrand 1998). As a result, a growing portfolio of technological capabilities (Gambardella and Giarratana 2013) expands technology-based opportunities for product diversification (Baysinger and Hoskisson 1989; Gambardella and Torrisi 1998; Pavitt 1998). Although such mechanisms suggest a positive relationship between technological and product diversification, the firm may not be able to expand its product offering if it does not have complementary downstream assets (Gambardella and Giarratana 2006; Gambardella and Torrisi 1998; Teece 1986). Firms may therefore look for alternative ways to exploit their technological resources. One of these would be to license their technologies (Bianchi et al. 2014; Khoury et al. 2019). Researchers have also drawn on transaction cost theory to understand how such external markets for technology shape technological diversification and its consequences (Coase 1937; Miller 2006; Silverman 1999; Williamson 1981). For example, the absence of efficient markets and strong intellectual property rights (IPR) regimes (Arora and Ceccagnoli 2006; Gambardella and Giarratana 2006; McGahan and Silverman 2006), as well as contractual difficulties with licensing, may lead to greater technological diversification (Cantwell and Santangelo 2006; Miller 2006).

A complementary line of enquiry has considered the relationship between a firm’s technological diversification and its prior technological base. Evolutionary theory and learning perspectives (Nelson and Winter 1982; Piscitello 2004; Sydow et al. 2009) suggest that firms learn incrementally, close to their core, and therefore diversify their technology base gradually, incrementally and into related technological fields (Cantwell and Fai 1999; Cantwell and Vertova 2004; Fai and Tunzelmann 2001; Penrose 1959; Piscitello 2000, 2004). Just as technological development has been more generally, technological diversification is also characterized by path dependence (Hohberger et al. 2015; Sydow et al. 2009).

A number of mechanisms play a role here. Learning spill-overs, local learning (Breschi et al. 2003), economies of scope (Breschi et al. 2003; Kim et al. 2016; Miller 2006; Piscitello 2000) and the ability to link and jointly exploit technological domains (Piscitello 2000) point to the importance of knowledge-relatedness. Research has therefore considered not only the extent of technological diversification but also its pattern. The notion of
corporate coherence (Teece et al. 1994) links technological diversification to product diversification (Piscitello 2000) and considers their joint impact on performance (Piscitello 2004).

In contrast to this focus on relatedness and coherence, evolutionary theory has also been used to explore how structural shocks can lead to a reconfiguration and change of diversification patterns in the technological base (Cantwell and Santangelo 2006). Similarly, organizational learning, particularly from other firms, can lead to an expansion of a firm’s technological base (Lai et al. 2010a; Levitt and March 1988). Technological diversification is therefore seen to increase absorptive capacity and thus the ability to integrate and exploit external technological knowledge (Corradini and De Propris 2017; Hohberger et al. 2015; Zhang et al. 2007).

**Temporal evolution of research on technological diversification**

We traced the development of the literature over time in order to understand possible changes in the primary themes considered in research on technological diversification (Akinci and Sadler-Smith 2012; Booth et al. 2012; Greenhalgh et al. 2005). We identified four overlapping phases, characterized by different focal points (Figure 2). In Phase 1, research followed the pioneering studies of Kodama (1986a, 1986b) and Pavitt et al. (1989) and explored the phenomenon of firm-level technological diversification. Work focused initially on the firm-specific technology base (Granstrand and Sjölander 1990) and its interconnection with the product portfolio (Granstrand and Oskarsson 1994; Oskarsson 1990; Patel and Pavitt 1997; Pavitt 1998). This led to the articulation of the theory of the technology-based firm (Granstrand 1998).

Early researchers were constrained by the limited availability of appropriate data. They relied on case studies to gain empirical insights into issues such as the management of R&D and external technology sourcing (Granstrand and Sjölander 1990). Two large datasets were developed to overcome this limitation. One of these included interview and survey data from a sample of firms from the USA, Japan and Sweden (Granstrand and Oskarsson 1994; Granstrand et al. 1997). In addition, the SPRU patent database collected data on the world’s most technologically active firms (Granstrand et al. 1997; Patel and Pavitt 1997), which enabled the first financial performance studies (Gambardella and Torrisi 1998) to be conducted. This led into Phase 2, where research focused primarily on the impact of technological diversification on financial performance outcomes (Lin and Chen 2005; Miller 2004, 2006).

In Phase 3, research continued to focus primarily on outcomes but looked beyond financial performance outcomes to consider the wider consequences of technological diversification (Hohberger et al. 2015; Huang and Chen 2010). Studies focused initially on innovation quantity, followed by later work on innovation quality (Nicholls-Nixon and Woo 2003). Papers analysed the impact of technological diversification on levels of innovation output (Garcia-Vega 2006; Leten et al. 2007), the potential to create highly cited patents, so-called ‘technological hits’ (Mariani 2004) and explorative as well as exploitative
innovation (Quintana-García and Benavides-Velasco 2008). Other studies explored technology internationalization (Cantwell and Piscitello 2000), strategic alliances (Giuri et al. 2004; Zhang et al. 2007) and the relationship between technological product diversification (Miller 2004, 2006; Silverman 1999, 2002). In Phase 4, scholars increasingly became interested in the role of contextual factors (Kim et al. 2009, 2016; Shin 2010). Research began to focus on the moderating effects of resource and portfolio characteristics (Kim et al. 2009, 2016) and organizational slack (Chen et al. 2013; Lai and Weng 2014), as well as interactions between technological diversification and inter-firm collaboration (Hohberger et al. 2015) and prior performance (Eggers and Kaul 2018).

Empirical research on technological diversification

We have organized this review of empirical research on technological diversification around the antecedents and outcomes of technological diversification as well as associated moderating effects (Figure 3). This structure is based on established formats which we adapted in line with our research objectives (Figure 1) and the research patterns observed in the focal literature (Dada 2018; Hitt et al. 2006; Hoskisson and Hitt 1990; Hutzschenreuter and Israel 2009; Kotlar et al. 2018; Raisch and Birkinshaw 2008). Although research considers external, organizational and group-level factors, the vast majority of work has focused on the organizational level, in particular the relationship between technological diversification and organizational-level outcomes. Few studies have explored the role of antecedents in shaping technological diversification. Table 1 presents an overview of studies that focus on the antecedents, outcomes and moderating effects of firm-level technological diversification.

Antecedents

Research into the antecedents of technological diversification has been limited. Its focus has been on organization-level factors. Only one study within the parameters of our structured review considers group-level factors. None focuses on the external context.

Organizational antecedents – innovation. Although the impact of technological diversification on innovation has been a focal point of the literature, only two studies in our review consider the reverse relationship: the impact of innovation on technological diversification (Corradini et al. 2016; Fai 2003). They suggest that both quantitative and qualitative aspects of innovation shape technological diversification. Drawing on a dataset tracking large firms between 1930 and 1990, Fai (2003) identified a positive association between technological scale – expressed as the number of patents – and technological diversification. In contrast, Corradini et al. (2016) found a negative

