METAKNOWLEDGE AND THE STRATEGIC REUTILIZATION OF KNOWLEDGE ASSETS

ABSTRACT

We identify a set of metaknowledge-based activities that underpin the leveraging of organizational knowledge as a strategic resource. Using interpretive grounded theory methods, we examined how two large firms reproduced their knowledge assets while transferring and adapting them to new contexts of utilization. We found that the activities of reutilization and adaptation of such knowledge assets were supported and guided by specific types and functions of metaknowledge. Our findings offer a nuanced characterization of the role of metaknowledge in collaborative settings, and open a new perspective on the relationship between managerial cognition and metacognition and the foundations of dynamic capabilities.

INTRODUCTION

Organizational knowledge is a fundamental resource of firms (Barney, 1991a; Grant, 1996; Schendel, 1996; Spender & Grant, 1996), and its transfer and reuse underpins the realization of sustained competitive advantage (Argote, 1999; Kogut & Zander, 1992; Schendel, 1996; Spender, 1996a). However, the causal relationship between organizational knowledge and superior performance is not yet fully understood, and scholars often find it difficult to study this complex, fluid, and ambiguous resource (McEvily & Chakravarthy, 2002). Research addressing how knowledge can be leveraged strategically (Carlile & Rebentisch, 2003; Carlile, 2002; Carlile, 2004; Håkanson, 2007; Hargadon & Sutton, 1997; Majchrzak, Cooper, & Neece, 2004; Nerkar, 2003) has found that the task of creating idiosyncratic knowledge assets entails transformations that go well beyond the mere tacit/explicit conversion (Nonaka, 1994). Instead, it involves complex activities of articulation (Håkanson, 2007), recombination (Nerkar, 2003), integration, (Carlile, 2002; Carlile, 2004), and representation (Carlile & Rebentisch, 2003). However, how these activities can be combined to create distinctive firm resources is still largely unclear (Kraaijenbrink, Spender, & Groen, 2010; Ray, Barney, & Muhanna, 2004; Stieglitz & Heine, 2007).

Initial progress in this direction has been made by work that has addressed specifically how managers employ existing knowledge in new ways. For example, Majchrzak et al. (2004) found that knowledge-related activities such as the reconceptualization of problems and the use of metaknowledge – or "knowledge about knowledge" (Latour, 1987: 7) – enabled reusers to generate radical innovation from past knowledge. Nag and Gioia (2012) unveiled that managers are influenced by their interpretive frameworks when assessing the value of new knowledge. Together, these studies highlight the need for further investigation into the transformative activities performed by managers to support knowledge reutilization for strategic purposes. In particular, the evidence that metaknowledge plays a role in orienting the reutilization of

knowledge assets prompts for further research into the diverse features of knowledge that have an impact on specific aspects of the process of reutilization (Schulz, 2001). Therefore, we ask the following research question: *How do managers employ metaknowledge for the strategic reutilization of existing knowledge assets?*

To address this research question, we conducted an interpretive study of two multinational firms of the information technology (IT) industry and studied how they reused and updated their productive knowledge. We examined several instances of interfirm knowledge transfer for the provision of IT solutions through an inductive analytical process involving theoretical sampling and constant comparison of qualitative data. In accordance with grounded theory building methods (Glaser & Strauss, 1967), we carried out multiple reiterations of data collection and analysis, through which theoretical insights emerged from empirical evidence.

We found that managers at both firms activated specific types and functions of metaknowledge. Two theoretical dimensions emerging from our findings – (1) *Metaknowledge engine*; and (2) *Metaknowledge-based patterning* – describe the central role of metaknowledge in combining activities of knowledge reproduction and adaptation, generating new design rules and principles, and establishing new patterns of organizing. Our findings shed light on the transformative mechanisms governed by metaknowledge and open a new perspective on the relationship between managerial cognition and metacognition and the foundations of dynamic capabilities (Barr, 1998; Helfat, Finkelstein, Mitchell, Peteraf, Singh, Teece et al., 2009; Nag & Gioia, 2012; Salvato, 2009; Teece, 2007; Teece, Pisano, & Shuen, 1997; Tripsas & Gavetti, 2000).

THEORETICAL BACKGROUND

Research on the antecedents of sustained competitive advantage has increasingly focused on the central role of organizational knowledge, and investigated knowledge-related constructs,

such as routines (Nelson & Winter, 1982), organizational capabilities (Eisenhardt & Martin, 2000; Helfat & Peteraf, 2003; Teece et al., 1997; Winter, 2003), core competences (Hamel & Prahalad, 1996), and knowledge assets (Boisot, 1998; Nonaka, Toyama, & Nagata, 2000; Teece, 1998, 2000; Winter & Szulanski, 2001). In particular, the view that knowledge may be the firm's most strategically important resource (Grant, 1996; Kogut & Zander, 1992; Spender, 1996b; Spender & Grant, 1996) has triggered valuable theoretical advancement in several areas of management studies (Eisenhardt & Santos, 2002; Foss, 2011). However, more research is needed to understand the linkages between knowledge as a resource and the attainment of sustained competitive advantage, and uncover the processes of knowledge utilization and/or transformation that enable the effective leveraging of such resource for strategic purposes (Kraaijenbrink et al., 2010; Ray et al., 2004). In particular, we are still to gain a complete understanding of how knowledge concurs to support the development of the firm's dynamic capabilities (Augier & Teece, 2009; Helfat, Finkelstein, Mitchell, Peteraf, Singh, Teece et al., 2007; Teece, 2007) and the creation of idiosyncratic and difficult-to-imitate resources (Stieglitz & Heine, 2007).

An increasingly coherent body of studies of the path-dependent reutilization of organizational knowledge (Carlile & Rebentisch, 2003; Carlile, 2002; Carlile, 2004; Håkanson, 2007; Hargadon & Sutton, 1997; Majchrzak et al., 2004; Nerkar, 2003) has started to offer insights into the dynamics of knowledge work and transformations. For example, Hargadon and Sutton (1997) drew on fieldwork conducted at a product design firm to outline a sequence of knowledge acquisition, storage, and retrieval that contributes to accrue organizational learning and memory (Huber, 1991; March & Simon, 1958; Walsh & Ungson, 1991). However, their model neglects the transformative mechanisms that connect the three phases. To start looking inside this "black box," Carlile and Rebentisch (2003) examined the integration of knowledge across domains for the transfer of complex technologies and the development of

new products. The authors induced a process of knowledge transformation that takes into account the key role played by knowledge attributes such as novelty, dependence, and specialization, and highlighted the need for further research on how managers use different types of knowledge and leverage their respective attributes. Examining the role of time in the process of new knowledge creation, Nerkar (2003) found that current and historical knowledge can be recombined in novel ways to mitigate the effects of path dependency. Overall, these studies have the merit of unveiling that the challenge of creating new knowledge goes beyond mere tacit/explicit conversions (Nonaka, 1994), and involves complex activities of knowledge articulation (Håkanson, 2007), recombination (Nerkar, 2003), integration, (Carlile, 2002; Carlile, 2004), and representation (Carlile & Rebentisch, 2003). More research, however, is needed to understand how these activities relate to each other, and how managers can orchestrate them for strategic purposes. In fact, studies that have specifically investigated the processes by which managers reuse existing knowledge in novel ways indicate that we still have much to learn about the linkages between certain transformations of knowledge and the intertwined leveraging/innovation of knowledge resources. For instance, research conducted by Majchrzak et al. (2004) on the reutilization of past knowledge for the purpose of radical innovation showed that transformative actions such as the reconceptualization of problems and the acquisition of *metaknowledge* – that is, knowledge about knowledge (Latour, 1987) – facilitated the evaluation of new ideas, and enabled reusers to redefine problems in nontraditional ways.

