Commonalities and Specificities of Dynamic Capabilities:
A Mixed Methods Study of UK High-Tech SMEs

Abstract

This study aims to examine the commonalities of dynamic capabilities (DCs) across firms and identify their idiosyncratic practices within firms - an under-researched area within the strategic management and related innovation management literature. Although the existing research has attempted to identify commonalities of DCs across firms, there is hardly any research on specific practices within firms identified under those commonalities. We address this critical research problem to understand how firms can develop and deploy idiosyncratic practices of DCs but also align such firm-specific practices with common best practices of DCs across firms. Based on a mixed methods study, we first conceptualize and empirically examine the commonalities of DCs across firms using quantitative survey data from 113 UK high-tech SMEs. This is followed by identifying specificities of developing and applying DCs within firms based on qualitative interview data from 20 UK high-tech SMEs. Our findings reveal that the commonalities of DCs are manifested in two components: absorptive capability and transformative capability, and that these two capabilities are embedded in specific practices within firms. Therefore, this study contributes to the understanding of how DCs are developed and deployed in the specific context of firms, but also aligned with 'best practices' of DCs across firms.

Key words: dynamic capabilities, commonalities and specificities, mixed methods

1. Introduction

The dynamic capabilities (DCs) perspective has been a significant area of research in the strategic management and related literature, such as innovation management, since the late 1990s. DCs reflect a firm's ability to renew itself in light of environmental changes and to gain competitive advantage in a new and innovative way (Teece et al., 1997). However, DCs used to be viewed as an "elusive black box" (Pavlou & El Sawy, 2011), as it was surrounded by a debate on its conceptualization and limited empirical research on how DCs are manifested across and within firms (Danneels, 2010; Eisenhardt & Martin, 2000; Teece, 2007). Despite the continuing calls for further research on DCs (Alvarez & Busenitz, 2001; Newbert, 2007; Peteraf et al., 2013; Salvato & Vassolo, 2018), a specific debate remains surrounding the commonalities and specificities of DCs.

Eisenhardt and Martin (2000) argue that how DCs are manifested can be identified as commonalities - 'best practices' across firms. Whilst demonstrating commonalities across firms, DCs may be idiosyncratic within firms (Aragon-Correa & Sharma, 2003; Eisenhardt & Martin, 2000). Therefore, Laaksonen and Peltoniemi (2018) believe that DCs logically cannot be studied by comparing them between firms, but propose a practical approach to studying DCs: "if a researcher wishes to compare the DCs in a sample of firms, he/she should first identify a set of best practices and then look at which firms employ which ones", and such approach "would enable building a DC 'profile' for each firm that could then be used as a basis for comparison" (Laaksonen & Peltoniemi, 2018: 186).

The divide between commonalities of DCs and specificities of DCs are different perspectives that can be complementary to the conceptualization and operationalization of DCs (Peteraf et al., 2013). Indeed, the two research streams have shown some convergence over the years (Wilden et al., 2016), but have failed to create a clear link between commonalities across firms and their specificities within firms. Therefore, it would be a priority to clarify how generic and firm-specific DCs can be mapped out (Ambrosini & Bowman, 2009; Laaksonen & Peltoniemi, 2018). Our study addresses this significant research problem by focusing on two research questions: (1) How are the commonalities of DCs manifested across firms? and (2) How are the commonalities linked with the specificities of DCs within firms?

In addressing the above research questions, we aim to achieve two objectives: to identify the commonalities of DCs across firms based on a quantitative survey of 113 UK high-tech small and medium-sized enterprises (SMEs); and to map out firm-specific practices of DCs in which the commonalities are embedded based on qualitative interviews with 20 executives from 20 high-tech SMEs who took part in the survey. We intend to contribute to the DCs literature within strategic management (Teece et al., 1997; Eisenhardt & Martin, 2000; Alvarez & Busenitz, 2001; Newbert, 2007; Peteraf et al., 2013; Salvato & Vassolo, 2018; Laaksonen & Peltoniemi, 2018) and related innovation management, by addressing how firms can develop and deploy idiosyncratic practices of DCs but also align such firm-specific practices with common best practices of DCs across firms. This ensures that firms not only renew, reconfigure and recreate resources in a new and innovative way internally, but also in tune with industry best practices, in order to attain and sustain competitive advantage. Our study also contributes to the dimensionalization of DCs (Schilke et al., 2018), by identifying the common component factors of DCs in UK high-tech SMEs.

Methodologically, qualitative research has identified a wide range of idiosyncratic firm practices (specificities) in which DCs are embedded (Camuffo & Volpato, 1996; Petroni, 1998; Tripsas, 1997; Warner & Wäger, 2019), whereas quantitative research has attempted to conceptualize the commonalities of DCs (Pandza & Holt; 2007; Wang & Ahmed, 2007; Wang et al., 2015). Despite the emerging convergence of theoretical insights on the commonalities and specificities of DCs, empirical research on the two research streams has

largely been developed in parallel. To the best of knowledge, our study is the first to map out the DCs' commonalities across firms and to identify their specificities within firms using mixed methods. Additionally, our findings have practical implications for executives and managers to identify, reconfigure or introduce business processes toward the development and application of DCs.

2. Literature review

2.1. The dynamic capabilities perspective

The DCs perspective (Teece & Pisano, 1994; Teece et al., 1997) emerged as a response to the criticism of the resource-based view (RBV) of the firm (Barney, 1991; Penrose, 1959; Wernerfelt, 1984). The latter is challenged for its key assumptions on resource heterogeneity and immobility (Foss, 1998; Lazonick, 2002; Lockett et al., 2009; Teece, 2018), causality between valuable, rare, inimitable, and non-substitutable (VRIN) resources and firm performance (Lin & Wu, 2014; Priem & Butler, 2001), conceptual tautology (Eisenhardt & Martin, 2000; Lockett & Thompson, 2001; Priem & Butler, 2001), not focusing on creating new resources (Abell et al., 2008; Foss, 1998; Nagano, 2020), and not addressing market dynamism (Foss & Ishikawa, 2007; Priem & Butler, 2001). Firms need to be responsive, rapid, and flexible in product innovation along with capable management to win in the global marketplace (Teece & Pisano, 1994). Therefore, addressing the criticisms of the RBV, the concept of DCs emerged focusing on "the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments" (Teece et al., 1997:516). DCs emphasize a firm's capacity to alter its resource base and create new resources (Helfat et al., 2007). There is empirical evidence that a firm's strong DCs increase its levels of radical innovation capabilities (Mikalef et al., 2019). Given the wide recognition in the literature, the originality of it, and its comprehensive nature, we adopt Teece et al.'s (1997) definition of DCs in this paper.