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| Year | Study | Rel. | TD Measure | Data | Setting | Major Findings |
|------|-------|------|------------|------|---------|----------------|
| 1992 | Granstrand et al. | 1–3 | HHI | Survey and case study | SWE, JAP, USA – 1982, 1987 | External technology acquisition increased TD, which is related to growth in R&D costs and sales. |
| 1992 | Granstrand et al. | 3–4 | | | | |
| 1995 | Cantwell and Barrera | 1–3 | RTA | Secondary data (patents) | USA, UK, GER – chemical and electrical equipment | Cartelized firms become technologically more specialized. |
| 1996 | Argyres | 1–3 | Concentric index | Secondary data (patents) | 105 F500 firms | Fewer divisional boundaries increased TD. |
| 1998 | Cantwell and Barrera | 1–3 | RTA | Secondary data (patents) | 82 groups – USA, UK, GER | Cartelized firms become technologically more specialized. Varying specialization patterns between industries. |
| 1998 | Estades and Ramani | 1–3 | Interviews | Qualitative data | Biotech firms UK and FRA | Participation of firms in networks affects technology trajectory (e.g. technology widening/breadth). |
| 2000 | Cantwell and Piscitello | 1–3 | RTA | Secondary data (patents) | Industrial firms USA and EU – 1901 to 1995 | Internationalization of technology and growth of technology is associated with TD – time variations identified. |
| 2000 | Piscitello | 1–3 | Technological relatedness index | Secondary data (patents) | 248 US, EU, JAP firms | TD is related to technological coherence and vice versa. |
| 2000 | Prencipe | 1–3 | No. of technologies used | Secondary data (patents) | Case studies aircraft engine control systems | Firms increase their TD through links with universities and specialized suppliers. Macro-technological changes induce the need for increased TD. |
| 2003 | Breschi et al. | 1–3 | No. of patents per technology field | Secondary data (patents) | 1982–1993 USA, GER, FRA, JAP, ITA, UK | Technological knowledge relatedness is positively related to technological diversification. |
| 2003 | Fai | 1–3 | RTA | Secondary data (patents) | 32 large firms 1930–1990 | Technological scale, in terms of patents, positively influences technological diversification. |
| 2004 | Cantwell and Piscitello | 1–3 | RTA | Secondary data (patents) | USA and EU – 1901 to 1995 | Internationalization of technology and growth of technology is associated with TD – time variations identified. |
| 2004 | Quintana-García and Benavides-Velasco | 1–3 | No. of technologies used | Secondary data (patents) | EU biotech – 1995 to 2000 | Cooperating with competitors is positively related to TD. No significant relation for cooperation with non-competitors. |

(Continued)
| Year  | Study                        | Rel. | TD Measure | Data                  | Setting                                           | Major Findings                                                                                                                                                                                                 |
|-------|------------------------------|------|------------|-----------------------|--------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2005  | Le Bas and Patel            | 1–3  | HHI        | Secondary data        | 345 US, JAP, EU, other firms 1988–1996           | TD is weakly explained by technological internationalization. TD increased by MNCs following a home-base-augmenting R&D strategy.                                                                           |
|       |                              |      |            | (patents)             |                                                  |                                                                                                                                                                                                            |
| 2006  | Cantwell and Santangelo     | 1–3  | RTA        | Secondary data        | 25 international large firms – 1996 to 1995       | M&As as a tool for corporate technology portfolio restructuring and TD.                                                                                                                                      |
|       |                              |      |            | (patents)             |                                                  |                                                                                                                                                                                                            |
| 2010a | Lai et al. (a)              | 1–3  | Entropy    | Secondary data        | Taiwan – 1997 to 2005                            | External corporate venturing is related to increased TD. Complementary assets negatively moderate the relationship.                                                                                  |
|       |                              | 1–3 (6)|            | (patents)             |                                                  |                                                                                                                                                                                                            |
| 2013  | Toh and Kim                 | 1–3  | HHI        | Secondary data        | US communications industry – 1996 to 2006         | Greater technological uncertainty is related to increased technological specialization. Rivals litigiousness and innovativeness increase technological specialization.                                               |
|       |                              | 1–3 (5)|            | (patents)             |                                                  |                                                                                                                                                                                                            |
| 2014  | Lai and Weng                | 1–3  | Entropy    | Secondary data        | Taiwan – 1998 to 2006                            | Technological knowledge distance between alliance partners and TD are described by an inverted U-shape. Absorbed and unabsorbed slack moderate the relationship.                                   |
|       |                              | 1–3 (6)|            | (patents)             |                                                  |                                                                                                                                                                                                            |
| 2015  | Lee and Kang                | 1–3  | No. of technologies used | Secondary data        | 97 US firms – 1990 to 2010                        | U-shaped relations between amount of CVC investments and industrial portfolio diversity and the CVC firm TD. Absorptive capacity moderates the outlined relations.                                            |
|       |                              | 1–3 (6)|            | (patents)             |                                                  |                                                                                                                                                                                                            |
| 2016  | Corradini et al.            | 1–3  | HHI        | Secondary data        | 339 UK small innovators – 1990 to 2006            | Inverted U-shaped relation between technological opportunities and TD. Impactful innovations are negatively related to TD. Higher generality is positively related to TD.                                      |
|       |                              |      |            | (patents)             |                                                  |                                                                                                                                                                                                            |

**Primary Interest of the Study: Organizational Antecedents**

**Primary Interest of the Study: Group-Level Antecedents**

| Year  | Study                        | Rel. | TD Measure | Data                  | Sample                                           | Major Findings                                                                                                                                                                                                 |
|-------|------------------------------|------|------------|-----------------------|--------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2014  | Cecere and Ozman             | 2–3  | Blau index | Secondary data        | 222 firms worldwide ICT – 1995 to 2003           | Curvilinear relation between inventor tie strength and TD. Positive relation between inventor components and TD. Scale-freeness parameters are negatively related to TD. Inventor components moderate tie strength to TD relation. |
|       |                              | 2–3 (7)|            | (patents)             |                                                  |                                                                                                                                                                                                            |

(Continued)
| Year | Study | Rel. | TD Measure | Data | Sample | Primary Interest of the Study | Organizational Outcomes (Financial, Growth, Survival) | Major Findings |
|------|-------|------|------------|------|--------|-------------------------------|---------------------------------------------------|---------------|
| 1994 | Granstrand and Oskarsson | 3-4 | R&D engineer education and interviews | Primary data | 13 SW, 14 JPN, 16 US large corporations | TD is a significant driver of increased R&D costs and sales growth. | Different knowledge strategy groups are identified. Innovations and explorers (highest TD) score highest in R&D and RoA. TD as opposed to business diversification, is positively associated with higher performance (sales, profits). No significant relation between TD and firm scope of technology/technology options and Tobin’s Q. | |
| 1996 | Bierly and Chakrabarti | 3-4 | Dispersion index | Secondary data (patents) | 21 US pharmaceutical firms – 1977 to 1991 | | Different knowledge strategy groups are identified. Innovators and explorers (highest TD) score highest in RoS and RoA. | |
| 1999 | Gambardella and Torrisi | 3-4 | HHI | Secondary data | US, EU electronics – 1984 to 1992 | TD, as opposed to business diversification, is positively associated with higher performance (sales, profits). | TD, as opposed to business diversification, is positively associated with higher performance (sales, profits). | |
| 1999 | Wilbon | 3-4 | HHI | Secondary data (patents) | 40 firms – computer | | Internal technological diversification is positively related to performance (RoI, RoA, Tobin’s Q). Diversifying firms have broader technological portfolios and TD is positively related to performance (RoA, Tobin’s Q). | |
| 2002 | Giuri et al. | 3-4 | HHI | Secondary data (patents) | 256 industrial firms – F-500 | | Coherent patterns of technological diversification are positively related to performance (profits, RoA, sales). Core-field TD is negatively related to performance. Core-field TD is negatively related to performance. | |
| 2002 | Wilbon | 3-4 | HHI | Secondary data (patents) | 227 diversified firms – 1980 to 1992 | | | Coherent patterns of technological diversification are positively related to performance (profits, RoA, sales). Core-field TD is negatively related to performance. Core-field TD is negatively related to performance. | |
| 2004 | Miller | 3-4 | HHI | Secondary data (patents) | 248 US, EU, Japan firms – F-500 | | | Coherent patterns of technological diversification are positively related to performance (profits, RoA, sales). Core-field TD is negatively related to performance. Core-field TD is negatively related to performance. | |
| 2004 | Piscitello | 3-4 | HHI | Secondary data (patents) | 94 US tech firms – 1987 to 1995 | | | Coherent patterns of technological diversification are positively related to performance (profits, RoA, sales). Core-field TD is negatively related to performance. Core-field TD is negatively related to performance. | |
| 2005 | Watanabe et al. | 3-4 | HHI | Secondary data (patents) | Japan (Canon) | | | TD is positively related to performance (operating income to sales). Core-field TD is negatively related to performance (operating income to sales). Core-field TD is negatively related to performance (operating income to sales). | |
| 2006 | Lin et al. | 3-4 | HHI | Secondary data (patents) | 94 US tech firms – 1987 to 1995 | | | Coherent patterns of technological diversification are positively related to performance (profits, RoA, sales). Core-field TD is negatively related to performance. Core-field TD is negatively related to performance. | |
| 2006 | Miller | 3-4 | Breadth/industry applicability index | Secondary data (patents) | 747 US firms – 1986 to 1994 | | | Coherent patterns of technological diversification are positively related to performance (profits, RoA, sales). Core-field TD is negatively related to performance. Core-field TD is negatively related to performance. | |
| 2007 | Watanabe et al. | 3-4 | HHI | Secondary data (patents) | Japan | | | Coherent patterns of technological diversification are positively related to performance (profits, RoA, sales). Core-field TD is negatively related to performance. Core-field TD is negatively related to performance. | |