Metaknowledge has traditionally been intended as knowledge at a meta level, beyond the lower, object level of specialized knowledge (Latour, 1987). The concept has been fruitfully employed to advance research in information systems (Hicks, Culley, Allen, & Mullineux, 2002), behavioral decision making (Gardner, 2006; Smith, Shields, & Washburn, 2003), and managerial cognition (Glazer, 1998; Russo & Schoemaker, 1992; Sammarra & Biggiero,

2008). Work in these areas has ascertained that metaknowledge is a key enabler of individual learning (Glazer, 1998), and is usually employed and developed in people's mind rather than made explicit through formalization or articulation (Hicks et al., 2002). It confers on individuals a higher level of expertise and the ability to grasp the nature, scope, and limits of their own knowledge (Russo & Schoemaker, 1992). As Smith et al. (2003) put it, "some minds contain a cognitive executive that looks in on thought or problem solving to see how it is going and how it might be facilitated" (p. 318). It is widely accepted that the effective use of metaknowledge by individuals manifests in specific abilities – for example, the ability to synthesize elements of knowledge that are usually processed separately and use them as building blocks of superior knowledge structures (Gardner, 2006), or to integrate knowledge across substantive domains, such as markets, technologies, and processes (Brusoni, Prencipe, & Pavitt, 2001; Sammarra & Biggiero, 2008). It is also well understood that one type of metaknowledge possessed by individuals – knowledge of who knows what – underpins team-level knowledge structures such as situation models (Rico, Sánchez-Manzanares, Gil, & Gibson, 2008), and transactive memory systems (Argote & Ren, 2012; Brandon & Hollingshead, 2004; Mell, Van Knippenberg, & Van Ginkel, 2014). Transactive memories enable the members of a team to use each other as memory storage locations (Argote & Ren, 2012; Wegner, 1987; Wegner, Erber, & Raymond, 1991), which can be leveraged to process knowledge collaboratively (Faraj & Sproull, 2000). Extant research has found that the use of this type of metaknowledge has a positive impact on team-level performance, learning, and creativity, (Akgün, Byrne, Keskin, Lynn, & Imamoglu, 2005; Austin, 2003; Gino, Argote, Miron-Spektor, & Todorova, 2010; Kanawattanachai & Yoo, 2007; Liang, Moreland, & Argote, 1995; Moreland & Myaskovsky, 2000; Ren, Carley, & Argote, 2006), but the processual links between transactive memories and organizational outcomes are still largely obscure.

The fact that managers search for and acquire metaknowledge to support their decisions of reutilization (Majchrzak et al., 2004) suggests that the hierarchical relationships between different types and levels of knowledge may play a role in the process. Certain characteristics of knowledge – for example, its perceived relevance – represent preconditions for its acquisition and transfer, and have an impact on specific phases of the transfer process (Schulz, 2001). Additional evidence that confirms the need for further investigation of these relationships is provided by a recent study of how top managers create distinctive, uncommon knowledge that is strategically relevant (Nag & Gioia, 2012). Nag and Gioia found that participants in their study searched for and used knowledge in different ways, because their interpreting frameworks produced varying perceptions about the value and significance of new knowledge. Different perceptions channeled managerial efforts into alternative paths of novel reuse: the development of novel solutions (knowledge adaptation), or the development of new understandings of existing problems (knowledge augmentation). Both the Majchrzak et al. (2004) and the Nag and Gioia (2012) studies indicate that further inquiry is needed into the transformative activities performed by individuals and teams to support firm-level strategies of knowledge reutilization. In particular, it is important to find out which types of knowledge are involved in such activities, and what specific role they play.

METHODS

Research Design and Empirical Setting

Informed by a grounded theory building approach (Charmaz, 2006; Glaser & Strauss, 1967; Strauss & Corbin, 1998), we carried out theoretical sampling and constant comparison of data from empirical cases in which the theoretically relevant categories could be studied in a transparent way (Yin, 2013). Alpha and Beta, two Fortune Global 500 corporations of the IT industry, offered the ideal setting for the study. These knowledge-intensive firms (Alvesson,

2004; von Nordenflycht, 2010) reused but also changed, innovated, and upgraded their knowledge bases for the provision of IT systems. From a knowledge-theory point of view, the components of these systems comprise different types of knowledge assets that are reproduced and implemented at the customer through a dedicated transfer project (Argote, 2012; Argote & Ingram, 2000). The repeated transfer of these knowledge assets across different clients and the need for carrying out related knowledge transformation made this setting particularly interesting to address our research question. Our case selection also responded to the logic of comparison, and aimed at maximizing cross-case differences – in corporate histories, organizational structures, strategies, and roles played within the industry. Cross-case differences and within-case variety made it reasonable to expect that the processes associated with the replication-adaptation exercise could be studied and understood by comparing its diverse, firm-specific manifestations, so that the emerging theoretical insights could be investigated further across the two settings (Langley, Smallman, Tsoukas, & Van de Ven, 2013).

We studied in parallel a family of IT solutions in each firm: respectively, AlphaCore, and BetaSuite (fictitious names). At both firms, implementing the solutions involved replicating configurations of the systems successfully delivered in the past, but also adapting them to specific requirements, such as local regulations, technical constraints, or the clients' established procedures. Our first interest was to understand: (1) which types of components were included in a typical configuration of each solution; (2) how such components had been created or acquired; (3) how they worked together as a system; and (4) what practical problems they solved. We then focused on client projects as definite, self-contained instances of implementation of the solutions. For each project, we analyzed the configuration of the overall solution implemented, and each of the components comprised in the solution to ascertain what was being replicated, removed, replaced, or adapted. We kept collecting data about knowledge

transformations related to the implementation of the solutions in client projects until new iterations of data collection and analysis, aided by the concurrent review of relevant literature, produced no refinement of theoretical insights (Glaser & Strauss, 1967). Although data collection and analysis proceeded jointly, we provide a separate account of each to illustrate the research process in detail.

Data Collection

In the six months before starting our fieldwork, we collected preparatory information about the firms – from public documents and through conversations with experts – to become familiar with the type of 'knowledge work' performed by them and to acquire "interactional expertise" (Collins, 2004; Collins & Evans, 2008). Then, we collected and analyzed qualitative data in form of interviews, archival data, current documents, and field notes. Guided by our lead contact at each firm, we carried out a purposeful selection of informants (Lincoln & Guba, 1985) and added new informants following a snowball approach (Biernacki & Waldorf, 1981; Lincoln & Guba, 1985). A total of 92 interviews with 65 informants were conducted either face-to-face during visits to the firms or by telephone. Certain informants were interviewed more than once to ask follow-up questions and for validation purposes (Denzin & Lincoln, 2011; Gibbert, Ruigrok, & Wicki, 2008). Interviewees were informed beforehand about the topic, purpose, and format of the interview. Interviews averaged an hour and ranged from 35 minutes to three hours. Of all interviews, 74 were audio-recorded and transcribed within 15 days of interview. For the 18 non-recorded interviews, detailed notes were taken during the interview and then ordered and complemented by additional notes within the following 36 hours. Tables 1 provides details of the interviews conducted at Alpha and Beta respectively.

Insert Table 1 about here

At the outset, we interviewed executives and top managers as key informants (Kumar, Stern, & Anderson, 1993). These initial interviews were unstructured and questions varied based on the respondents' hierarchical position and understanding of the research problem. After an introductory part addressing the companies' profiles and corporate structures, our questions probed more deeply into the different types of knowledge assets typically possessed, created, or acquired by the two firms, and sought to identify concrete examples of transfer and reutilization. This first round of interviews allowed us to appreciate interesting aspects of the transfer problem (for example, the different roles played by tangible and intangible assets) and to identify a number of key categories (such as "standardization", or "customization"). Subsequently, we focused on the AlphaCore and BetaSuite solutions and their implementation in the selected projects to study how the solutions were implemented. We first interviewed the project manager for an overview of the project, and then proceeded with other managers – in charge of design, development, implementation, delivery, and support – when new informants could add new and relevant data. We conducted semistructured interviews to gather information about the project teams, the solutions, and their transfer. Introductory questions regarded the interviewees' background, competences, experience, and current position and tasks. Further questions concerned the recent history of the teams, the characteristics of the solutions, the different types of knowledge assets involved, their interrelationships and interdependences, and the practical problems they solved for the recipient organization. As the interview progressed, the focus shifted onto the activities carried out for the creation, acquisition, management, transfer, and reutilization of the knowledge assets. Informants where asked to think retrospectively about such activities, describe them in detail referring to project documentation, and clarify why specific interventions had been necessary, how and when they had been implemented, and whether and how the learning about altered and newly developed assets had been applied in subsequent projects. Throughout the investigation, we used

interview guides to maintain consistency, and occasionally adapted them to the informant's hierarchical position or role played in the project.

Project documentation helped us identify how knowledge assets were used across projects. Project teams in both firms kept meticulous records of the activities and, crucially for our investigation, they produced detailed documentation of which components had been reproduced and employed without changes (conforming to the template), and which ones had been replaced, altered and adapted (departing from the template). This information enabled us to triangulate and better contextualize informant data, reconstruct the sequence of events, and track the use of templates within a project, and from that project through the following ones. Besides providing a complementary source of data, documents helped us identify crucial elements of discussion for the interviews. Table 2 reports details of the documents collected and analyzed.