DCs play an important role in achieving sustained competitive advantage by firms, but not without criticism (Breznik & Lahovnik, 2016; Jurksiene & Pundziene, 2016; Priem & Butler, 2001; Williamson, 1999). In particular, DCs have been criticized for being conceptually vague and elusive (Danneels, 2010; Kraatz & Zajac, 2001; Pavlou & El Sawy, 2011), with empirical evidence lagging behind conceptual development. Eisenhardt and Martin (2000) argue that the extent of the "idiosyncratic firm effects" in the literature (Brush & Artz, 1999; McGahan & Porter, 1997) is overstated. Commenting on Eisenhardt and Martin (2000) idea that DCs can be captured as "best practice", Teece (2014) warns that such view makes DCs seen as imitable, in which case DCs cannot be a source of competitive advantage. In reconciling the above divide, Teece (2014; 338) claims that Eisenhardt and Martin (2000) are focused on a different class of capabilities, i.e., ordinary capabilities, "which can be benchmarked for best practice and are vulnerable to imitation". Referring back to his original definition of DCs, Teece (2014) iterates that "a well understood and replicable best practice is not likely to constitute a dynamic capability" (Teece, 2007: 1321).

Identifying organizational change capability as a generic dynamic capability, Andreeva and Ritala (2016) propose that in each organization DCs are built on idiosyncratic processes; an idea that is in line with Eisenhardt and Martin (2000) and Wang and Ahmed (2007). In resolving the issue of vulnerability to imitation by competitors in line with the argument that DCs have commonalities across firms (Teece, 2014), Andreeva and Ritala (2016) provide an illustrative example: in an Research & Development (R&D) intensive firm, the R&D related processes and routines in that firm represent functional/operational capabilities, which can be easily imitated by competitors, whereas DCs lie in the R&D capabilities including collaboration and connectivity with internal and external stakeholders, as well as management mechanisms related to firm-specific R&D activities; such a capability is much

more difficult to imitate due to its complex nature (Andreeva & Ritala, 2016). Therefore, Andreeva and Ritala (2016) suggest that, in order to develop the theory of DCs further, research should go beyond the conceptual focus on idiosyncratic, domain-specific capabilities. They question, "if all DCs are unique, how can one formulate any general recommendations for managers for the development of DCs?" (Andreeva and Ritala, 2016:243)

The idea of commonalities of DCs (Eisenhardt & Martin, 2000) has partly paved the way to Teece's (2007) framework of the microfoundations of DCs (sensing, seizing and reconfiguring). Teece (2007:1322) recognizes that Eisenhardt and Martin's (2000) work on cross-functional R&D teams, new product development routines, technology transfer and/or knowledge transfer routines, and quality control routines are important elements (microfoundations) of DCs. A microfoundations approach focuses on collective constructs such as routines and capabilities that need explanation, and that require consideration of lower-level entities, such as individuals or processes in organizations, and their interactions (Felin et al., 2012). Collective level constructs can also be part of the relevant explanation, specially in unpacking routines and capabilities in understanding heterogeneity among firms (Felin et al., 2012). The microfoundations of DCs refer to "the distinct skills, processes, procedures, organizational structures, decision rules, and disciplines, undergird enterprise-level sensing, seizing, and reconfiguring capacities" (Teece, 2007:1319); they must be necessarily "incomplete, inchoate, and somewhat opaque and/or their implementation must be rather difficult" as otherwise DCs could be vulnerable to imitation (Teece, 2007:1321; Teece, 2014).

According to Eisenhardt and Martin (2000) the commonalities of DCs across firms are identifiable and there are idiosyncrasies in details within those commonalities. In other words, firms may adopt different practices for the above routines, but they are equivalently effective in sensing and seizing opportunities and reconfiguring resources to pursue opportunities (Kindström et al., 2013). Suddaby et al. (2019) points out that the value of Teece's (2007) theory of microfoundations of DCs is based on their ability to explain how some firms are uniquely able to adapt to profound change while others are not. Nevertheless, no prior research exists to map out DCs' commonalities across firms and specificities within firms in a single study. We address this gap by identifying both commonalities and specificities of DCs to understand the best practices of DCs across firms and to recognize the need of customizing DCs to firms' specific contexts. Such effort also helps to advance empirical work beyond the current ad-hoc and piecemeal evidence.

2.2. Commonalities and specificities of DCs

Scholars have attempted to conceptualize DCs' commonalities. Some examples are, Teece's (2007:1319) three elements of DCs mentioned above (*sensing* and shaping opportunities and threats; *seizing* opportunities, and maintain competitiveness through enhancing, combining, protecting, and, when necessary, *reconfiguring* the business enterprise's intangible and tangible assets) and Eisenhardt and Martin's (2000) three categories of DCs (*resource integration* capabilities, *resource reconfiguration* capabilities, and *resource gaining and releasing* capabilities). Wilhelm et al. (2015) and Pavlou and El Sawy (2011) report quantitative evidence related to Teece's (2007:1319) elements of DCs whereas Ellonen et al. (2009), Fourné et al. (2014), Kindström et al. (2013), and Mezger (2014) presents qualitative evidence related to Teece's (2007:1319) elements of DCs. Mezger (2014) and Weimann et al., (2019) identify business model innovation as a DC and this is particularly important in dealing with a volatile, uncertain, complex, and ambiguous environment (Schoemaker et al., 2018). Presenting practical examples of both microfoundations generating DCs, Bojesson and Fundin (2020) suggest that to succeed with organizational reconfiguration, great importance

lies in creating a fit between the DC of the firm and the internal and external context of the firm. Their findings highlight the firm-level factors affecting generating and implementing DCs.

Teece's (2007) components of DCs are mostly supported by qualitative or conceptual studies (e.g., Sun & Anderson, 2010). Subsequently, DCs have been operationalized as absorptive and transformative capabilities (Wang et al., 2015). Teece's (2007) components of DCs sensing and seizing are compatible with Wang and Ahmed's (2007) 'absorptive capability', and reconfiguring is well-matched with Wang and Ahmed's (2007) 'adaptive' and 'innovative' capabilities. Scholars (e.g., Zahra & George, 2002) have further analyzed absorptive capacity as a DC, and identified four dimensions of absorptive capacity that could be 'distinct but complementary capabilities', i.e., acquisition, assimilation, transformation, and exploitation. While Zahra and George's (2002) 'acquisition' and 'assimilation' capabilities could fall under absorptive capability of Wang et al. (2015), and the former's 'transformation' capability could correspond to transformative capability of Wang et al. (2015). However, exploitation, the fourth dimension of Zahra and George's (2002) concept of absorptive capacity might not be included in Wang et al.'s (2015) components of DCs as exploitation represents 'use' or 'implementation' which could be considered as ordinary capabilities of an organization (Teece, 2014). Nevertheless, the gist of Zahra and George's (2002:189) argument is that "although these capabilities have some commonalities across different firms and attain equifinality, they are idiosyncratic in the specific ways firms pursue, develop, and employ them".