(Continued)
Table 1. Continued

| Year | Study | Rel. | TD Measure | Data | Sample | Major Findings |
|------|-------|------|------------|------|--------|----------------|
| 2008 | Chiu et al. | 3–4 | HHI | Secondary data (patents) | 582 listed large Taiwanese firms 1997–2005 | TD is positively related to performance. The relationship is moderated by specialized complementary assets, especially by marketing and human capital complementary assets. |
| 2008 | Nesta | 3–4 | No. of technologies used | Secondary data (patents) | 156 large firms worldwide – 1986 to 1996 | The relation between knowledge diversity and productivity is non-significant. |
| 2009 | Bergek et al. | 3–4 | Entropy | Secondary data (patents) | AAB and GE – 1988 to 1998 | The more focused technological portfolio of the GE power generation division led to higher performance than the diversified portfolio of the ABB power division. |
| 2009 | Kim et al. | 3–4 | HHI | Secondary data (patents) | 71 KOR firms – 1990 to 2006 | Core-field diversity is positively related to performance. Broad-field diversity is non-significant. Technology stock positively moderates the broad-field diversity–performance equation. |
| 2010 | Chen | 3–4 | Dispersion index (see also Miller 2006) | Secondary data (patents) | Taiwan, South Korea – 1998 to 2002 | Firm effects (e.g. TD) are stronger in explaining performance differences than industry effects. |
| 2010 | Lin and Wu | 3–4 | Depth index | Secondary data (patents) | US electronics – 1993 to 1999 | TD has a positive effect on performance. TD positively moderates the relationship between alliance, acquisition, R&D intensity and performance (RoA, sales growth). |
| 2011 | Ndofor et al. | 3–4 | HHI | Secondary data (patents) | 69 US firms in vitro – 1995 to 1999 | TD is positively related to performance (RoA) and deviance of competitive behaviour. The competitive behaviour of the firm mediates the relation between TD and performance. |
| 2013 | Chen et al. | 3–4 | See Miller (2006) and Chen (2010) | Secondary data (patents) | 55 firms Taiwan – 2004 to 2011 | TD has a non-significant relation with RoA and EVA, as well as a negative relation with Tobin’s Q and MVA. Absorbed and unabsorbed slack moderates the relationships. |
Table 1. Continued

| Year | Study | Rel. | TD Measure | Data | Sample | Major Findings |
|------|-------|------|------------|------|--------|----------------|
| 2016 | Kim et al. | 3–4 | Entropy | Secondary data (patents) | KOR manufacturing – 1991 to 2005 | TD (overall, related, unrelated) and sales growth are described by an inverted U-shaped relation. Core technological competence moderates the relation between TD and performance. |
| 2017 | Lee et al. | 3–4 | HHI | Secondary data (patents) | 168 S&P firms 2008 | TD is positively related to performance. Firm size and financial slack positively moderate the relation independently and jointly. |
| 2018 | Pan et al. | 3–4 | Entropy | Secondary data (patents) | CHN large firms | TD is positively related to performance. Subsamples confirm the relation in ‘low-tech’ firms. Complementary assets negatively moderate the relationship. |

| Year | Study | Rel. | TD Measure | Data | Sample | Major Findings |
|------|-------|------|------------|------|--------|----------------|
| 2003 | Nicholls-Nixon and Woo | 3–4 | No. of technologies used | Secondary data (patents) | 26 US pharmaceuticals – 1981 to 1991 | There is no significant relation between TD and technical output. |
| 2004 | Almeida and Phene | 3–4 | Distribution of patents around technology classes | Secondary data (patents) | 58 US semiconductors – 1981 to 1992 | There is no significant relation between MNC knowledge base diversity and a subsidiary’s innovation performance. |
| 2004 | Mariani | 3–4 | No. of technologies used | Secondary data (patents) | 693 US biotech and chemicals – 1987 to 1996 | Technological specialization is positively related to technological hits in biotechnology and negatively related in traditional chemicals. |
| 2005 | Lin and Chen | 3–4 | HHI | Secondary data (patents) | 78 US firms – 1976 to 1995 | Technology concentration has no significant relation with Tobin’s Q, and negative significance on four R&D performance measures. |
| 2005 | Nesta and Saviotti | 3–4 | No. of technologies used | Secondary data (patents) | US biotech – 1990 to 1998 | TD has a positive impact on patent output. Coherence in the technology portfolio positively moderates the relation. |
| 2005 | Piscitello | 3–4 | HHI | Secondary data (patents) | 248 firms worldwide F500 – 1987 to 1993 | Technological specialization is negatively related to patent output and has no significant relation with R&D intensity. |
| 2006 | Garcia-Vega | 3–4 | HHI | Secondary data (patents) | 554 EU firms – 1995 to 2000 | TD is positively related to patent output and R&D intensity. |

(Continued)
| Year | Study | Rel. | TD Measure | Data | Sample | Major Findings |
|------|-------|------|------------|------|--------|----------------|
| 2006 | Wadhwa and Kotha | TD moderator | Entropy | Secondary data (patents) | 1989 to 1999 – 36 US firms | TD moderates the curvilinear relationship between CVC investments and knowledge creation. |
| 2007 | Leten et al. | 3–4 | HHI | Secondary data (patents) | 184 firms – USA, EU, JAP | The relationship between TD and technological performance follows an inverted U-shaped relation. Technological coherence positively moderates this relationship. |
| 2008 | Quintana-García and Benavides-Velasco | 3–4 | HHI | Secondary data (patents) | 115 US biotech – 1976 to 2002 | TD is positively related to innovation competence. It further influences exploratory innovation competences more than exploitative. |
| 2010 | Huang and Chen | 3–4 | Entropy | Secondary data (patents) | 305 Taiwanese firms – 1995 to 2004 | TD and innovation performance are described by an inverted U-shaped relation. Absorbed slack positively moderates the relation, whereas unabsorbed does the opposite. |
| 2010 | Lahiri | TD moderator | Blau index | Secondary data (patents) | 100 semiconductor firms – 1972 to 1997 | TD moderates the relation between geographic distribution of technology and innovation quality. |
| 2010 | Shin and Jalajas | 3–4 | Euclidean distance | Secondary data (patents) | 201 US firms – 1993 to 1998 | Technological relatedness between corporate sub-units has a positive relation with the knowledge flow within the corporation and an inverted U-shaped relation with boundary-spanning innovation and corporate innovation impact. |
| 2010 | Shin | 3–4 | Euclidean distance | Secondary data (patents) | 215 firms – 1996 to 1997 | Technological relatedness between corporate sub-units has an inverted U-shaped relation with R&D performance. Institutional and managerial ownership moderate the relationship. |
| 2011 | Chan | 3–4 | HHI | Secondary data (patents) | 115 US and non-US firms | There is no significant relation between TD and innovation variety. |