Insert Table 2 about here

Data Analysis

The study involved joint collection and analysis of data, review of the relevant literature, and examination of emerging conceptual insights in iterative fashion (Locke, 2001). As interviews transcripts, documents, archival data, and field notes were produced, we analyzed them inductively in accordance with naturalistic inquiry (Lincoln & Guba, 1985) and constant comparison methods (Glaser & Strauss, 1967; Miles & Huberman, 1994; Strauss & Corbin, 1998). We carried out open, axial, and selective coding (Strauss & Corbin, 1998), and organized the data into chronological accounts (Miles & Huberman, 1994). The overall agreement between two coders was 93.5% – which suggests high levels of intercoder reliability (Weber, 1990) – and remaining disagreements were resolved through discussion.

Open coding. As we collected raw data, we read and broke them down into segments, interpreted data segments, noted as many relevant incidents and ideas as possible, and organized them as first-order concepts describing "facts" in the data (Van Maanen, 1979). To label them, we used either brief, descriptive phrases or terms present in the data, generally referred to as in-vivo codes (Strauss & Corbin, 1998). When we recognized similar codes, we grouped them into broad, homogenous categories, and reviewed incidents and codes across categories several times until no new concepts emerged.

Axial coding. Next, we compared categories, codes, and data incidents within and across cases. We reordered and regrouped categories in systematic search for relationships among and patterns across them. As we refined categories one-by-one in greater depth, we kept pursuing, identifying, and coding their properties. When the properties of relevant categories could not be clarified in depth within and across the two cases due to insufficient data, we sampled and collected new data. We used visual maps to arrange codes and categories, and link the related properties. Some categories began to stand out as core, higher-order themes capable of subsuming and integrating the first-order concepts; other categories, instead, were reconceptualized and absorbed by the former, more abstract themes.

Selective coding. Finally, we reviewed the data again with a few themes in mind to determine whether they could be illustrated by the first-order concepts. The refinement, selection, and illustration of second-order themes through first-order concepts and raw data went on recursively until we were able to isolate aggregate theoretical dimensions as elements of the emerging model, and explain their interrelationships within the phenomenon of study (Corley & Gioia, 2011).

Chronological accounts. As we read and coded the data, we also organized them into chronological accounts to weave together interviews, documentation, and field notes, and to outline the sequence of events. We used the visual maps of codes and categories to make sense

of the cross-case common patterns emerging from the chronological accounts. By joint use of visual maps and chronological accounts we developed interpretations of the emerging process model that were at the same time theoretically driven and internally consistent (Miles & Huberman, 1994).

Trustworthiness of the Data

To ensure accuracy and transparency of the coding process, we resorted extensively to reflective notes. These included methodological memos (reminders, amendments, and instructions about the analysis), theoretical memos (attempts to extract meanings from and to identify patterns within the data), and conceptual diagrams. These notes helped to explicate the relationships among categories and their properties and dimensions, and identify gaps in the emerging insights.

We endeavored to minimize informant bias in a number of ways. First, we used documents and multiple knowledgeable informants to crosscheck the information and used follow-up questions to ensure that key concepts (such as “knowledge as asset”) had the same meaning across informants. Second, informants were highly motivated to provide accurate information by virtue of the confidentiality that we offered and the relevance of the study to their own profession (Huber & Power, 1985). Third, we investigated concrete facts and events, which are less prone to cognitive biases than opinions or speculations (Huber & Power, 1985; Miller, Cardinal, & Glick, 1997). Fourth, we focused as much as possible on recent events to minimize recall bias (Golden, 1992; Koriat & Goldsmith, 2000) and triangulated factual accounts of the more remote past with documentation and other informants. Fifth, we used open-ended questions within naturally flowing conversations in a way that encouraged free reporting and allowed interviewees not to answer when they did not have or could not recall the information.

FINDINGS

The repeated implementation of AlphaCore and BetaSuite in multiple client projects involved reusing as much as possible existing assets. To signify the interest and incentives to reuse existing knowledge, managers at both firms used expressions like: “why would I design something that is bespoke and individual, that I have to redo every single time I want to do something”, or “you can’t achieve any of that [commercial success] without having repeatability.” However, each implementation of the solutions also entailed altering and customizing them to meet local requirements, because “as soon as a package starts to touch the outside world, it tends to come under strain, and customization can be quite high.” We found that the practice of reusing and altering variable configurations of the firms’ knowledge assets within and across projects involved enacting specific types and functions of metaknowledge, and combining such functions to attain different purposes. Two theoretical dimensions emerge from our findings: (1) *Metaknowledge engine* identifies a set of five functions of metaknowledge – that is, representing, assimilating, realigning, pooling, and integrating; (2) *Metaknowledge-based patterning* refers to the generation of new design rules and patterns of organizing enabled and guided by the metaknowledge engine.

In the remainder of the section, we illustrate the evidence that led us to identify each dimension, the respective constituent themes, and their interrelationships. Figure 1 shows the overall data structure, which includes first-order concepts, second-order themes and aggregate theoretical dimensions; Table 3 reports representative data incidents.

Insert Figure 1, and Table 3 about here

Metaknowledge Engine

As we analyzed data about the activities involved in the transfer of the solutions, relevant incidents emerged about the fact that managers from both the AlphaCore and BetaSuite units

regarded themselves as concerned with the "big picture of what would you deliver." Having studied the interdependences among knowledge assets for decades, these managers had "developed a hierarchy of abstractions" and used them to solve complex business problems for clients. Gradually, it became clear to us that the expertise acquired through professional experience and interaction with multiple sources of knowledge – both internal (technical and commercial areas) and external (chiefly customers, suppliers, and technological and service partners) – had conferred on these managers metaknowledge abilities. These abilities enabled them to work with multiple knowledge resources, areas, and domains involved in the transfer of the solutions. The following quotes exemplify how distinct aspects of a problem or different domains of knowledge (regulations, industry, business, technology, operations, human resources, and so forth) were connected together into coherent sets of interrelationships.

> The regulators, the governments, everybody is calling out for more simplicity in [financial] products, and less innovation around some of these toxic derivatives. If you apply it to an organization, that implies that you should have a more utility-based approach to your back office and technology, because you start to question the real cost of being in business. *AlphaCore Unit Director*

> Financial services is not a very efficient industry because, when you go into these [big banks], they have 2,000 applications, and every night there is some sort of fix on that application. That is not a stable system that is supportive of a commoditized volume-based business. These are built one way historically, because everybody has convinced themselves that's been innovation and that's how they use their proprietary knowledge, but in reality what they've got today is something that actually isn't fit for purpose. *AlphaCore Industry Technical Executive*

> We already knew some limitations. We knew that, if the technology was very new or very immature, [customers] wouldn't like this approach. We also knew that in some cases, as a result of that thing, the technology was quite difficult to standardize. […] We also knew that there would always be big customers who would never accept the standardized approach, although you could make a lot of what's underneath standardized. We're now pushing up against another limit, which says, for certain types of products and service, by all means, standardize, that's fine, but the sales approach mustn't be standardized. You

> know, the customer prefers the personal, the guys who are going to do the delivery and that kind of thing. *BetaSuite Unit Director*

> It's very easy for us to take a process and automate it and give it back to the customer with some hardware and say, there you are, that is now how you manage your field workforce. A customer, almost always, in my experience, underestimates the cultural change and the people issues, the behavioral stuff. *BetaSuite Head of Solutions Implementation*

As we probed further into how this understanding of the interdependences between knowledge resources and domains was put to work, we found that the decisions related to the implementation and alteration of the solutions were underpinned by a set of interrelated activities of knowledge transformation involving specific functions of metaknowledge. We call these set of functions the *metaknowledge engine* to signify their interdependences and interrelationships. The dimension of the metaknowledge engine comprises five main themes, each describing a specific type and function of metaknowledge: 1) *Representing*; 2) *Assimilating*; 3) *Realigning*; 4) *Pooling*; and 5) *Integrating*.