It's worth noting that Lee and Kelley (2008) particularly focus on the components of DCs relevant to managing innovation where they identify firm-level practices for managing in a comparative case study. Studying components of DCs and firm-level practices within those components among more case companies would make the findings more generalizable. Findings of the quantitative empirical studies of Hsu and Wang (2012), Protogerou et al. (2012), and Verona and Ravasi (2003) support Wang and Ahmed (2007). In addition, Pandza and Holt's (2007) and Wang et al.'s (2015) quantitative studies identified two components of DCs: 'absorptive' and 'transformative' capabilities. Qualitative findings of Macher and Mowery (2009), McKelvie1 and Davidsson (2009), and Lin and Wu (2014) correspond to the DCs components of Wang and Ahmed (2007). Research has also identified an array of DCs' specificities using conceptual or anecdotal evidence (Helfat et al., 2007; Wang & Ahmed, 2007). Tripsas (1997: 373-374) identifies that 'development of external integrative capability and utilization of multiple R&D locations' help to develop DCs, while Danneels (2010) considers that DCs operate through 'resource alteration processes'.

Literature highlights the need to understand the connection between commonalities and specificities of DCs. For example, Peteraf et al. (2013) claim that if commonalities of DCs are different in idiosyncratic details, they may be a source of competitive advantage. Based on Zott (2003), Peteraf et al. (2013) also point out that depending on timing, cost, and other aspects, firms with relatively homogeneous DCs can report significantly different performance. Even after a best practice has become a common practice in one industry, it may still provide a competitive advantage in other industries (Peteraf et al., 2013). Therefore, while acknowledging DCs as a helpful tool of strategic analysis, Winter (2003: 995) points out that strategic analysis requires "understanding the link between the idiosyncratic attributes of a firm and its prospects in a particular competitive context."

Since scholars (e.g., Eisenhardt & Martin, 2000; Zollo & Winter, 2002) have portrayed DCs as collective endeavors but do not specify how they emerge and operate within firms, Salvato and Vassolo (2018) invite researchers to consider these multiple levels (individual, interpersonal, and organization levels) that integrate the contrasting approaches to DCs simultaneously (i.e., a multi-level theory of DCs). Andreeva and Ritala (2016) also pinpoint

that those specific managerial activities within firms aimed at developing DCs deserve further research. This reinforces Teece's (2014:332) claim that "dynamic capabilities reside, in part, with individual managers and the top management team".

Even though our study may not have gone deeper into the individual and interpersonal level, it might partially address this gap by looking into both commonalities of DCs across firms and specific practices within firms that could contribute to the emergence of those commonalities. Therefore, we bridge the gap in the literature where research on the specificities and commonalities of DCs has been disconnected by empirically validating DCs' commonalities as recommended by Pandza and Holt (2007) and Wang and Ahmed (2007) using a quantitative study, and then mapping out DCs' specificities through firms' idiosyncratic practices using a qualitative study.

3. Methodology

3.1. Research approach

In linking the microfoundations research to existing capability-based work like Teece (2007) that defines DCs as "sensing, shaping and seizing of opportunities", Felin et al. (2015) illustrates how sensing, shaping, and seizing opportunities happen in organizations. Extant research on organizational capabilities might not have gone into this level of detail, providing a significant opportunity for future research (Felin et al., 2015). When it comes to studying the microfoundations of DCs, and as far as managerial DCs are concerned, although large datasets can be used to trace them to some extent, in-depth qualitative research can be the best to analyze them (Teece, 2012). This is further emphasized by Felin et al. (2012) who think that the study of the microfoundations of routines and capabilities needs methodological pluralism.

Therefore, we employed a mixed methods approach to identify DCs' commonalities using quantitative data in Stage 1 and their specificities using qualitative data in Stage 2. Even though a mixed methods approach is taken, our study primarily follows a deductive logic, as the qualitative data were used to gain further insights into the quantitative findings of commonalities of DCs through identifying firm-specific practices within those commonalities. Mixed methods research allows researchers to collect a richer and stronger array of evidence (Creswell & Plano Clark, 2007; Molina-Azorin, 2012; Yin, 2009), and tends to have more impact in the field of strategic management (Molina-Azorin, 2012), especially within the RBV paradigm (Hoskisson et al., 1999). In understanding DCs in SMEs, Heider et al. (2020) suggest that it would be better to use qualitative and quantitative studies as SMEs are not created alike and DCs differ across those firms. Mixed methods can also provide stronger evidence for a conclusion. Nevertheless, the integration of quantitative and qualitative methods should not diminish the value of both methods (Johnson & Onwuegbuzie, 2004; Sale et al., 2002). Therefore, to effectively integrate methods, we adopted an explanatory research design (Harrison III, 2013) where the qualitative findings in Stage 2 explain the quantitative findings in Stage 1. This is "a case study within a survey" (Yin, 2009:63).

3.1. Methods of data collection

3.1.2. Quantitative methods

Survey sample

In Stage 1, we conducted a mailed survey among UK high-tech SMEs with 10-250 employees (European Commission, 2009), responding to the specific call for conceptual and empirical advancement of DCs in SMEs (Sapienza et al., 2006; Zahra et al., 2006). High-tech industries are characterized by complex nature of their products and systems and uncertainty of the environment they operate in (Olausson & Berggren, 2010). This makes successful

strategy formulation for high-tech firms very difficult (Meade et al., 2006) and, thus, the role of DCs in those industries is crucial. As mentioned above, DCs research in high-tech industries is particularly important as DCs consist of a broad range of activities (e.g., new product development, business model innovation, and alliance formation).

High-tech firms were defined as those with a Standard Industrial Code (SIC) for one of the five high-tech industries: aerospace; pharmaceutical and biotechnology; office and computing; radio, TV and communication; and medical and optical equipment (OECD, 2003). Given (a) their theoretical relevance to DCs and the quick adaptability (Crick & Spence, 2005), (b) their practical relevance, and (c) their policy relevance (Mason et al., 2009) attracting increasing government support to develop their DCs (CBI, 2011), high-tech SMEs were studied. Using the Experian Database, Companies House, Yellow Pages, and Thomson Directory, we identified 1211 UK high-tech SMEs and a questionnaire was posted to the intended respondents that included CEOs/Directors of each company. Only 522 surveys (the effective sample) reached the addressees, and 134 questionnaires were completed and returned. There were 113 effective responses (21.65 percent effective response rate). Table 1 reports our sample firms' profile.