(Continued)
| Year | Study          | Rel. | TD Measure     | Data            | Sample                                | Major Findings                                                                                                                                                                                                 |
|------|----------------|------|----------------|-----------------|---------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2012 | Lee et al.     | 3–4  | HHI            | Secondary data  | 289 US telecom firms – 1998 to 2008   | The relation between TD and innovation quality follows an inverted U-curve.                                                                                                                                             |
| 2014 | Aktamov        | 3–4  | Entropy        | Secondary data  | 59 automotive CHN firms – 2002 to 2009 | The relationship between TD and innovation performance follows an inverted U-curve.                                                                                                                                     |
| 2015 | Hohberger et al.| 3–4  | Gini coefficient | Secondary data | 147 US and EU firms                   | TD decreases alignment with innovation focus. TD moderates the relation between R&D alliances, internal publications, external individual collaboration and alignment with the general innovation direction.                             |
| 2015 | Lee et al.     | TD   | Entropy        | Secondary data  | 29 US ICT firms – 1995 to 2005        | TD moderates the curvilinear relation between CVC investments and knowledge transferred from start-ups to investor firms in a way that enlarges the potential to source and absorb knowledge from entrepreneurial ventures.                             |
| 2017 | Natalicchio et al. | 3–4  | HHI            | Secondary data  | Green sector, 390 firms and 243 PROs – 1976 to 2010 | TD has a positive impact on joint patent development between firms and public research organizations.                                                                                                               |
| 2018 | Eggers and Kaul | TD   | HHI            | Secondary data  | Firms patenting in USPTO between 1980 and 1997 | The negative relation between a firm’s performance below aspiration in a given technology field and radical invention is stronger for firms with high levels of TD.                                                      |

Primary Interest of the Study: Organizational Outcomes (Strategy)

| Year | Study     | Rel. | TD Measure          | Data            | Sample                                                                 | Major Findings                                                                                                                                 |
|------|-----------|------|---------------------|-----------------|-----------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|
| 1999 | Silverman | 3–4  | Technological       | Secondary data  | 344 firms                                                             | Firms diversify into those industries where the resources of their technologically diverse portfolio are most applicable.                               |
| 2004 | Cesaroni  | 3–5  | resource applicability index | Secondary data  | 40 EU, US, JAP firms                                                 | Higher TD is related to a higher propensity to license out technology.                                                                                   |
| 2004 | Suzuki and Kodama | 3–4  | Technological        | Secondary data  | Canon and Takeda                                                       | Technological diversification is related to product diversification and sales growth.                                                                  |
|      |           |      | relatedness index   | (patents)       |                                                                       |                                                                                                                                                       |
### Table 1. Continued

| Year   | Study          | Rel. | TD Measure | Data                  | Sample                                                                 | Major Findings                                                                                                                                 |
|--------|----------------|------|------------|-----------------------|----------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|
| 2007   | Zhang et al.   | 3–4  | No. of technologies used | Secondary data(patents) | 43 biotech from US and EU – 1993 to 2002 | TD is positively related to formation of new alliances. Centralized R&D structure negatively moderates the relation.                              |
| 2012   | Schildt et al. | 3–4  | HHI        | Secondary data(patents) | 110 largest US firms – 1991 to 1996 | TD is positively related to the rate of learning in alliances. Learning is higher in alliances’ initial phases than in later.                   |
| 2015   | Ndofor et al.  | 3–4  | HHI        | Secondary data(patents) | US firms in vitro – 1995 to 1999 | TMT heterogeneity positively moderates the mixed relation between TD and competitive actions. Three-way interaction between TMT heterogeneity, faultline strength and TD shows mixed results with performance (Tobin’s Q). |
| 2016   | Krammer        | 3–4  | HHI        | Secondary data(patents) | Worldwide tyre industry – 1985 to 1996 | TD is positively related to entering alliances for exploration. Mixed signs for the entrance into exploitation alliances.                     |
| 2017   | Marhold and Kang | 3–4 | HHI        | Secondary data(patents) | 68 US semiconductor firms – 1990 to 2010 | TD is negatively related to alliance portfolio diversity.                                                                          |
| 2018   | Ardito et al.  | TD moderator | HHI | Secondary data(patents) | 303 biotech firms – 1982 to 2012 | TD moderates the curvilinear relation between geographic R&D dispersion and continuous technology acquisitions.                      |

### Table 1. Continued

| Year   | Study          | Rel. | TD Measure | Data                  | Sample                                                                 | Major Findings                                                                                                                                 |
|--------|----------------|------|------------|-----------------------|----------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|
| 2010b  | Lai et al.     | 3–4  | HHI        | Secondary data(patents) | 582 Taiwanese technology firms – 1997 to 2005 | TD is positively related to organizational divisionalization. Complementary assets negatively moderate the relationship.                     |
| 2013   | Shin and Shin  | 3–4  | Euclidean distance | Secondary data(patents) | 128 US manufacturing firms – 1991 to 1999 | Technological relatedness drives institutional ownership, but not the other way around. The effect is stronger for pension fund ownership than for non-pension fund ownership. |

Notes: TD = technological diversification; HHI = Herfindahl or Herfindahl–Hirschmann index; CV/CVC = corporate venture capital; RoS = return on sales; RoA = return on assets; RoI = return on investment; RoE = return on equity; M&A = merger and acquisition; R&D = research and development; EVA = economic value added; MVA = market value added; TMT = top management team.
Organizational antecedents – strategy. Work exploring the impact of firm strategy on technological diversification has focused primarily on inter-organizational relationships. The findings suggest that the nature of these relationships is critical. Whereas research demonstrates that cartels have led to greater technological focus (Cantwell and Barrera 1995, 1998), alliances with competitors (Quintana-García and Benavides-Velasco 2004) and network cooperation have been found to increase technological diversification. This is because firms access and integrate externally acquired technologies (Estades and Ramani 1998).

A related cluster of work considered the role of external corporate venture investments and identified both positive linear and inverted U-shaped relationships with technological diversification (Lai et al. 2010a). An inverted U-shaped pattern was identified for the impact of both alliance partner technological distance (Lai and Weng 2014) and the diversification of a firm’s corporate venture investments (Lee and Kang 2015) on technological diversification. For all types of inter-organizational relationships, resource heterogeneity plays an important role.

Mergers and acquisitions can provide access to heterogeneous resources and, as a result, increase technological diversification (Cantwell and Santangelo 2006). This effect is particularly pronounced in ‘cross-border mergers and acquisitions’ (Cantwell and Santangelo 2006, p. 179). In contrast, two studies examining the degree of patenting attributable to foreign R&D locations (Cantwell and Piscitello 2000; Le Bas and Patel 2005) found no significant impact of such technology internationalization. The acquisition of international firms enhances technological diversification, but the internationalization of R&D may not. Intent matters here. Positive effects (Le Bas and Patel 2005) have been identified, but only for a subsample of MNCs with strategies that aim explicitly to exploit host country-specific knowledge (Kuemmerle 1999). Firms tend to become technologically diverse if they strategically aim to source knowledge in international environments, supporting the ‘technology seeking hypothesis’ (Frost 2001, p. 103).