Representing. The implementation of the solutions was accompanied by the incessant production of knowledge representations. Specifically, textual and graphic representations were used to facilitate communications and exchanges within the teams in charge for designing and delivering the systems, or between those teams and other departments, particularly sales. For example, "we've taken these matrices, these definitions, and these prices, and we've put them in sales tools so that a salesman can sit in front of the customer with a version of that matrix on the screen; they can select what they want, and it will sort of design and price BetaSuite for them." Similarly, a senior IT architect from Alpha showed us a spreadsheet "that's a one-page solution for each of these competencies, and a cost." Representing knowledge proved fundamental to "catalogue, organize and make searchable and discoverable an effective set of assets." An industry technical leader at Alpha remarked that "we've got more

products than forests have insects; and one of the issues that we got was, what are we supposed to use and when. So me and some of my team came up with what we call this integration model." Knowledge representations also improved the communication with the customers and facilitated their understanding of complex offerings. For example, one of Alpha's senior technical leaders clarified that "the tooling that we provide is to help people understand or zoom in on the bits of the content. We provide very, very large models, tens of thousands of elements. That's more content than any human being can consume in one go, certainly more content than any one project would want to bring on board." The following quote illustrates how a specific type of metaknowledge (*knowledge of how knowledge structures are understood*) informed knowledge representations:

> One of the challenges I've hit is the different mental models people have. […] When you abstract knowledge in the patterns, you actually produce visual shortcuts and textual shortcuts to help people navigate them. If you take the visual shortcuts, in particular, not everybody thinks visually. So when you draw diagrams and say, here's a pattern at a very high level of abstraction describing the solution, some people look at it very blankly and say, well, how does that help me write a line of code? Whereas other people who do think visually find that a visual cue is very helpful in guiding them to picking the right assets. So that's a challenge that we have in terms of explaining to people what assets exist. *Alpha's Innovation & New Technologies Leader*

Assimilating. The second theme of the metaknowledge engine refers to the fact that, as soon as knowledge structures and relationships within systems, processes and activities were represented, important analogies, similarities and commonalities became apparent, which could be used to identify opportunities for reusing knowledge assets in multiple situations. For example, Alpha's new product development expert explained:

> The first thing that you notice is all the steps that look alike. They have to do with project management or, you know, starting up a project, or closing a project. All of those things instantly look very similar, and so get turned into some kind of highly componentized and highly standardized guidance. So, that's how our worldwide project management method came about. And, over time, in numerous other areas the same sort of things are observed.

Assimilating knowledge entailed comparing representations (of product architectures, business processes, sequences of activities, or sets of requirements), identifying similarities, and leveraging those similarities to enhance reusability. One of Alpha's industry technical executives explained that "a fundamental business reality for the large multinational corporations is that their data is going to be different by line of business; but you can then start to record what's common and what's not common." He then went on to provide a more detailed account of "things that are the same across a number of industries:"

> Our banking, insurance, retail, healthcare [solutions], have four, five, six thousand individual information elements. And why are they about the same? Because, actually, most industries are very similar. They have different labels on things, but they are still very similar. If you want to know everything about your client, there's probably a couple of thousand elements, and that's it. There's only so much you can know about your client, from their phone number, their bank references, their health history, their personal history, their dates of birth and all that. It isn't an infinite list, if it's a human; it isn't an infinite list if it's an organization. Alpha

When prospective customers in a target industry showed "commonalities" – for example, they ran business and operational processes that were "known," or similar to those that the units had dealt with in the past – they were regarded as "familiar setting," or "adjacent space." In those cases, the metaknowledge function of assimilating was activated to make use of *knowledge of the different possible applications of a knowledge asset*, and support the reutilization of existing knowledge assets for the purpose of commercial expansion. For example:

> We're moving into an adjacent space, so we have an insurance model [existing template] and we built a health plan model [new template], so the jump from insurance to health insurance and health plans is not enormous. *AlphaCore Product Development Director*

> We've found that it's not just applicable to financial services, it's applicable to retail, construction, anywhere where they kind of, have remote, remote sites, so we've got six of those. Beta

Realigning. The third theme of the metaknowledge engine dimension captures the fact that the units systematically strove to realign the views and understanding of the different groups involved in the implementation of the solutions. Both the AlphaCore and BetaSuite units regarded groups, teams or departments in their firms, but also in the customer organizations, as different knowledge contexts. A business development manager from the AlphaCore unit, for example, pointed out that, "even in the same organization, what mortgage means for the IT people could be something different from what mortgage means for the people at the branches." Similarly, project managers from Beta underlined that "within the customer, there's usually a split between the people managing the change and the people managing the business." Realignment was pursued and maintained by sharing *knowledge of how knowledge is used or understood in different contexts*. Realignment within the units was pursued by holding periodical meetings "where we do discuss in some detail the issues and problems that we're having;" "so we have what I'd call a 'learning and sharing session' on a regular basis so that we can share the experiences that are taking place." Realignment was sought between the members of the units and the customer. For example, one of the AlphaCore project consultants explained that:

> A very common problem is language [because] when I get to the project the customer speaks a different language than I do. […] I have my consolidated, generic, reusable view of the world and then I speak with customers, IT people, businesspeople, and they're talking in their lingo... at the beginning I'm not sure whether I really understand what they're saying. I do understand what they're saying, but I'm not sure that my understanding is the right one. So what needs to be done is bringing into the mind the need to consolidate the terminology and, which is even worse, bring them to accept our terminology.

When asked for an account of how realignment was achieved between the units and the customers, interviewees used expressions such as "we've imposed a tremendous discipline on them, that this is what you mean, and if you don't get this right it's going to cost you a fortune;"

or, “we give training upfront on AlphaCore for both business and technical people; they will be trained on the content of the solution and basically how it fits together between the various areas of the solution, the high level view and getting down to the more detailed view.” After the initial training, the approach adopted by both units consisted of proceeding by small, incremental steps, limiting the initial scope of implementation to priority areas through “a proof of concept” or “pilot,” and then extending it to other areas. Managers from both AlphaCore and BetaSuite provided similar illustrations of such approach:

> It’s like giving a heart transplant to some person running a marathon, because you’re trying to establish a change capability. And so the way you end up doing it is domain by domain. You figure out tactically which domain is broken, like product management or customer management, and then you figure out how to do, if you take that slice out and retrofit it, and modernize it, and then go on and do the other things. *AlphaCore Senior IT Architect*

> The key point is the proof of concept. They wanted to see if the idea really fits what they were looking for, really fulfilled those expectations, and then the proof of concept was especially important to do that. *AlphaCore Business Development Manager*

> [The customer] didn't really know what they wanted during the pilot. We walked into a concept pilot scenario that lasted for six months and proved the concept, and they would see what they thought could be achieved with the transformation. *BetaSuite Customer Support Manager*

Pooling. The fourth theme of the metaknowledge engine dimension reflects the fact that the members of the AlphaCore and BetaSuite units pooled together the various competences available in the team with other, complementary knowledge sourced from across the firm and its partners. One of the AlphaCore senior management consultants explained that the unit needed to “plaster over the cracks between Alpha, because our team can only do certain parts of the project; the technology division have to do other parts, because we won’t have the skills.” Similarly, a manager from Beta said that “we take products from other capabilities, put them

together with services, and sell them on as solutions." The successful pooling of knowledge resources relied on a particular type of metaknowledge, *knowledge of who knows what, or of where relevant knowledge resides*. Evidence of this type of metaknowledge was provided, to variable extent, by all interviewees. For example:

> We have researchers based in different parts of the world who research the marketplace. They publish a lot of material on Alpha's point of view around the marketplace, and create a specific set of material for the client team. That will hone in 'this is what the marketplace is doing, but this is the real issues you client will face over the next year'. *Alpha's Senior Managing Consultant*

> You might be hidden in Hong Kong, or in Sydney, you know, we end up having what we call 'hidden jewels.' The team that does this kind of innovation go find the best expertise, wherever it may be on the planet. *Alpha Senior Strategy Consultant*

> Beta's a very big company. So, although we have a small core team, if we have a particular piece of work that needs a resource of a special type, that skill exists in Beta. We can take someone out of Beta operationally, and put them on a piece of work for two to three weeks or a month to support us. *Beta Product Development Manager*

Our interviewees also showed awareness of strategic issues when asked to reflect on the factors that enabled or hindered knowledge pooling. For example, referring to the mutual incentives of technological partnerships, one of Alpha's industry technical leaders said that he maintained "a network of probably 30 or 40 external partners that we work with; and that's a symbiotic relationship. They get value out of coming to us because they will get insight into opportunities for their product development as well. We get the value for both sides." Similarly, the general manager of the BetaSuite unit, with whom we were investigating the role of partners as sources of complementary knowledge, explained that the reliability and small size of those organizations were

crucial: “they’re specialized, but the one thing that we always look for is that they’ve got to be reliable, because nearly all of our sales are managed services.”