Insert Table 1 here

Measures for the survey

Since DCs lack universally applicable scales (Makkonen et al., 2014), we adopted the construct as conceptualized by Pandza and Holt (2007) and Wang and Ahmed (2007). Pandza and Holt (2007) propose two components of DCs: "absorptive capability" - a firm's ability to recognize external information, assimilate, and apply to commercial ends (Cohen & Levinthal, 1990:128), and "transformative capability" - a firm's ability to constantly redefine a portfolio of product or service opportunities based on knowledge endogenous to the firm (Pandza & Holt, 2007). Wang and Ahmed's (2007) three components absorptive, adaptive, and innovative capabilities seem to resemble those of Pandza and Holt (2007). We started with Wang and Ahmed's (2007) three components, as they were conceptually clear and measurable with available measures. As mentioned above, qualitative findings of Macher and Mowery (2009), McKelvie1 and Davidsson (2009), and Lin and Wu (2014) correspond to the DCs components of Wang and Ahmed (2007).

Thus, in operationalizing DCs along Wang and Ahmed's (2007) dimensions of DCs, four items of García-Morales et al. (2008) were adopted to measure realized "absorptive capability" (Zahra & George, 2002). Adaptive capability was measured using three items that were originally developed to measure adaptability by Gibson and Birkinshaw (2004). Innovative capability was measured from an input perspective focusing on the innovative behaviors (Calantone et al., 2002) using three items of Hughes and Morgan (2007) plus one item adopted from Wang and Ahmed (2004). This makes more sense as use of indicators like R&D spending to measure innovative capability has been challenged in the literature as it may be a false assumption that R&D spending, and also firms could measure R&D differently (Coombs & Bierly III, 2006). In sum, we measured DCs as a higher-order reflective construct using 11 items (Table 2).

Insert Table 2 here

3.1.3. Qualitative methods

Interview sample

To investigate the commonalities of DCs identified across firms in Stage 1, our Stage 2 qualitative research involved 20 semi-structured interviews with senior executives who were

survey respondents from 20 UK high-tech SMEs (Table 3); an effective way of sampling for a qualitative study following a survey (Pearce, 2002).

Interview guide

The need for more research to measure firm-level DCs through managers' evaluations (e.g., Capron & Mitchell, 2009; von den Driesch et al., 2015) has been highlighted by Laaksonen and Peltoniemi (2018). While acknowledging that the role of the interviewee matters when it comes to their knowledge of how the firm operates (Stake, 2013), our interview questions were designed to give more prominence to the case than the interviewee. Our questions covered (a) the firm background; (b) self-assessment of firm resources and capabilities; (c) how the firm acquired new information and assimilated; and (d) how the firm adapted its resources or capabilities to suit the best strategy to capitalize on environmental changes. The average duration of each interview was 60 minutes, and the interviews were recorded and transcribed.

Insert Table 3 here

3.1. Methods of data analysis

Quantitative data analysis

We tested non-response bias (Armstrong & Overton, 1977) based on early responses (received before the survey due date; *n*=54; 47.8 percent), and late responses (received after the due date; *n*=59; 52.2 percent). The Analysis of Variance (ANOVA) test results of key variables indicated that there was no significant non-response bias. We used exploratory factor analysis (EFA) to explore the factor structure of the DCs construct, followed by confirmatory factor analysis (CFA) to validate the factor structure (Pallant, 2010).

Qualitative data analysis

Our data analysis was guided by the component factors of DCs "absorptive capability" and "transformative capability", identified in the quantitative data analysis. We prepared a descriptive summary of the sample cases and associated practices, based on the analysis of interview quotes form each firm. In analyzing the interview data, predetermined codes based on the quantitative findings (Table 2) were initially used in identifying the firm-specific practices under the above two components of DCs. Illustrative interview quotes for firm-specific practices of DCs are presented in Table 4.

Data were coded and analyzed in a four-stage process (Glaser & Strauss, 1967; Miles & Huberman, 1994). First, data were manually coded and checked to identify broad categories relevant to how DCs' commonalities were manifested in specific practices within firms, and these broad categories formed the first-order concepts (Corley & Gioia, 2004; Gioia et al., 2012) (Figure 1). Second, we explored the links among the first-order concepts and grouped them into second-order themes (Corley & Gioia, 2004). Third, we conducted cross-case comparisons (Eisenhardt, 1989; Miles & Huberman, 1994). Themes and patterns within each case emerged in the second stage were compared, and similar themes and patterns were gathered into aggregate dimensions of "absorptive capability" and "transformative capability".

Insert Figure 1 here.

4. Findings

4.1. Quantitative findings

The EFA results revealed that the three components proposed by Wang and Ahmed (2007), merged into two dimensions; absorptive capability remained a component of DCs as we

originally defined it (AC4 was removed due to low factor loading 0.37); adaptive and innovative capabilities loaded together forming the other component of DCs, akin to transformative capability (Pandza & Holt, 2007). The above result seems to be logical as it corroborates with the findings of Teirlinck and Spithoven's (2013) mixed methods study among knowledge-intensive small firms: highly research-intensive firms demonstrated higher innovative capabilities, and were open to external knowledge interactions. All the items clearly loaded onto one of the two components (factor loadings of above 0.50). We then performed CFA and removed TC2 that cross-loaded with TC3. The final construct consisted of nine items: three items for absorptive capability and six items for transformative capability. The model fit indices and item loadings were satisfactory (see Table 2).

We conducted multigroup CFA (Anderson & Gerbing, 1982) to test whether DCs varied across firms in different industries: First, we tested the unconstrained model (where absorptive and transformative capabilities were allowed to vary freely across groups) resulting in χ^2 =234.20, *df*=130. Second, we tested the constrained model (where the correlation between absorptive and transformative capabilities was specified as equal across firms in five industry categories) resulting in χ^2 =245.87, *df*=134. The results of the constrained model were significantly worse than the unconstrained model ($\Delta\chi^2$=11.67, Δdf=4, p<0.05). This suggested that the DCs construct varied across firms within different high-tech industries, and that the relationships of absorptive and transformative capabilities varied: it was strongest in aerospace (0.81) and medical and optical equipment industries (0.75), medium in pharmaceutical and biotechnology (0.44) and office and computing (0.28), and weakest in radio, TV and communication (-0.07).

4.2. Qualitative findings

A range of firm-specific practices, associated with aggregated dimensions "absorptive capability" and "transformative capability" emerged from the interview data, were categorized into four second-order themes: acquiring knowledge, assimilating knowledge, adapting business systems, and innovating, which were in turn associated with a range of first-order concepts (Figure 1).

4.2.1. Specificities of absorptive capability

Absorptive capability demonstrates firms' ability to acquire and assimilate new knowledge (Cohen & Levinthal, 1990; Pandza & Holt, 2007), and our qualitative findings identified specific practices associated with acquiring and assimilating knowledge (i.e., development of absorptive capability).

Acquiring Knowledge

Practices of acquiring new knowledge fell into five categories (Figure 1). We present illustrative cases of firms and exemplar interview quotes to support the adoption of those firm-specific practices in the sample firms in Table 4.