Organizational antecedents – structure and ownership. Both structure and ownership have received very limited attention. The creation of more divisions has been found to reduce technological diversification, as problems of inter-divisional coordination in the exploitation and commercialization of technologies become more pronounced (Argyres 1996). Subsequent work found that centralized R&D structures contribute to broader technological search (Argyres and Silverman 2004), suggesting possible long-term effects of organizational structures on technological diversification. A study by Shin and Shin (2013) found that neither ownership by pension funds nor other institutional investors had an impact on corporate technological relatedness, measured by the technological relatedness between the firm’s business units. The same study found that corporate technological relatedness affected the extent to which institutional investors took up ownership stakes in the firm, suggesting that ownership effects may be expressed at the investment selection stage rather than through voice.

Organizational antecedents – resources. In the words of Breschi et al. (2003, p. 86), ‘relatedness in technologies is a major driver of firms’ technological diversification’. This view is shared widely in the literature (Cantwell and Piscitello 2004; Hohberger et al. 2015; Piscitello 2000). There is, however, limited empirical work (Piscitello 2000). Research has nevertheless found that firms in developed economies have followed related and coherent patterns of technological diversification from the mid-1980s onwards (Breschi et al. 2003; Piscitello 2000).

Group-level antecedents. Only one reviewed study has considered the impact of group-level factors on a firm’s technological diversification. Cecere and Ozman (2014) have shown that moderately strong ties between inventors foster technological diversification, whereas very strong ties reduce variation in knowledge and learning, leading to an inverted U-shaped relationship. The study finds that a greater number of independent groups of inventors is associated with greater technological diversification (Cecere and Ozman 2014), a relationship that interacts
negatively with the strength of ties between these teams.

Overall, research into the antecedents of technological diversification remains limited, unsystematic and fragmented. Further work is needed to solidify the findings. The area that has attracted the most attention is inter-organizational relationships and their impact on technological diversification – a focus repeated throughout the literature.

Outcomes

As shown in the historical overview, technological diversification has been linked to a wide range of outcomes. Research has, however, focused primarily on financial and innovation performance. A more limited set of studies has considered outcomes such as growth and survival, as well as the impact of technological diversification on strategy (Krammer 2016), structure (Lai et al. 2010b) and ownership (Lai et al. 2010b; Shin and Shin 2013).

Organizational outcomes – financial performance outcomes. Early research suggested a positive association between technological diversification and financial performance (Bierly and Chakrabarti 1996). This positive relationship has been confirmed in a range of contexts and settings (Chiu et al. 2008; Gambardella and Torrisi 1998; Giuri et al. 2004; Lee et al. 2017; Miller 2004; Ndofor et al. 2011; Pan et al. 2018; Watanabe et al. 2005). Contextual factors may, nevertheless, play a role. A recent study offered a more detailed analysis and found the positive relationship held only in low-tech, but not in high-tech, industries (Pan et al. 2018).

Given the importance of knowledge-relatedness to the development of technological diversification, it is notable that Kim et al. (2009) found that diversification within a firm’s core technology field (core-field diversity) had a positive impact on financial performance, but that diversification across different technological fields (broad-field diversity) did not generate statistically significant effects. Only one study within the parameters of our systematic review found technological diversification to have a negative impact on financial performance: Chen et al. (2013) identified a negative association between technological diversification and both Tobin’s Q and market value. Whereas some studies have found insignificant relationships – Chen et al. (2013) for return on assets (RoA) and economic value added, and Lin and Chen (2005) for Tobin’s Q – most evidence suggests that technological diversification has a positive impact on financial performance.

Organizational outcomes – growth and survival. A limited number of studies explored the effect of technological diversification on firm growth. Granstrand and Oskarsson (1994) suggested a positive relationship, but subsequent case study-based work is inconclusive. Watanabe et al. (2005) identified a positive relationship for the Japanese electronics firm Canon, but Bergek et al. (2009) argued that the comparatively focused technological portfolio in the GE power generation segment enabled more substantial growth than the more technologically diversified respective segment of ABB.

More recent findings point to an inverted U-shaped relationship between total technological diversification and sales growth, with the relationship holding for both related and unrelated technological diversification (Kim et al. 2016). Reflecting the lack of research on the relationship between technological choices and survival in the wider literature (Furr and Kapoor 2018), only Wilbon (2002) explored the impact of technological diversification on survival. The study found that high-tech firms which are technologically focused at their initial public offering (IPO) have better chances of survival (Wilbon 2002).

Organizational outcomes – innovation. Studies of the impact of technological diversification on innovation have considered both innovation quantity (Almeida and Phene 2004; Garcia-Vega 2006; Nicholls-Nixon and Woo 2003) and innovation quality (Lee et al. 2012; Mariani 2004; Quintana-García and Benavides-Velasco 2008). For innovation, quantity research initially identified a linear and positive relationship (Garcia-Vega 2006). Subsequent work found the effect to be particularly pronounced for exploratory innovation (Quintana-García and Benavides-Velasco 2008). Findings have, however, not been entirely consistent. Research at the corporate (Nicholls-Nixon and Woo 2003) and subsidiary level (Almeida and Phene 2004) has yielded statistically insignificant effects. More recently, research has pointed to an inverted U-shaped relationship, suggesting that after a certain point organizational complexity and associated coordination costs outpace the benefits offered by economies of scope and knowledge spill-over (Aktamov 2014; Huang and Chen 2010; Leten et al. 2007; Shin 2010).

Studies considering the effect of technological diversification on innovation quality have used a range
of different measures. Nevertheless, the overall pattern of results suggests that the ability to leverage and recombine knowledge in diversified technological portfolios leads to a positive impact on innovation quality. Technological diversification has thus been found to be associated positively with increased innovation quality in terms of patent citations (Lee et al. 2012), originality (Corradini and De Propris 2017) and the impact of patents developed jointly with universities and other public research organizations (Natalicchio et al. 2017). Similarly, technological focus has been found to have a negative impact on patent quality and intellectual asset intensity (Lin and Chen 2005). Technologically focused firms are also more likely to become locked into path-dependent and local learning, which reduces their ability to follow emerging innovation patterns (Hohberger et al. 2015; Sydow et al. 2009). Only Chan (2011) found that greater technological diversification was unrelated to innovation quality, specifically with variety in the innovation portfolio.

Industry context may play a role. Mariani (2004) found that technological specialization has negative consequences for ‘technological hits’ (highly cited patents) in traditional chemical sectors, but positive ones in the biotechnology sector. The organization and distribution of technological capabilities in the firm may also matter. Shin and Jalajas (2010) have shown that technological relatedness between sub-units has an inverted U-shaped relationship with boundary-spanning innovation, defined as ‘novel combinations of multiple technological domains’ (Shin and Jalajas 2010, p. 91).

Organizational outcomes–strategy. Whereas early work on technological diversification considered its relationship with product diversification (Granstrand and Sjölander 1990), later studies examined this relationship empirically (Cantwell and Piscitello 2000; Piscitello 2000; Silverman 1999; Suzuki and Kodama 2004). Initial work focused on the relationship between technological resources and market entry decisions (Silverman 1999), but did not explore the relationship between the extent of technological and product diversification. In a case study of Canon, Suzuki and Kodama (2004) linked the company’s gradual increase in technological diversification to its expanding business and product diversification. This association was confirmed by Miller (2004), who found that more technologically diversified firms were more likely to engage in product diversification than their technologically focused counterparts. In contrast, Piscitello (2000) observed that empirical evidence indicated firms were increasing their technological diversification but decreasing their product diversification. She suggested that the two types of diversification were becoming independent. The observed empirical pattern is, however, also compatible with the increasingly complex nature of multi-technology products (Pavitt 1998).