Integrating. The fifth and final theme subsumed by the dimension of the metaknowledge engine reflects the integration of knowledge from different domains – for example, strategy, business processes, operations, system design, technological innovations, changes in regulations, and so on. While knowledge pooling referred to mapping and linking knowledge contributors, sources and repositories, integrating involved using *knowledge of the connections and interdependences between different elements or domains of knowledge* to synthesize complex structures. For example, the team responsible for managing AlphaCore components “is an unusual bunch of people, in that they have that sort of weird combination of really understanding the technical computer science detail and the business analysis.” In another set of statements, interviewees emphasized that their “key strength is bringing together the business point of view all the way through to the end; it’s the full end-to-end view of the solution.” Similarly, the BetaSuite product development manager provided a detailed account of his role and tasks, stressing the ongoing need to merge knowledge about strategy, product development, technological evolution, and competition:

> Day to day, I look at the strategy where we’re going, to make sure that, you know, we're constantly going forward; because, in my view, if the products don’t carry on being developed, then the opposition will catch up and go past us. I'm constantly looking at feedback that we get from customers, from the vendors themselves, from our team and our sales teams, as to what would be good to take forward, to keep the products at the forefront of technology. Beta

Metaknowledge-based Patterning

The outcome of the interrelated functions of metaknowledge subsumed in the metaknowledge engine was the generation of “rules” and “principles” that informed, with some degree of stability, the decisions of the units in terms of solution implementation and alteration.

Through these rules and principles, the metaknowledge engine directed the evolution of the solutions, and contributed to shape the collaboration between the units and other parts of the firms, as well as clients and partners. Specifically, two themes were associated with the dimension of metaknowledge-based patterning: (1) *New design rules and principles*; and (2) *New patterns of organizing*.

New design rules and principles. This theme captures a first set of decisions influenced by the rules and principles generated by the metaknowledge engine in terms of solution design. Some of these rules and principles, for example, aimed at establishing the desirable ratio of standardization/customization towards which the design of the system had to evolve over time, as it became more mature. As managers at both the AlphaCore and BetaSuite units reported:

> This 80/20 rule refers to the rising line of standardization in [a new family of] projects. New applications set for the first or second projects use components which are 50-60% standardized. So at the start its 60/40 [standardized/customized]. By the time we move to the third project, it tries to achieve the 80/20 rule. *AlphaCore Senior Strategy Consultant*

> They're looking at the 70:20:10 rule, where 70% of everything is standard, 20% is a little bit non-standard, and 10% is bespoke; which obviously then increases our ability to match customer requirements. [...] It's formalized in [document code]. *BetaSuite Sales Manager*

A second set of emerging rules and principles suggested the right "level of granularity" of the solutions and their components. For example, an industry technical leader from Alpha remembered questioning, "what is the right granularity of these assets? are they too fine-grained? These should be things that developers can assemble and make something out of it." Similarly, a senior IT architect, who illustrated a case in which the granularity of a category of "widgets components" had to be reduced, provided an account of his thinking that linked together his knowledge about system design, business success/failure, current operations, and availability of related knowledge assets across the firm. The BetaSuite solution portfolio manager illustrated that a consulting component of BetaSuite had to be "broken down into bits"

so that, while the interdependences between parts of the content were preserved, the increased granularity helped the unit meet more effectively the needs of different customers. The following account from the AlphaCore new product development global expert provides an exemplary illustration of how knowledge about product, process, and country specificities influenced the decision to introduce more variants of a service component:

> Some of the standardized components are just not very good. If you take an area like say, change management, then the real centers of expertise in Alpha are, you know, places like the big American government practices, the [European] private sector for practice, the [Asian] kind of small or medium sized business practices. Well, those are three quite different areas in their own right, but we only have one set of components, and the concept of a variant isn't particularly well embedded.

Another category of design rules generated by the metaknowledge engine aimed at simplification, because, "to embed a method in a software tool, generally means that it gets dumbed down quite a lot." The AlphaCore unit sought to "make AlphaCore easier for clients to implement, and get to look at their unique 20% faster." The same principle emerged at Beta, as "we quickly realised that our major systems were far too complicated. Obviously, Beta's a large company of thousands of engineers, and we built some really powerful systems. But when you're trying to sell externally, they're too expensive." The BetaSuite product development manager clarified that "the complexity we needed for Beta we don't need for our customers, because they operate a lot more simply. So, when we first started we thought we needed loads of complex solutions; and then we quickly realised that, no, we actually need loads of simple solutions, because our average customer is 15 years behind Beta in terms of technology." Other design rules and principles concerned the decision, taken by both units, to adopt a "neutral" or "agnostic" approach to the use of third-party components, and ensure that "the solutions are not linked to a specific technology; or if they are, they are also, kind of, open to work with other [third-party] applications." A BetaSuite project manager commented that, as consequence

of such decision, “we don’t sell Beta’s mobile airtime; so, what we tend to do is say to the customer, look, you’ve got a mobile airtime contract with [other providers]… we don’t want you to change your airtime contract to buy that from us.” For Alpha, analogous principles meant that “it is irrelevant to us if the system that the company has is a [Brand X], an [Alpha] product, or [a Brand Y] product. AlphaCore is totally independent and intentionally pure.” Finally, other principles addressed commercial and financial constraints, and prescribed the achievement of “a sensible mix” of hardware, software, and service components, “because if we’re not careful and we sell too many [hardware components], the margins will be lower.”

Patterns of organizing. This theme reflects the fact that the activation of the metaknowledge engine facilitated the emergence of patterns in the way the units organized themselves and managed their exchanges and collaborations with others. According to one of Beta’s senior managing consultants, “the way we are organized always evolves on the basis of how your knowledge evolves and how your understanding evolves. So one of our big challenges is to make sure that we all work in the same way, that we do stuff is common.” For example, our informants mentioned the emergence of new policies and approaches that aimed to specify who in the team was expected to do what. In the BetaSuite unit, “the policy we apply is, whoever has engaged the customer right from the outset, as far as a solution is concerned, we would normally try to continue with that person in that relationship.” At Alpha, “usually, if a consultant is expert in process modeling, they wouldn’t get involved in a data warehouse project,” and “it’s pretty much a standard situation at Alpha when we are dealing with service oriented architecture, there would be a business process modelling team I would discuss with and derive the use-cases and the rest from there.” Patterns of organizing shaped by a combination of representing, aligning, and integrating functions had led the BetaSuite unit to conclude that “BetaSuite is not really a technology-led sale. When we go and talk to a customer, we don’t want to talk about technology; technology is secondary, we leave it outside the door.

What we want to do is understand the customer's business problems." Describing how work with the customer was carried out, the AlphaCore business development manager remarked that "service consultants have to be at least 80% of the time with customers, because that is the nature of our work, whereas the development [consultants] don't have to be a lot of the time facing customers, because that is our role." And yet, "we prefer to allocate consultants on a full-time basis [on a single project] rather than perhaps handling two or three projects at the same time; that will enable the consultant to understand the customer very well." Other patterns emerged when the team decided that "the role of core consulting is to create the business opportunities to do things like system integration work, and leverage activities;" or that "the presales piece is always a big challenge because the customers push you [to reveal information about the structure of AlphaCore] as far as you get to the point of saying, no, now you have to buy it; and the question is how far you want to go in that space."

Other examples of the filtering or mediating role of metaknowledge were provided by our informants when they explained how they assessed the impact of specific interventions on the future content and shape of the solutions.

> [When] the client has encountered a situation that they want to do, say, the business intelligence, where AlphaCore just doesn't do that, that becomes a judgement call, because I would make some type of determination as to whether this is a really local, parochial change [*assimilating*]. I mean, if I'm in Belgium, for example, there might be some specific things that do with the registration of organizations, and that's purely a consequence of Belgian legislation… so in that case I probably would not send it back to [the unit], because AlphaCore is designed to be such that it's generic across all countries and legal regimes. Then what we do is we put a place holder, where specific country or bank information can be inserted [*representing*]. But if I think it's something that is of general interest, but we just haven't discovered it so far, then I would send it back to [the unit]. […] In the development area, they surely will then make a second determination as to whether what I sent back was of general interest or not [*assimilating*, and *realigning*].
> *AlphaCore Project Consultant*

The new patterns emerging from the activation of metaknowledge functions affected both the design of the solutions (product layer) and the dynamic reorganization of the units and their collaborative exchanges (organizational layer). For example, a couple of years before the start of our fieldwork, Alpha had transferred the ownership of AlphaCore from its consulting division to the software and technology division. We learned that such decision was based on metaknowledge, in the sense that the firm's intent was to "apply the [software division's typical] discipline and ethos in the development of [productized assets]." Another metaknowledge-based change in Alpha's organization was the creation of an "asset architecture committee" that, building on the experience accrued by the AlphaCore business, aimed to coordinate firm-wide initiatives of knowledge productization, and introducing individual-level "annual incentives and rewards for both the contribution of new assets and reuse of existing assets."

The most important outcome of the concerted use of different types of metaknowledge was that the units acquired over time the ability to reconcile the opposite pressure to reuse and adapt. Customization started to be treated as a regular phase of the transfer process, so that "right from the beginning, we explain to the customer, and we know that, and the customer should be aware that customization is a phase." But at the same time, customization could be limited to a predictable but crucial part of the whole solution, through which local specificities could be converted into business value.