It was evident in firms M&O-1 and O&C-2 that in acquiring new knowledge, firms considered *customer feedback and interaction with customers* as a source of new knowledge confirming the role of customer in acquiring new knowledge (Kindström et al., 2013; Teece, 2007; Von Hippel, 1988) in high-tech industries (Smith, 2013). Firms also *acquired new knowledge through collaborations with suppliers* (Teece, 2007) particularly in firms Aero-4, O&C-1, and RT&C-1. Our findings agree with Macpherson et al. (2004) who reported how a knowledge dependent firm renewed their own firm's DCs through building relationships with suppliers and customers. Since investing in developing internal expertise helps develop firms' absorptive capability (Bougrain & Haudeville, 2002; Cohen & Levinthal, 1990), overcoming resource constraints (Freeman et al., 2006; Zahra et al., 2009), the case firms *acquired*

knowledge through new people with broad experience (O&C-4, M&O-3 and RT&C-3) *and external mentors and consultants* (P&B-1). In addition, it was also reported that in *collaborative projects in high-tech R&D environments,* project team members brought in new knowledge (Verma & Sinha, 2002), for example in firms P&B-5 and Aero-3. The above findings concur with Enkel et al.'s. (2020) view that, in order to stay competitive, 'visionary' firms use open innovation to increase their DCs by building up a wide range of partner networks. Past research has reported that SMEs engaged in many open innovation practices (Van de Vrande et al., 2009; Lichtenthaler, 2008). For example, universities are a key element in the ecosystem and collaborations with universities can affect the development of innovations even in low to medium technology industries (McKelvey & Ljungberg, 2017). SMEs collaborate with other firms for acquiring technology when there is no danger of technology exposure, although they prefer universities and research centers to other firms for strategic alliances (Lee et al., 2010). Finally, firms (M&O-2 and P&B-2) *kept pace with new scientific literature* (Acs et al., 1994; Autio, 1997; Verma & Sinha, 2002).

Assimilating Knowledge

The firms assimilated newly acquired knowledge through three groups of practices (Figure 1). Illustrative case firms and exemplar quotes are presented in Table 4. Newly acquired, knowledge is internalized through *brainstorming* (Nonaka & Takeuchi, 1995) in high-tech SMEs (Egbu et al., 2005). Brainstorming could happen informally (P&B-2) or formally (P&B-2). *Employee training* was used (O&C-4, Aero-4, M&O-3, O&C-1, and R&T-3) to impart new knowledge and to facilitate assimilation (Cabrera & Cabrera, 2005) that can affect absorptive capability of SMEs in particular (Gray, 2006), and DCs in general (Wohlgemuth et al., 2019). Case firms (P&B-4, O&C-2, O&C-3, M&O-1, and O&C-5) also assimilated new knowledge through *knowledge sharing* and free flow of information (Hutchinson & Quintas, 2008; Li et al., 2011).

4.2.2. Specificities of Transformative Capability

Transformative capability demonstrates a firm's ability to constantly create or redefine product or service opportunities based on knowledge within the firm (Pandza & Holt, 2007). In the case firms, the specificities of transformative capability were mainly reflected by their ability to adapt business systems and to innovate (Figure 1).

Adapting Business Systems

The case firms transformed their resources and capabilities by adapting to the internal and external environmental changes. Illustrative case firms and exemplar quotes that are presented in Table 4 supports the availability of those firm-specific practices among the sample firms. *Adaptive human resource management* (HRM) is vital to firms' overall adaptive capability (Chakravarthy, 1982). Changing behavior and attitude through adaptive HRM requires the adaptation of styles and teams of management. Such changes in the management structure and work organization affect the existing human resources policies of SMEs (Kinnie et al.,1999). Adaptive HRM was reported in firms P&B-5, O&C-5, and O&C-5. High demand for finance forced the high-tech SMEs to adapt their ways of raising capital, investing and cost control. *Adaptive financial management* is common among small start-ups (Latham, 2009). Whilst the majority tend to depend on banks for funding which can be risky (Carey & Flynn, 2005), more dynamic SMEs like RT&C-3 relied on alternative sources and cost control, and O&C-1 increased investments. Firms also *adapted business operations* to growing competition. A firm's ability to reconfigure its core focus and operations indicates its ability to maintain competitiveness (Teece, 2007). Some adaptive measures included

purchasing from low-cost suppliers (RT&C-1), increasing production capacity using machines (Aero-1), and subcontracted manufacturing (P&B-1).

Innovating

The case firms transformed their resources and capabilities through innovating, manifested in four specificities. To *offer unique solutions* (RT&C-1 and Aero-2) and to identify market opportunities (M&O-3), the firms often generated innovative ideas through collaborations with suppliers and customers. Customer-led innovation is vital to new product success (Huang et al., 2002). For example, M&O-3 was successful in catering to a niche market. Proactive SMEs and those use innovative technology compete successfully (Avlonitis & Salavou, 2007; Knight, 2000). The firms tended to *develop innovative product technology* through in-house research (RT&C-3) and to use technology to solve clients' IT problems remotely (O&C-1). Some firms *instilled a creative culture to facilitate innovation*. O&C-3 employed creative people with great ideas. Adopting both bottom-up and top-down approaches simultaneously, P&B-3 developed new ideas. High-tech SMEs focused on *incremental innovation*, due to resource constrains or apprehension of possible exploitation (Aero-4 and P&B-4). Those firms that were into technology scouting (observing technology trends) tended to develop more incremental innovation (Parida et al., 2012) making transformation of resources and capabilities also incremental (P&B-4). Absorptive and transformative capabilities as DCs' common factors across firms are manifested through a wide range of specific practices within firms (Table 4). Below, we discuss how those two commonalities of DCs mutually reinforce each other in light of both quantitative and qualitative findings.

5. Discussion

Our study makes a key contribution to the DCs literature in terms of identifying the commonalities of DCs across firms and mapping out such commonalities with firm-specific processes. First, we identified and validated the component factors of DCs "absorptive capability" and "transformative capability" drawing on evidence from a quantitative survey of 113 UK high-tech SMEs. The findings support that DCs' commonalities are identifiable (Eisenhardt & Martin, 2000), and the validated DCs construct is consistent with Pandza and Holt's (2007) conceptualization. Absorptive capability allows firms to acquire and assimilate new knowledge that help identify opportunities (Cohen & Levinthal, 1990; Garud & Nayyar, 1994; Liao et al., 2003), whereas transformative capability enables them to adapt and innovate using new knowledge responding to such opportunities (Garud & Nayyar, 1994; Pandza & Holt, 2007). As Pandza and Holt (2007:350) describe, absorptive capability is "concerned with exogenous technological change" and transformative capability demonstrates "the capability to constantly redefine a portfolio of product or service opportunities based on knowledge endogenous to the firm". Absorptive and transformative capabilities, as *outward-looking* and *inward-looking* organizational capabilities that complement each other, help with the renewal and creation of resources and capabilities of firms (Eisenhardt & Martin, 2000; Teece et al., 1997). Thus, the above components of DCs seem to represent the entrepreneurial and asset orchestration dimensions of strong DCs described by (Teece & Leih, 2016), which enable companies to do a better job in responding to and shaping unknown futures. In addition, our findings might also provide some empirical evidence related to the question "whether micro-variables are firm-specific drivers that provide sustainable competitive advantages or whether they can be understood to be commonalities all over different firms" (Wilkens & Sprafke, 2019:31).