Only one study has considered international diversification. It is, however, extensive. It covers 94 years and found a positive relationship between technological diversification and internationalization before the 1970s and from the 1990s onwards (Cantwell and Piscitello 2000). Overall, this suggests that interdependencies between technological diversification and other aspects of corporate diversification may depend on context.

A firm’s technological diversification also affects its relationship with other organizations. Technological diversification can signal the possession of valuable capabilities and make it easier to recognize learning opportunities and absorb knowledge (Krammer 2016). Research has therefore found that technological diversification has a positive association with entry into strategic alliances (Zhang et al. 2007), in particular explorative (for example R&D-based) alliances (Krammer 2016). In the same study, Krammer found that exploitative (e.g. marketing and licensing-based) alliances were more likely to be complementary, matching technologically diversified firms with technologically focused partners.

Technological diversification may also shape the configuration of alliances (Marhold and Kang 2017). Technologically diversified firms may limit the technological diversification of their alliance portfolio in order to avoid substantial coordination costs. More fundamentally, they may also abstain from acquiring external technological knowledge (Marhold and Kang 2017; Srivastava and Gnyawali 2011).

The consequences of technological diversification for competitive strategy have received limited attention. A key study, however, considered how technological diversification affects competitive behaviour (Ndofor et al. 2011). As technological diversification reduces a firm’s dependence on other organizations, it reduces the need to conform to established norms and practices and insulates the firm from these isomorphic pressures (DiMaggio and Powell 1983; Quirke 2013). By exposing the firm to a wide range of factor markets, greater technological diversification broadens a firm’s strategic repertoire and allows it to behave in
ways that are different from its competitors (Ndofor et al. 2011).

Organizational outcomes – structure and ownership. The impact of technological diversification on organizational structure has also received little attention (Lai et al. 2010b). However, early in the literature’s development, Granstrand and Sjölander (1990) proposed that technological diversification would increase the degree of organizational divisionalization. Later research confirmed this suggestion. Firms create sub-units in response to diverging operational requirements brought about by technological diversification, and increase specialization in ‘problem-solving and knowledge acquisition’ (Lai et al. 2010b, p. 992). Lahiri et al. (2010) made a similar point, suggesting that greater overall technological diversification would lead to the creation of more specialized sub-units. This was not tested directly. Finally, one study explored the impact of technological diversification on ownership. Shin and Shin (2013) found that related technological diversification attracts more institutional investors, as they are better able to identify potential long-term earnings associated with related technology profiles.

Overall, research on the outcomes of technological diversification has generated a number of findings and themes that extend across different types of outcomes. First, it is notable that research is suggestive of a positive impact on both financial performance outcomes and innovation. Second, research has explored how technological diversification affects a firm’s interaction with other organizations. For example, studies show that technological diversification both increases a firm’s ability to engage in alliances and enhances its competitive repertoire. Third, whereas technological diversification has been linked to organizational complexity, structural and managerial implications have received less attention. Important questions, therefore, remain unanswered.

Moderating effects

Recently, research has begun to focus on moderating effects, described as Phase 4 in the timeline in Figure 2. On the one hand, researchers have investigated moderators of the relationships between technological diversification and its antecedents and outcomes. On the other hand, they have considered how technological diversification itself shapes the relationship between other firm characteristics and organizational outcomes. We begin by considering research that has focused on the former, before exploring work on the moderating effect of technological diversification.

External moderators. Although external contextual factors have received limited attention, research has considered both the implications of technological change and the competitive context. Using a case study approach, Prencipe (2000) suggested that profound technological change, alongside the focal firm’s organizational configuration and external linkages, leads to an increase in its technological diversification. Toh and Kim (2013) found that competitors’ litigiousness and innovativeness positively moderate the relationship between the expected performance volatility arising from technological uncertainty and technological specialization. More litigious competitors deter firms from diversifying more broadly in order to access potentially winning technologies. They will instead focus on developing their existing technologies (Toh and Kim 2013). Competitor innovativeness, as an indicator of lead-time advantages and accumulated technological competencies, may deter technological diversification and motivate technological specialization (Toh and Kim 2013).

Organizational moderators – strategy. Several studies considered the role of strategy as a moderator of the relationship between technological diversification and financial performance. Miller (2006) explored the relationship between product and technological diversification, and found a positive interaction when considering their impact on market-based financial performance. Ndofor et al. (2011) focused on competitive strategy, and found that the complexity of a firm’s competitive behaviour, as well as its deviation from the competitive behaviour of its competitors, moderated the relationship between technological diversification and financial performance. They suggest that complex competitive behaviour allows technological resources to be exploited more comprehensively. They also argue that unique combinations of technologies in deviating competitive behaviour makes imitation more difficult (Ndofor et al. 2011).

Organizational moderators – ownership and structure. Research in this area has been limited. Shin (2010) found that managerial and institutional ownership reinforce the inverted U-shaped relation between related technological diversification and R&D performance. Lee et al. (2017) found support for the hypothesis that the structural options open to larger firms
lead to a positive moderating effect of size on the relationship between technological diversification. Their study, however, did not measure structure directly.

**Organizational moderators – resources.** The literature has considered the moderating effects of technological resources, complementary resources and slack. Considering technological resources, Lin et al. (2006) found a negative interaction between technology stocks (in terms of patents) and technological diversification in a firm’s primary technology area (core-field diversity) when considering the effect on Tobin’s Q, but a positive interaction between technology stocks and a firm’s diversification across technological areas (broad-field diversity) when focusing on RoA. Kim (2016), who identified an inverted U-curve for the relationship between technological diversification and growth, found that core-technology competence (measured on the basis of patents) extended the optimal level of technological diversification. In contrast, Pan et al. (2018) found that intangible complementary resources such as brand names negatively moderate the relationship between technological diversification and performance for Chinese listed firms, a result that the authors link to lock-in effects. Specialized complementary assets have been found to negatively moderate the relationship between external corporate venturing and technological diversification, a consequence of firms seeking to exploit their existing assets (Lai et al. 2010a).

Absorbed slack, described as excess costs that are hard to redeploy (Singh 1986), as well as financial slack, has been shown to positively moderate the relationship between technological diversification and performance in two studies (Chen et al. 2013; Lee et al. 2017). In contrast, inefficiencies were seen to underpin a negative effect for unabsorbed slack (Huang and Chen 2010), a firm’s ‘currently uncommitted resources’ (Tan and Peng 2003, p. 1251). The findings, however, remain sensitive to the choice of financial performance measures. No effect was identified for the common RoA measure (Chen et al. 2013).

**Group-level moderators.** Ndofor et al. (2015) found that heterogeneity of the top management team (TMT) positively moderates the relationship between technological diversification and deviance from the behaviour of competitors, but that strong fault lines in the TMT interact with technological diversification and TMT heterogeneity to reduce the pursuit of deviant strategies. Although heterogeneous teams are more open to diverse information and able to identify and value deviating competitive actions, the existence of clear subgroups may lead the team to disintegrate and curtail its ability and willingness to adopt deviating strategies. Cecere and Ozman (2014) found that the positive effect of ties between inventors was negatively moderated by the number of subgroups because of increased coordination problems.

**Moderating effect of technological diversification.** A further set of studies has explored how technological diversification moderates the impact of other key strategic factors on organizational outcomes. This work has highlighted the complex mechanisms that shape technological diversification and its consequences. Two studies have considered the interaction between technology strategy and the distribution of R&D activity at the national (Lahiri 2010) and international (Ardito et al. 2018) level. Both point to the important role of organizational complexity. Technological diversification has thus been found to negatively affect the relationship between geographic distribution of R&D activity and innovation quality (Lahiri 2010), as well as the relationship between R&D internationalization and the acquisition of patents (Ardito et al. 2018).