Finally, we found that, over time and through series of solution implementations, the emerging patterns shaped the management of both units in ways that separated them from the rest of the firm. For example, the unit director remarked that, although some very small partner companies provided components that were pivotal to the BetaSuite architecture, "there's no point in buying these companies, because we get 40% margin, and they've got quite good operations in day-by-day. If we brought them into Beta, they'd become like Beta, and instead

of being quick-footed and able to do innovative developments quickly, they'd need to talk about it for six months before. That's why [the unit's] model is most unusual to any other part of Beta." Other indications of the peculiar approaches held by the units were provided by several interviewees at both firms. For example:

> What makes us unique in the BetaSuite team is that in a lot of parts of Beta the propositions are split up. So, you might get a group of people that are responsible for the product, you might get another group of people in a different area that are responsible for the implementation, you might get another disparate group that are responsible for the sales or the accounts and that. What makes us unique is that we'll take a customer from the consultancy, through to trail, to pilot, to deployment, to inline, to account management inline as well. Although we have account teams in Beta, we still keep an interest in all the accounts and we'll talk to each customer on a regular basis. So, we really do manage almost as a separate business within Beta's wider business." *BetaSuite Product Development Manager*

> If you look at our [AlphaCore] development organization compared to, let's say, a typical development organization within Alpha, our developers would have a lot more interaction with various banks, insurance companies, telcos, around the world. […] That's something slightly different than a more technology-oriented group, where they don't necessarily need that particular level of interaction. *AlphaCore Client Technical Advisor*

DISCUSSION

Metaknowledge and Managerial Metacognition

This study highlights the multifaceted nature of metaknowledge and uncovers important aspects of its dynamic acquisition, development, and functioning in organizational life. Our findings of multiple, interrelated metaknowledge functions (representing, assimilating, realigning, pooling, and integrating) show that different types of metaknowledge are employed together by managers to transform and leverage knowledge resources, and that each type plays a more prominent role in a specific instance of knowledge transformation. The distinction between functions of metaknowledge goes beyond taxonomic utility. It supports a deeper

understanding of the sequence of actions through which knowledge resources can be processed to reconcile contradictory goals. It also provides refined conceptual tools for zooming in on more aggregate constructs of knowledge work, such as articulation (Håkanson, 2007), augmentation (Nag & Gioia, 2012), or chauffeuring (Culnan, 1983; Majchrzak et al., 2004). In general, this study offers a more nuanced characterization that the use of metaknowledge can take in collaborative settings, and helps us understand better processes that involve variable combinations of metaknowledge types. For example, the function of knowledge pooling performed by the studied business units involved knowing what others in the team knew – that is, transactive memory. However, our analysis shows that each member of the AlphaCore and BetaSuite units possessed not only transactive memory but also awareness of where other knowledge resources external to the team resided or could be found. The use of these two types of metaknowledge was evident in the pooling function, and was combined with other functions of the metaknowledge engine to attain concerted team-level achievements. In this respect, the realigning function played a fundamental role in weaving together individual and team cognitions, and helping the members of the units to develop increasingly convergent understanding and sensemaking (Weick, 1995; Weick & Roberts, 1993; Weick, Sutcliffe, & Obstfeld, 2005). Based on previous research, we would expect that these seniors managers possessed different knowledge schemes when they first joined the units, and that such differences would normally support distinct ways and methods of searching for, acquiring, and employing knowledge (Nag & Gioia, 2012). Instead, across the two case study firms, we observed remarkably strong homogeneity in the views, approaches, and schemes of the unit members, who carried out collectively interrelated activities of knowledge transformation directed and coordinated through the metaknowledge engine. At the same time, the units differed from other parts of the firms. Our evidence suggests that such internal homogeneity

was driven and maintained over time through the metaknowledge engine, and in particular by a combination of the metaknowledge functions of pooling, realigning, and integrating.

Metaknowledge Engine and the Foundations of Dynamic Capabilities

This study improves our understanding of the mechanisms through which managerial efforts aiming at creating new organizational knowledge and reusing it innovatively support the development of the firm's dynamic capabilities (Barr, 1998; Helfat et al., 2009; Nag & Gioia, 2012; Salvato, 2009; Teece, 2007; Teece et al., 1997; Tripsas & Gavetti, 2000). We know that capability development rests not only on resources that are *per se* rare and difficult to imitate (Barney, 1991b; Priem & Butler, 2001), but also on factors arising from the cognitive processes of individuals and groups involved in the use of such resources (Adner & Helfat, 2003; Argote & Ren, 2012; Kaplan, 2008). In the evidence emerging from this study, the theoretical dimension of the metaknowledge engine captures the recursive interplay between different functions of metaknowledge that were activated, in variable combinations, to support specific modes and purposes of knowledge transformation. Indeed, the metaknowledge engine appears as a system of activities through which individual cognitive abilities are harnessed and synthesized dynamically into team- and firm-level capabilities. In their embryonic stage, these capabilities arose in the form of new design rules and patterns of organizing. Over time and through experience, they consolidated into more viable products, and more efficient and effective operations. This process of capability development unfolded in ways that were fundamentally idiosyncratic to certain organizational and historical contexts. Consistently with the view that identifying the origins of dynamic capabilities requires fine-grained conceptualizations of their operational constituents (Helfat & Winter, 2011; Mahmood, Zhu, & Zajac, 2011), we explored transformations that occur at a lower level than products and routines, and found that changes in products, technologies, and routines were essentially driven

by microlevel changes in the underlying knowledge endowment. The capabilities resulting from such changes were peculiar to the firm, and difficult to transfer or imitate (Barney, 1991a; Dierickx & Cool, 1989) in two main respects. First, when activated repeatedly across multiple instances of transfer, the metaknowledge engine connected knowledge-related activities at the individual, team, and organizational levels (Schulz, 2001; Zellmer-Bruhn, 2003). Individual and organizational knowledge endowments were recombined and reconfigured (Kogut & Zander, 1992; Teece, 1998, 2007; Teece et al., 1997) to create path-dependent assets embedded into unique cognitive and sociomaterial contexts. Moreover, through the dynamic recombination of knowledge into new templates, managers enhanced the productivity of the underlying knowledge and delayed their depreciation (Argote, 1999; Darr, Argote, & Epple, 1995). Second, reiterated transfers of organizational knowledge into diverse contexts strengthened the firms' dynamic capabilities (Helfat et al., 2007; Teece, 2007; Teece et al., 1997) by renewing and updating the peculiar connections between their knowledge assets and the environment. Over time, the units developed the ability to identify attractive opportunities for matching the evolving systems and components with diverse ranges of external needs and requirements.

Capabilities of technological recombination, a particular type of dynamic capabilities widely regarded as underpinning innovation in firms (Fleming, 2001; Galunic & Rodan, 1998; Henderson & Clark, 1990; Kogut & Zander, 1992), appear as the main capabilities developed through the metaknowledge engine by our case study firms to resolve the replication/adaptation tension. In particular, both knowledge framing and knowledge fitting seem to directly support capabilities of "recombinant creation" and "recombinant reuse" (Carnabuci & Operti, 2013). Carnabuci and Operti (2013) posit that recombinant creation consists of creating technological combinations that are new to the firm. It involves exploring new connections and interdependences among technologies, and expanding the portfolio of viable technological

combinations. Recombinant reuse, instead, consists of reconfiguring and adapting technological combinations that the firm has used in the past, and involves amending and improving them to fit new contexts of utilization. Looking for the antecedents of these two capabilities, the authors find that they are usually supported by alternative sets of factors, but the presence of an integrated collaboration network and a diverse knowledge base can enable both, and even activate synergies between them. In our case study firms, the tight collaborative networks maintained within and around the units, as well as the availability of a wealth of knowledge resources from multiple domains, certainly supported the recombinant activities of managers. But our findings shed light on the specific knowledge transformations that enabled the realization of such potential, and show that specific functions of metaknowledge had to be activated in the process. Extending previous research on the effect of knowledge and experience on the innovation performance of individual and teams, these findings suggest potential explanations for why "combining knowledge requires a deep understanding of knowledge, rather than information scanning or exposure" (Taylor & Greve, 2006).