These findings might also address the concerns of Andreeva and Ritala (2016) who classify DCs into two types, i.e., "domain-specific" and "generic" DCs. They suggested that

domain-specific DCs are applicable mainly within a given organizational domain, whereas generic DCs are applicable within any organizational domain and across firms and industries making DCs exhibit commonalities across firms. Whilst identifying and validating the component factors of DCs - absorptive capability and transformative capability, the results of our multigroup CFA (Anderson & Gerbing, 1982) also revealed that DCs varied across firms in different high-tech industries, and that the relationships of absorptive and transformative capabilities also varied, indicating the "domain-specific" and "generic" nature of DCs (Andreeva & Ritala, 2016).

Second, we identified firm-specific practices of developing and applying absorptive capabilities and transformative capabilities based on a qualitative case study of 20 UK high-tech SMEs that participated in the survey. Our qualitative findings reveal a range of specificities of DCs within firms. Absorptive capability is manifested through two broad categories of firm-specific practices (Figure 1). Such findings provide empirical evidence to support the long-standing conceptualization of absorptive capability as a firm's ability to acquire and assimilate new knowledge (Cohen & Levinthal, 1990; Liao et al., 2003). For example, our findings on acquiring new knowledge through new recruits concur with those of Romijn and Albaladejo (2002) on the innovative capability of small high-tech firms in the Southeast region of the UK: prior experience of the staff in science and engineering is significantly related to the innovative performance of those firms.

The empirical findings of Parida et al. (2012) highlight that open innovation activities can increase innovative performance of high-tech SMEs. Our findings also reveal that high-tech SMEs engage in open innovation activities (e.g., in acquiring new knowledge). Therefore, it can be argued that because closed innovation systems are unusual, high-tech firms often take on highly risky projects that require a great deal of upfront investment, they often collaborate to pool resources and expertise, and share risks as well. Therefore, high-tech firms are likely to engage in open innovation though the degree of open innovation may vary from firm to firm. Because of this, firms are likely to share best practice and learn from others through collaboration. This also means that firm-specific DCs may be learned by others over time, contributing to the commonalities of DCs in the industry.

Further, transformative capability is demonstrated through two broad categories of firm-specific practices (Figure 1). Adapting business systems reflects a firm's ability to process information (Chakravarthy, 1982) and to reconfigure resources and capabilities (Gibson & Birkinshaw, 2004), whereas innovative capability "concerns the specific expertise and competence related to the development and introduction of new processes and products" (Hagedoorn & Duysters, 2002:168).

In the context of high-tech SMEs, absorptive and transformative capabilities are distinctive but complementary component factors of DCs. Absorptive capability is demand-driven and transformative capability is supply-driven (Pandza & Holt, 2007). Our findings clearly demonstrate that the high-tech SMEs adopt specific practices related to both acquiring exogenous knowledge and assimilating it into the firm and specific practices related to adapting and innovating products and processes using their endogenous knowledge. Small technology-driven firms, once they have established an identity based on their expertise in an emergent technology, they have a less need for absorptive capability than transformative capability (Pandza & Holt, 2007). Nevertheless, Garud and Nayyar (1994) believe that absorptive and transformative capabilities are complementary organizational capabilities; absorptive capability itself is not sufficient for sustaining competitive advantage, as, in a continually changing environment, sustainable competitive advantage does not derive from simply reacting to external changes but from changing the "rules of the game" through their own actions.

Finally, our findings, through mapping out DCs' commonalities across firms and specificities within firms, provide empirical evidence to support possible firm-specific drivers that could provide sustainable competitive advantages (Wilkens & Sprafke, 2019:31). For example, our findings suggest that acquiring knowledge was associated with different sources of knowledge and follow unique paths to reach the same DCs (Eisenhardt & Martin, 2000). Firms' practices associated with acquiring knowledge differ in detail, but they all contribute to knowledge acquisition and consequently, development of DCs (Cockburn et al., 2000). Firm-specific practices associated with absorptive and transformative capabilities, and consequently development of DCs, may be interchangeable and equivalent (Eisenhardt & Martin, 2000; Kindström et al., 2013).

Methodologically, our study is the first mixed methods study that examines commonalities and specificities of DCs. Prior DCs research has been either qualitative (Camuffo & Volpato, 1996; Petroni, 1998; Tripsas, 1997) or quantitative (Cepeda & Vera, 2007; Marcus & Anderson, 2006; Pandza & Holt, 2007). Despite their respective contributions, prior research has been of limited use in mapping out the commonalities and specificities of DCs in a given context. Adopting a mixed methods approach, we have contributed to fill the above gap in the DCs research.

6. Conclusions

Our study contributes to the debate on DCs' commonalities across firms and specificities within firms in the strategic management literature and related innovation management literature. Using a mixed methods approach, we find that the commonalities of DCs across firms are reflected in the two dimensions - absorptive capability and transformative capability- which are in turn associated with a range of firm-specific practices. Absorptive capability and transformative capability mutually reinforce each other albeit distinctive in conceptual and empirical terms.

6.1. Managerial implications

Our study has practical implications for high-tech firms in developing and applying DCs. The findings will be useful for the managers of high-tech SMEs in deciding what DCs they need, how they can develop them and when they need them in achieving firm goals. Firms must focus on developing both absorptive and transformative capabilities in order to build their DCs. However, their starting points, paths taken, and practices adopted can vary depending on their existing resources and capabilities. Whilst absorptive and transformative capabilities are integral parts of DCs, the need for absorptive or transformative capability may depend on firms' stage of operations. For example, once a small technology-driven firm has established its technological expertise, more emphasis may be needed on transformative capability than absorptive capability. Moreover, whilst learning from and adopting best practices in the industry, firms must take into account their unique paths and existing resources and capabilities to introduce new practices and reconfigure existing practices toward the development and application of DCs.

6.2. Limitations and future research

Our findings are subject to limitations. The quantitative survey was conducted in high-tech SMEs in the UK, whilst different industry sectors and country contexts might result in different configurations of the DCs construct. The qualitative interviews were conducted with firms that took part in the survey. Whilst this was an efficient and effective sampling method for our study that aimed to map out commonalities and specificities of DCs, such sampling method might introduce a bias. Moreover, given our research focus and the overall deductive research design, the qualitative analysis was to identify firms-specific practices associated

with absorptive and transformative capabilities. Whilst the data analysis effectively served our research focus, further research may adopt an inductive approach to investigate further firm-specific practices. In addition, the cross-sectional nature of the study may have limited the validity of the findings and therefore, future researchers are encouraged to conduct longitudinal studies in the topic area.