Greater technological diversification increases organizational complexity and, in interaction with other aspects of firm strategy, can have a negative impact on the acquisition of knowledge and innovation. However, technological diversification also increases a firm’s absorptive capacity (Hohberger et al. 2015), facilitating the acquisition and transfer of external knowledge. In the context of inter-firm collaborations, more focused patterns of technological diversification have therefore been shown to limit the firm’s ability to align itself with emerging areas of innovation when considering its interaction (Hohberger et al. 2015).

Technological diversification has also been found to affect positively the relationship between external investments and knowledge transfer (Lee et al. 2015; Wadhwa and Kotha 2006). Although technological diversification stretches managers’ knowledge and capabilities, the likely increase in competitive pressures between the firm’s technological areas, together with the risk-balancing effect of the wider technological portfolio, may make attempts at radical invention more likely (Eggers and Kaul 2018). Technological diversification can therefore strengthen the negative relationship between a firm’s below-expectations performance and the likelihood it will pursue radical invention (Eggers and Kaul 2018).
Discussion and future research

This paper reviews over three decades of research on technological diversification. It considers the literature’s evolution over time (Figure 2) and the current state of research (Figure 3). From this, we can identify a number of broad patterns. First, even after more than 30 years, significant gaps and unresolved questions remain. Some areas, such as research into performance implications, have received considerable attention. Others, such as the antecedents of technological diversification, are underdeveloped. Research has focused almost exclusively on the organizational level. In contrast, external and group-level factors have been largely ignored.

Second, although research on the relationship between technological diversification and performance suggests that this relationship is positive, key questions have not been answered. There is a lack of consideration of external and group-level factors. Organizational factors must also be explored in more detail. The association between technological diversification and organizational complexity, for example, has been noted repeatedly, particularly in the context of the interaction between technological diversification and other strategies (e.g., internationalization or alliances). As organizational complexity increases the costs of coordination, there is a need for further work to explore such organizational contingencies. This is particularly the case when considering technological diversification alongside other strategies such as product diversification, international diversification and inter-organizational linkages, all of which may impact organizational complexity (Goerzen and Beamish 2003; Mayer et al. 2015; Robson et al. 2008; Zhou and Wan 2017). Third, although interactions between a firm’s technological diversification and its external relationships have been considered, we argue that research has yet to fully recognize importance and implications of wider network relationships and the changing nature of firm boundaries.

Building on these observations, we explore in the following three sets of proposals for the future development of the field. First, future work must begin to explore the antecedents of technological diversification in a much deeper and more systematic manner; this would be similar to the trajectory taken by research on product and international diversification (Hitt et al. 2006; Hoskisson and Hitt 1990). Second, we suggest particularly promising ways of developing ongoing research into the impact of contextual factors on the relationship between technological diversification and performance. Third, we propose new avenues for research on technological diversification that recognize contemporary developments of both technology and business practice.

Antecedents

Research has highlighted the importance of studying the determinants of diversification (Hoskisson and Hitt 1990). However, relatively little is known about the drivers of technological diversification (Cantwell and Santangelo 2006). Given the significance of technological diversification for performance, this lack of understanding is unsatisfactory.

External antecedents. Adjacent literatures have explored extensively the impact of the environment on firm-level technological development (Asheim and Coenen 2005; Lundvall 2007), as well as other types of diversification (Hautz et al. 2014; Li and Tallman 2011). In contrast, no study covered within the parameters of our systematic review has considered external factors as primary antecedents of technological diversification. We suggest three areas that are of particular interest.

First, we need to understand in greater detail how technological change in general (Fai and Tunzelmann 2001) and technological discontinuities in particular (Asgari et al. 2017) affect technological diversification. Second, to account for possible national differences, it would be important to explore the impact of national innovation systems and wider institutional factors (Freeman 1995), particularly when exploring the similarities and differences between strategies of developed and emerging economy firms (Mahmood and Mitchell 2004; Meyer et al. 2009). Here, we should consider the role of IPR regimes (Arora and Cecchagnoli 2006), location-specific technology (Stiglitz 1987) and country technology specialization (Cantwell 1991).

Third, the role of the competitive environment (Ndofor et al. 2011) requires investigation. Increased rivalry, particularly from international competitors, has a profound effect on product and international diversification strategies (Bowen and Wiersema 2005; Hutzschenreuter and Gröne 2009). This suggests that changes in competitive conditions can have a similar impact on the profile of technological diversification, as firms are likely to adjust their resources and capabilities in response to changing patterns of competition. More generally, previous research suggests that
important predictors of strategic behaviour, such as environmental dynamism or competitive dynamics, have unexplored effects on technological diversification (Hutzschenreuter and Israel 2009; Raisch and Birkinshaw 2008; Toh and Polidoro 2013).

Organizational antecedents – strategy. Although the ‘complex pull–push relation’ (Granstrand 1998, p. 472) between technological and product diversification was recognized early on, research has almost exclusively considered the impact of technological diversification on product diversification (Miller 2006). Meanwhile, the impact of product diversification on technological diversification remains under-explored. This is an important gap in our understanding. In line with research on the interdependence between product diversification and international diversification, a useful point of departure would be to consider how organizational complexity, as well as the ability to leverage organizational and managerial mechanisms, might affect the impact of product diversification on technological diversification (Mayer et al. 2015). Although research has not identified an effect of technology internationalization, similar mechanisms are nevertheless likely to play a role for internationalization more generally. Localized learning in international environments (Berry 2014; Stiglitz 1987) and the integration of location-specific knowledge in the firm’s technology base (Almeida 1996; Asheim 2001; Frost 2001; Manolopoulos et al. 2005) may provide an impetus towards higher technological diversification.

Organizational antecedents – ownership. Research has not found an effect of ownership on technological diversification. But it has had a very narrow focus on US pension funds and other institutional investors (Lee and Kang 2015; Shin and Shin 2013). The wider literature on the impact of ownership has established how the motivations, capabilities and risk profiles of different types of owners, such as families and states, shape diversification patterns more generally (Hautz et al. 2013). Research on technological diversification should follow suit and explore how different patterns of ownership affect technological diversification in particular national contexts.

Group-level antecedents. Recent work has explored how TMT heterogeneity (Ndofor et al. 2015), as well as managerial knowledge and motivation (Eggers and Kaul 2018), interact with technological diversification. Future research should continue this line of enquiry by exploring the way senior managers’ human capital (Hitt et al. 2001), board capital (Hillman and Dalziel 2003) and managerial cognition (Stubbart 1989) shape technological diversification. Social capital and networks, whether created through education, careers or other affiliations, are also likely to affect firm-level technological diversification through the transfer of knowledge and ideas. Research would need to account for the role of the CEO (Hambrick and Quigley 2014). A related research opportunity is to link group-level factors to wider organizational and individual-level considerations by considering organizational culture (Andrews et al. 1999; Büschgens et al. 2013; Johnson 1992) and identity (Brown 2015). Strong identities and a shared understanding of what is ‘central, distinctive, and enduring about an organization’ may guide ‘key strategic decisions such as whether to make an acquisition, enter a new market, or divest a division’ (Tripsas 2009, p. 441) and in this way motivate or deter changes to the diversification of the technological base.

Contextualized understanding of performance outcomes

Research has recently begun to explore the importance of contextual factors and has increasingly considered the role of moderating effects. This work is reflected in Phase 4 in Figure 2. We focus our suggestions for further research on the factors that shape the relationship between technological diversification and performance outcomes. In particular, we suggest that the moderating effects of organizational factors and the external context must be considered.