This aspect of continuous engagement of the metaknowledge functions seems to separate the type of knowledge reuse performed by the studied units from alternative modes of reutilization, in which reusers tend to employ metaknowledge only at certain stages of the transfer process. For example, when knowledge is reused for the purpose of radical innovation (Majchrzak et al., 2004), metaknowledge is usually acquired and employed at more advanced stages of the transfer process, when the commitment to a specific idea or option of reutilization is confirmed. By contrast, in the context of our case study firms, very experienced managers were actively involved in processing information and guiding actions (Daft & Weick, 1984; Dosi, Faillo, & Marengo, 2008; Reus, Ranft, Lamont, & Adams, 2009; Vaccaro, Brusoni, & Veloso, 2011) in an ongoing fashion – before, during, and after the transfer.

Limitations and Future Research

Case studies offer thick and accurate observations, and support relatively simple and effective conceptualizations, but usually entail a compromise on generalizability (Thorngate, 1976; Weick, 2005). Interpretive studies based on a limited number of cases often raise questions about the transferability (Lincoln & Guba, 1985) of the findings to other domains. Some considerations about the characteristics of the empirical setting as situational boundary conditions of our work may help assess transferability.

When we started our investigation, the experience of two firms that had been dealing with replication and adaptation for decades appeared interesting for new theorizing (Siggelkow, 2007). Despite the peculiarities of the IT industry and the case study firms, we believe that the findings and the grounded theory model reported here are applicable to organizations in many different settings, and especially knowledge-intensive ones (Alvesson, 2004; von Nordenflycht, 2010). However, an important circumstance that might affect how the model works in other settings is the pace and magnitude of change. The type of change that we observed in the timeframe of this study occurred in relatively small shifts. This allowed the AlphaCore and BetaSuite units to attain new fit conditions through fine-tuning adjustments (responses to changing project requirements), system reconfigurations (shifts into new industries/sectors), or both. Yet we do not know whether and how the model works in a punctuated equilibrium scenario (Gersick, 1991, 1994; Romanelli & Tushman, 1994). Our data does not allow us to induce whether other types and functions of metaknowledge would intervene in the response to quick and dramatic changes. Although we expect that in those cases certain functions – such as, representing, or assimilating – would still be activated, we do not know in which different ways the metaknowledge engine could work, or whether it would have a different impact on the units' ambidextrous capabilities and absorptive capacity (O'Reilly & Tushman, 2013). Such scenarios would probably emphasize the role of

metaknowledge in prioritizing certain directions or patterns of knowledge reuse; however, further research is needed to find out which specific knowledge transformations would allow firms to establish completely new and largely unknown content-context connections. Inquiry into those cases may also help us understand if realigning cognitions, which the metaknowledge engine supports, leads to undesired levels of rigidities in individuals' schemas. Dane (2010) refers to such rigidities as "cognitive entrenchment", and argues that "the degree to which individuals engage in a dynamic environment within their expertise domain and the extent to which individuals focus their attention on tasks outside their expertise domain" help mitigate the excessive cognitive stability usually associated with expertise.

Another important direction for future research concerns the systematic identification and leveraging of metaknowledge across the firm to sustain capability development. Scholars tend to agree that dynamic capabilities, such as ambidexterity and absorptive capacity, reside in senior management teams (O'Reilly & Tushman, 2008; Rothaermel & Alexandre, 2009; Teece, 2007). In many respects, our findings provide support for this view, as all the managers involved in the AlphaCore and BetaSuite units were very senior experts. However, through our fieldwork, we learned that using metaknowledge is fundamentally different from exercising experience. Future studies could investigate, for example: (1) which other types of metaknowledge exist, and whether they play a role in the acquisition, utilization or transformation of other resources; (2) whether these types of metaknowledge are possessed or used by non-senior employees; and finally, (3) how they can be harnessed in ways that are both meaningful and strategically relevant.

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FIGURES AND TABLES

Table 1. Details of interviews and informants

Role/Job Title	Informants	Interviews	Length
Alpha			
Chairman Emeritus	1	2	1h45m
Chief Technology Officer	2	10	12h20m
Global Industry Director	1	1	1h
Senior Strategy Consultant	1	1	1h
Senior Managing Consultant	1	2	1h20m
New Product Development Global Expert	1	1	50m
Innovation & New Technologies Leader	1	1	45m
Industry Technical Leader	3	3	2h25m
Industry Technical Executive	2	2	2h
Strategy Executive	1	1	1h
Senior IT Architect	5	5	4h
Client Technical Advisor	2	2	1h30m
Unit Director	2	5	2h30m
Business Development Manager	2	2	2h15m
Product Development Director	1	1	35m
Project Consultant	4	4	3h10m
Services Manager	1	1	45m
Systems Engineer	1	1	45m
Total	***32***	***45***	***39h55m***
Beta			
Division Vice President	1	1	1h
Subdivision President	1	1	1h
Subdivision Director	1	4	2h20m
Senior Managing Consultant	1	1	1h
Senior IT Consultant	2	2	1h15m
Unit Director	3	6	6h30m
Unit General Manager	1	1	1h10m
Commercial Director	3	5	5h45m
Program Manager	1	1	45m
Product Manager	2	2	1h30m
Project Director	1	2	2h10m
Project Manager	6	8	7h10m
Solutions Portfolio Manager	1	1	45m
Product Development Manager	1	2	2h
Head of Solutions Implementation	2	3	2h25m
Commercial Manager	1	2	1h15m
Solutions Implementation Manager	1	1	50m
Customer Support Manager	1	1	1h10m
Sales Manager	3	3	2h
Total	***33***	***47***	***42h***

Table 2. Details of documents by type and source

Type of document	Alpha	Beta	Other sources	*Total*
Industry studies/reports	-	-	17	*17*
News articles	-	-	7	*7*
Case studies	-	6	19	*25*
Corporate profiles	12	26	12	*50*
Corporate reports	18	17	-	*35*
Executive speeches/presentations	21	27	-	*48*
Unit reports	12	4	-	*16*
Product brochures	2	28	-	*30*
Project documents	78	91	-	*169*
Total	**143**	**199**	**55**	**397**