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Table 1 The Sample Firms' Profile

Firm Size[a]			Firm Age[b]				Industry Type				
Micro	**Small**	**Medium**	**New**	**Young**	**Adult**	**Old**	**Aerospace**	**Pharmaceutical and Biotechnology**	**Office and Computing**	**Radio, TV and Communication**	**Medical and Optical Equipment**
23 (20.4%)	45 (39.8%)	45 (39.8%)	19 (16.8%)	16 (14.2%)	40 (35.4%)	38 (33.6%)	16 (14.16%)	11 (9.73%)	36 (31.86%)	25 (22.12%)	25 (22.12%)

Note: N = 113. The sample of survey firms were originally included only small and medium sized firms that were identified based on the above criteria. There were firms whose number of employees had gradually decreased over the three-year period considered for our study and those firms were still considered for the quantitative analysis

[a] Micro (Less than 10 employees), Small (Less than 50 employees), Medium (Less than 250 employees).

[b] New (Less than 6 years), Young (6–10 years), Adult (11–25 years), Old (Over 25 years).

Table 2 Results of Confirmatory Factor Analysis

Dynamic Capabilities (DC)[a] (α = 0.90)		**Item Loading**
Absorptive Capability (AC) (α = 0.93)		
AC1	This firm has the necessary skills to implement newly acquired knowledge.	0.89
AC2	This firm has the competences to transform the new acquired knowledge.	0.98
AC3	This firm has the competences to use the new acquired knowledge.	0.94
AC4[b]	This firm has a clear division of roles and responsibilities for acquiring new knowledge.	-
Transformative Capability (TC) (α = 0.89)		
TC1	People in this firm are encouraged to challenge outmoded practices.	0.73
TC2[c]	This firm is flexible enough to allow us to respond quickly to changes in our markets.	-
TC3	This firm evolves rapidly in response to shifts in our business priorities.	0.81
TC4	This firm is creative in its methods of operation.	0.85
TC5	This firm seeks out new ways of doing things.	0.92
TC6	People in this firm get a lot of support from managers if we want to try new ways of doing things.	0.79
TC7	This firm introduces improvements and innovations in our business.	0.79

[a]Seven-point Likert scales ranging from 1, "strongly disagree", to 7, "strongly agree" were used.
[b]AC4 was removed due to its relative low factor loading (0.37) generated in the EFA and relatively low item-total correlation coefficient (0.36) within the Absorptive Capability construct. The item also cross-loaded onto the transformative capabilities (0.34).
[c]TC2 was removed because it cross-loaded with TC3 as indicated by a high modification index in the CFA.
Note: The model fit indices of the final CFA were χ^2=52.70, *df*=27, χ^2/df=1.95, *GFI*=0.91, *CFI*=0.96, *RMSEA*=0.09.

Table 3 Case Firms[a]

Industry	Firm	Year Established	Core Products	Location	Interviewee
Aerospace	Aero-1	2005	Coatings	Northamptonshire	Chief Executive Officer
	Aero-2	1980	Alloy ingots	West Midlands	Sales Engineer
	Aero-3	1969	Solutions for interconnects and electrical assemblies	Staffordshire	Business Development Manager
	Aero-4	1960	Aircraft interiors	Surrey	Marketing Manager
Pharmaceuticals and Biotechnology	P&B-1	1947	Medicines and raw materials	Middlesex	Managing Director
	P&B-2	2006	Antibodies	Oxfordshire	Managing Director
	P&B-3	2008	Life science solutions	Oxfordshire	Bioanalytics Project Manager
	P&B-4	2001	Sample preparation products, consumables, and reagents	Berkshire	Chief Executive Officer
	P&B-5	2005	Biomarkers for neuropsychiatric illnesses.	Cambridge	Executive Chairman
Office and Computing (IT)	O&C-1	1991	Office communications solutions and IT services	London	IT Consultant
	O&C-2	2008	Intelligent wireless solutions	Hertfordshire	Executive Chairman
	O&C-3	2007	Web solutions	Cambridgeshire	Managing Director
	O&C-4	2003	Location solutions	Cambridgeshire	Lead Architect-Hardware Systems
	O&C-5	2006	Encoding technology	Cambridgeshire	Research Director
Radio, TV, and Communication	RT&C-1	1991	Printed circuit boards	Devon	Sales Director
	RT&C-2	1985	Radio Frequency equipment	Waltham Abbey	Finance Director
	RT&C-3	2000	CCTV systems	Essex	Commercial Manager
Medical and Optical Equipment	M&O-1	1964	Single use medical devices	Hertfordshire	Managing Director
	M&O-2	1988	Otoacoustic emissions instruments	Hertfordshire	Chief Administrator
	M&O-3	1956	Life support products	Greater London	Marketing Manager

a. Order of the industries are based on the Standard Industrial Codes.

Table 4 Illustration of firm-specific practices of dynamic capabilities

Commonalities of DCs	Firm-specific practices of DCs	Sample cases	Illustrative interview quotes
Absorptive Capability	***Acquiring knowledge***		
	▪ *Acquiring knowledge through interaction with customers*	Case firms M&O-1 and O&C-2	"We offer what we think is an innovative product. And then the customer says I would like to buy if you do this. Then we change it. It is a kind of dialogue between us and the customer to try and identify exactly what he wants..." (Executive Chairman, O&C-2)
	▪ *Acquiring knowledge through collaboration with suppliers*	Case firms Aero-4, O&C-1 and RT&C-1.	"We would expect our suppliers to do the test here. We are happy to run as a test site and to help them to bring the product to market. Whether it is new chemicals or new surface finishes and the like, we normally, ask our suppliers to try and get us the innovative [technology]." (Sales Director, RT&C-1)
	▪ *Acquiring knowledge through new recruits of employees and external mentors and consultants*	Case firms O&C-4, M&O-3 and RT&C-3	"We have just launched a new smaller device called [a product]. [Referring to some problems in new products] We brought in new people who understood where the problems were and that has now been solved." (Marketing Manager, M&O-3)
	▪ *Acquiring knowledge through collaborative projects*	Case firms P&B-5 and Aero-3.	"Those who are involved in a project, research it with suppliers, with customers, with publicly available information and seminars, things like that. Then when we win the business, we train our colleagues on it." (Business Development Manager, Aero-3)
	▪ *Acquiring knowledge through researching scientific literature*	Case firms M&O-2 and P&B-2	"People always try to keep up-to-date with scientific literature…and then feed back into the team. So, then discuss which areas they are going to be developing in the next year or two...and decide which products we want to develop." (Managing Director, P&B-2)
	Assimilating knowledge		
	▪ *Assimilating knowledge through brainstorming*	Case firms P&B-2 and P&B-2	"We have one of the major forums. It is a quarterly meeting of sales and marketing teams, and the product development teams…[We] bring ideas together, talk about them, decide which ones are good." (Managing Director, P&B-2)
	▪ *Assimilating knowledge through employee training*	Case firms O&C-4, Aero-4, M&O-3, O&C-1 and R&T-3	"We are a diverse group of people [with] different fields, different experiences, and different areas…We grow that knowledge base through a combination of internal training, general personal development…" (Lead Architect-Hardware Systems, O&C-4).
	▪ *Assimilating knowledge through knowledge sharing*	Case firms P&B-4, O&C-2, O&C-3, M&O-1 and O&C-5	"There are a number of part-time associates. They got some market and technical knowledge we need to use in the adaptable core team..." (Research Director, O&C-5)