Organizational factors. Technological diversification has been associated with increased R&D costs, which lead firms to consider mechanisms for successful value appropriation (Jacobides et al. 2006). Understanding how market-facing aspects of firm diversification, notably product and international diversification, moderate the relationship between technological diversification and performance is therefore likely to be particularly useful (Miller 2006). Such research would benefit from taking into account the impact of diversification on absorptive capacity (Hohberger et al. 2015) and organizational complexity (Srivastava and Gnyawali 2011). In this context, considering how organizational structures and processes (Argyres 1996; Argyres and Silverman 2004; Lai et al. 2010b) affect the performance
consequences of technological diversification is likely to be particularly promising.

**External context.** Surprisingly, the role of external factors in shaping the relationship between technological diversification and organizational outcomes has not been taken into account. Previous strategy research has shown that the external environment significantly affects performance (Lumpkin and Dess 1995) as well as technology strategy more generally (Li and Tallman 2011; Zahra 1996). If we want to understand the role of external contingencies, there is substantial work to be done, in two areas in particular.

First, external shocks offer particularly good opportunities to explore the impact of the external context (Cantwell and Santangelo 2006; Chakrabarti 2015). The global financial crisis, for example, is a suitable setting in which to explore the role of macroeconomic factors (Campello et al. 2010; Lim et al. 2009). Studying the interaction between technological diversification and the economic downturn could shed light on how, and to what extent, technological diversification enhances the resilience of organizations.

Second, future research needs to consider the role of national innovation systems (Asheim and Coenen 2005; Lundvall 2007), appropriability regimes (Jacobides et al. 2006) and intellectual property regimes (Gambardella and Giarratana 2006; Hurmelinna-Laukkanen et al. 2007). This is particularly relevant as cross-national differences in institutional factors have been shown to shape the relationships between assets and firm performance after technological disruption (Fuentelsaz et al. 2015). There are opportunities to conduct comparative studies between countries that differ in such institutional characteristics, for example emerging and developed economies (Hoskisson et al. 2000).

**Accounting for contemporary technological and organizational changes**

So far, we have focused on research opportunities that build on established work in the area. Although this would deepen our understanding of technological diversification, wider technological and organizational change presents new avenues for research. We propose three interdependent areas for development. First, there is a need for a deeper conceptual and empirical exploration of the implications of the digital economy and associated business practices on technological diversification and its focal relationships.

Second, although we have focused on the literature on firm-level technological diversification, we propose complementary work that takes a network perspective. Third, research in the area should look beyond its established – but narrow – conceptualization of technology-as-knowledge.

**Digital organizations and open boundaries.** Contemporary corporations such as Amazon or Google are built around a digital business strategy (Bharadwaj et al. 2013). This blurs industry boundaries and competencies (Yoo et al. 2010). Information technology also enables the creation of ‘virtual corporations’ (Ahuja and Novelli 2017, p. 381). Interfirm R&D networks and cooperation (Brusoni et al. 2001; Hagedoorn et al. 2006), interdependent business ecosystems (Baldwin 2012) and the inclusion of diverse external actors in both innovation (Chesbrough 2003) and strategy processes (Hautz et al. 2017; Whittington et al. 2011) have transformed solid external and internal firm boundaries into permeable membranes open to external knowledge, resources and capabilities (Chesbrough 2003; Felin and Zenger 2014; Fey and Birkinshaw 2005; Hautz 2017). These phenomena, which are often based on digital social technologies, increase knowledge transfer across organizations, with profound implications for technological diversification. The literature on technological diversification must therefore follow recent strategy and innovation research and explore the consequences of permeable organizational boundaries.

Future research needs to examine how factors and actors both within and outside the firm affect technological diversification. It must also consider how the changing nature of its boundaries affect technological diversification and its consequences (Cantwell and Santangelo 2006). A firm’s openness may not only shape innovation performance (Laursen and Salter 2006), but also technological diversification.

**Network perspective.** There is much research in the field on the role of inter-organizational relationships (Cantwell and Santangelo 2006; Krammer 2016; Quintana-García and Benavides-Velasco 2004). But future studies need to push further. Firms increasingly operate in networks for technological innovation (Hagedoorn and Duysters 2002), or rely on new external sources of knowledge and new ways of knowledge exchange across organizational boundaries (Chesbrough 2003; Laursen and Salter 2006).
A network view would better capture these developments and therefore offers substantial opportunities for future work on technological diversification. Social network research has examined networks in organizational contexts and has addressed research questions related to knowledge, knowledge transfer and accumulation (Phelps et al. 2012). These studies span multiple levels of networks analysed in terms of the scope of focal actors (e.g. individuals, teams, divisions, organizations) and the level of network constructs included in their theoretical models (e.g. network structures, dyadic relationships) (Borgatti and Foster 2003; Carpenter et al. 2012; Moliterno and Mahony 2011).

By building on this research, a network perspective would allow research to move from an actor-centred perspective towards a more relational, contextual and systemic understanding (Borgatti and Foster 2003). Rather than analysing organizations’ characteristics, such a perspective would focus on the relational system in which social actors are embedded (Borgatti et al. 2009; Granovetter 1973, 1983). This includes groups of interacting individuals, divisions or organizations in terms of their structure and interdependence, as well as actors and actors’ contributions within these social systems (Borgatti et al. 2009). We therefore suggest that a social network perspective (Borgatti et al. 2009) offers a novel and valuable repertoire of theories and frameworks and opens up new research avenues.

A network perspective would enable the use of social network analysis (Borgatti et al. 2009) to explore how specific network characteristics affect a firm’s technological diversification. These network characteristics could refer to: (i) the node level (e.g. divisions, individual firms), such as actors’ specific positions in the network (e.g. the degree of centrality, betweenness or cohesion); (ii) the relationship level, such as the strength of ties and reciprocity between actors; or (iii) the network level, such as network density, size, age and degree of formalization and specialization (Borgatti et al. 2009; Stadler et al. 2014). For example, inter-network comparisons could consider performance effects in industry-specific network types (Gulati 1998; Zaheer and Bell 2005). Depending on the costs associated with technology-related transactions (Gambardella and Giarratana 2006), some industries might favour networks built around highly technologically diversified firms, whereas others may be characterized by an accumulation of technologically focused firms (Jacobides 2008; Robertson and Langlois 1995). An accumulation of focused firms could be regarded as a business and innovation ecosystem with specialized interacting entities (Adner and Kapoor 2010; Zahra and Nambisan 2012), operating in an environment where market transactions are more efficient than internalization (Jacobides 2008).

The changing nature of technology and its use. As discussed at the beginning of this paper, research on technological diversification has consistently conceptualized technology as knowledge, measuring that knowledge using the patent system. The resulting limitations are made more apparent by the technological transformations we see around us. As Bharadwaj et al. (2013, p. 474) write in relation to diversification more generally, digital technologies require more ‘than simply computing distances based on SIC-codes and industry classification’. Understanding technological diversification similarly requires research to look beyond traditional perspectives.

Current developments associated with digital technologies – such as the IoT, augmented reality, artificial intelligence and robotics – mean that the relationship between technology and organizations, as well as human subjects, needs to be rethought (Bloomfield and Vurdubakis 2015; Fleming 2019). This makes it more limiting to conceive of technology only in terms of knowledge. Future research on technological diversification would therefore benefit from work engaging with the notion of sociomateriality, which challenges the ‘assumption that technology, work, and organizations should be conceptualized separately’ (Orlikowski and Scott 2008, p. 434). Recognizing that the technical and the social are deeply intertwined points to the importance of work that explores the actual use of technologies in firms (Orlikowski 2000) and the implications this has for the understanding of technological diversification.

There is still much to learn about the antecedents and performance consequences of technological diversification. Nevertheless, we have reached a point at which the field must again engage more directly with the nature of current technological and organizational developments. This would be a first step in working towards a more profound understanding of technological diversification, but also a return to one of the initial drivers of research in the area: the consideration of the impact of fast-changing technological paradigms (Aggarwal et al. 2017; Dosi 1982, 1997).
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