Transformative Capability	***Adapting business systems***		
	▪ *Adapting human resource management*	Case firms P&B-5, O&C-5 and O&C-5.	"We have got a good, quite a flexible team, so, as platforms and devices change, we change them to switch from one platform to another. And, there are a number of part-time associates." (Research Director, O&C-5)
	▪ *Adapting ways of financing*	Case firms RT&C-3 and O&C-1	"During this economic downturn, everyone else was cutting down their investments. But, we took the risk and increased investments. We have been benefitted by those investments." (IT Consultant, O&C-1)
	▪ *Adapting business operations*	Case firms RT&C-1, Aero-1 and P&B-1	"The regulations required by [the government] have increased over the last 10 years. But, what we do is to subcontract…All the quality testing, stability testing is done by the toll manufacturers." (Managing Director, P&B-1)
	Innovating		
	▪ *Innovating to offer unique solutions through market-based customization and specialization*	Case firms RT&C-1, Aero-2, M&O-3, RT&C-3 and O&C-1	"I am responsible for finding areas that are not being addressed and developing products to fit in to those areas…It is sort of a corporate decision to only sell products to babies…So, we believe that a good deal of our success is due to the fact that we are specialists in one very small niche area." (Marketing Manager, M&O-3) "The core technologies include network management, remote support to our clients, IT services, and voice and data services. We have been focusing on completely new technologies." (IT Consultant, O&C-1)
	▪ *Innovating to develop new technology through instilling a creativity culture*	Case firms O&C-3 and P&B-3	"They [the firm] seed ideas and info as much as possible to get rid of outsourcing. Several tens of million dollars available to invest in these new ideas…they call that top-down approach. But, they have also bottom-up approach…They do it every two years. Every employee can submit ideas through the intranet [that] go before the innovation board and [the best] get funded." (Bioanalytics Project Manager, P&B-3)
	▪ *Innovating to develop new technology through incremental improvement*	Case firms Aero-4 and P&B-4	"I would say all the research and development we have done have been extensions of what is out there...I would regard it as innovative…Because, I know from experience that anything innovative really, it is difficult for a small company to get into market." (Chief Executive Officer, P&B-4)

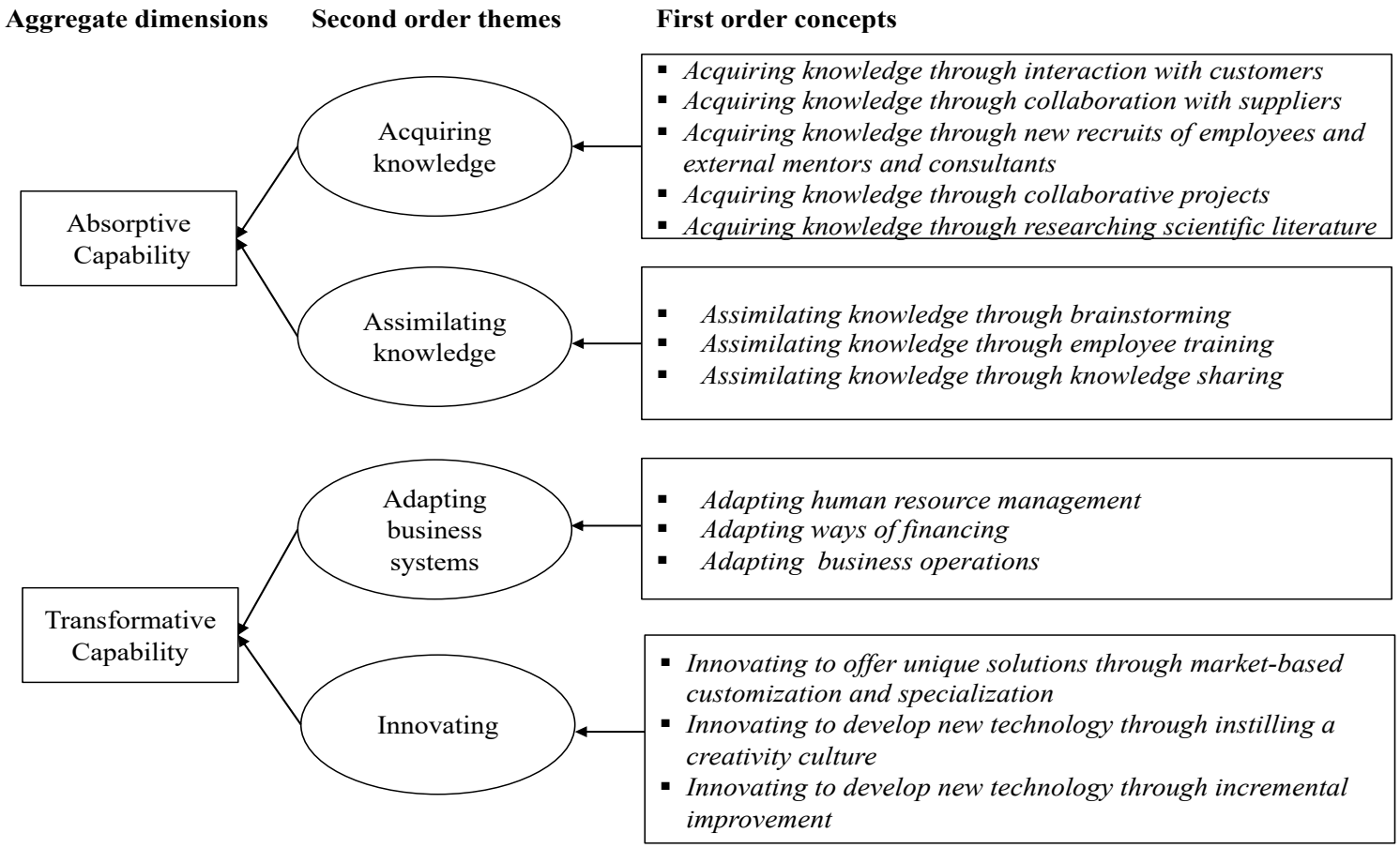

Figure 1
Data Structure