Figure 1. Data structure

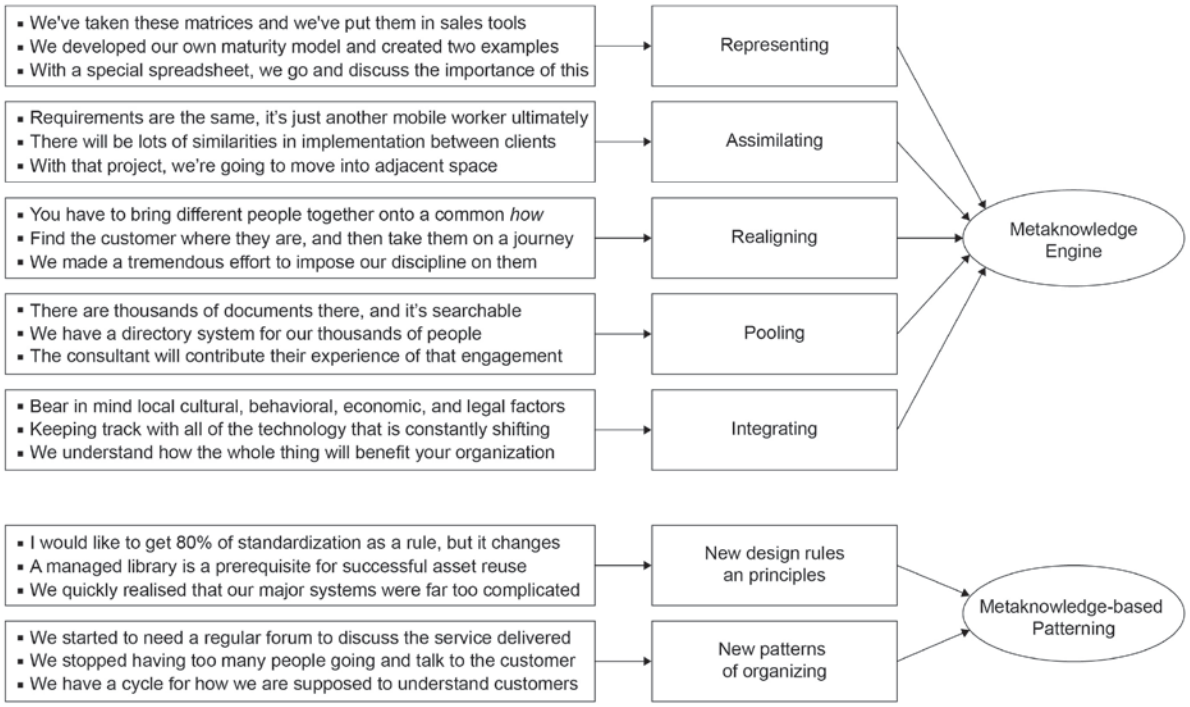

Table 3. Display of representative data supporting interpretations

Themes	Exemplary quotations
	Metaknowledge Engine
Representing	Some of those things are relatively well defined, so you could sort of get them off a menu. *Alpha Senior IT Architect*
	So, if you go to slide three, [it] shows the way that we look at this overall solution development, and that is looking at it from a standpoint of a business issue. *Alpha Senior IT Architect*
	Here are the components you've got, here's the tool kit to basically build out that assembly line, so you can develop new solutions. *Alpha Senior IT Architect*
	This describes a high-level functional application architecture. Then, in the middle you have this concept of a service bus. I don't want to get overly tech on you guys, but that's where that kind of service façade lies. *Alpha Senior IT Architect*
	Everything you see here, in that middle area, that is effectively, without even putting an Alpha name on it, that is how application architecture is laid out. *Alpha Senior IT Architect*
	There's quite a lot of business thinking that needs to go into that kind of solution up front, and the models are key to facilitate that. They don't do it by themselves, but they facilitate the discussion. *AlphaCore Services Manager*
	Typically, there, we have to have a series of architectural pictures as we transition from the current solution to the target solution. *AlphaCore Business Development Manager*
	It's a whole language thing, it's about how you wrap up the products and services *Beta Senior Managing Consultant*
	[Our sales force] like the BetaSuite because it's packaged up, and it's kind of made easy for them, and it's made easy for the customer to, one, understand, and secondly, engage. *Beta Senior IT Consultant*
	The solutions are in different blocks, which are quite complicated; so this looks at the different elements and who is responsible for what. *BetaSuite Project Manager*
	We're doing a campaign at the moment in the health service. So the pitch there was efficiency, with people actually having the right information for the patient in place at the right time. [...] But then the next day, literally... I was talking to a luxury watch repairing company. It was the same technology but a completely different wrap: 'you can find your watches in the building and you're not spending all these man hours.' So the business benefit's the same but the articulation of it is subtly different. *BetaSuite Sales Manager*
	If you take that bottom corner on the right, from [mobile platform] through to devices and service and support, that's probably the simplest solution and the most repeatable business that we do. And then they can move back across the page to take on more complex applications at a later date. We go from right to left, but also right, up and across as well, depending on what sort of solutions they're looking for. *BetaSuite Product Development*
Assimilating	We're actually looking at a couple of other sectors right now to look at the deployment of the same concept, there. *Alpha Industry Technical Leader*
	AlphaCore solutions are characterized by finding and capturing commonalities that run across an industry. If you have fewer commonalities that are easily identifiable, it's more difficult to build an industry solution. Alpha
	There are no miracles, whether it was banking, insurance, retail, and now up to healthcare, it's about understanding what's common, and then doing something about it. *AlphaCore Services Manager*
	When we moved into financial markets, we took the banking model as a base and, again, that was not a, you know, an enormous jump. *AlphaCore Product Development Director*
	You're moving into an industry which is adjacent to something you've already done. *AlphaCore Product Development Director*
	When you're talking about retail banks, it's actually a fairly homogenous market in a fairly homogenous space […] which means that the commonalities that we need to find in an the industry to build a credible industry model is much easier to find in retail banking versus financial markets. *AlphaCore Business Development Manager*
	There is overlap between financial markets and banking and we have actually labelled content along those lines. *AlphaCore Business Development Manager*

In effect, we've set up a unit that now sells externally what we actually did internally. *BetaSuite Unit General Manager*

It all starts with a piece of information which is a job or a task, that ultimately needs to be passed out to a mobile worker who would have to be a delivery driver, a trained technician, a postal worker. So the process is very, very similar. *BetaSuite Commercial Director*

[That customer's] solution is one that is very similar to the Beta internal service that we provide for our own technicians. So, although it was complex, it was easier to adopt for a first customer, because it replicated everything we do for ourselves. *BetaSuite Product Development Manager*

80% of what you do for BetaSuite is replicable in any industry sector. It is the writing of the software and the presentation of the material onto whatever type of device required by the client, [that] needs to be thought of for each individual sector. *BetaSuite Sales Manager*

Realigning

What we are doing, basically, is to facilitate them [customers] with a different view of how can you do a mortgage; let's compare your process with the process that we have in our framework and, in an open mind, let's see if you can learn something from that; and we are pretty sure they will. *AlphaCore Business Development Manager*

By having that framework, you can aim to have some homogeneous understanding, consistency, regardless which line of business or which country you are talking about regarding the mortgage product. So, with our models they can have a reference looking for that consistency, at least try to have everybody on the same page and not different opinions about the same product. *AlphaCore Business Development Manager*

We are coming to an organization who has no clue about real models in development, who have no clue about service architecture; and then you are in the situation where this customer has to be basically educated not only on AlphaCore, but on all the underlying technologies. *AlphaCore Project Consultant*

What needs to be done is bringing into the mind the need to consolidate the terminology and, which is even worse, bring them [customers] to accept our terminology. *AlphaCore Project Consultant*

It takes a lot of requirements gathering, requirements workshops, a whole lot of development, and therefore there's an overhead in terms of resources from us with the customer to ensure that we understand those requirements fully. *BetaSuite Commercial Director*

Rather than us saying that this is the way we measure your performance, we sat down with them and said, how do you want to be measured, what do you actually want to see, what information? And then we built a set of reports up based on what [the customer] wanted, rather than what we thought we could tell them. *BetaSuite Product Development Manager*

I'd had the experience of actually developing the application going into the [customer], sitting down, capturing these specification requirements, developing that application with them and actually trialing it. *BetaSuite Project Director*

We have regular meetings, very informal, and we talk about our issues and our experiences. *BetaSuite Project Manager*

We do sort of review everything every time we go through a major milestone on a project so that we can try and improve or confirm that we're doing things the right way. *BetaSuite Project Manager*

With all the projects that we do, we always conduct post implementation reviews which essentially is, you know, looking at what went well, what didn't go so well, how would we do better, what have we learned, that kind of thing. So that tends to be a team exercise where the team will go through and gets that joint learning and then ensure it is shared. *BetaSuite Solutions Portfolio Manager*

Pooling

We have an online directory system, where you can find out everything about the [Alpha employees]: locations, CV, experience, who they are. It's a wonderful system. *AlphaCore Services Manager*

We have a facility for publishing assets and intellectual property online and sharing them across the company and tracking who downloads them. *AlphaCore Systems Engineer*

We have the ability to use global resources right across the planet both for cost of delivery but also doing things like round-the-clock programming. *Alpha Industry Technical Executive*

My team is a set of specialist consultants, but they would normally be complemented with other consultants from [the professional services division]. *AlphaCore Services Manager*

Beta is a very big company; so, although we have a small core team, if we have a particular piece of work that needs a resource of a special type, that skill exists in Beta. We can take someone out of Beta operationally, and put them on a piece of work for two to three weeks or a month to support us, because they've got a skill that's needed. *BetaSuite Product Development Manager*

	We looked at what we had internally and we used what we had to fit that requirement; but, where we had any gaps, we went to the market and partnered with third party companies. *Beta Subdivision Director*
	If anything involves changing software code, we have the agreements with the partners to do that. *BetaSuite Unit Director*
	Beta's a wide company, with a lot of depth to it, and as long as you know where to go, you can pick up other solutions that we can plug in just as one-offs. So, although we've got a default set, we can add to it. *BetaSuite Product Development Manager*
	We draw on external suppliers. I mean, we obviously have our people who can do aspects of it, and we have support and service infrastructure which is generally Beta; but the hardware and some of the software is coming from our third party suppliers. *BetaSuite Solutions Portfolio Manager*
	Because we're not a very big team, I tend to sort of then work with a couple of other people to do the development of it and our local testing, make sure it gets rolled out, the changes get rolled out. *BetaSuite Project Manager*
	For that technical and physical layer, we have the expertise within my team. For the software integration we have the knowledge and expertise within my team. For the services layer, [for example, support services] we will leverage other parts of Beta, because they provide a 24-hour help desk. *BetaSuite Unit Director*
Integrating	Business service management is an innovation that we have worked on for probably four or five years now, and it is enormously helpful in bridging that gap in enabling, essentially, those two groups to have a much more constructive conversation, because it does focus on the availability of the business process, rather than the availability of the underlying hardware. *Alpha Senior Strategy Consultant*
	We have created one integrated team that will go to market as one. *Alpha Industry Technical Leader*
	The business is actually designing the business scope of the solution, if you like. So, the actual connection with the business is much stronger, and the chances of the solution meeting the business need is much higher. *AlphaCore Services Manager*
	There are on the market different competitors who are having, I think, quite good solutions, but I think that we still are the only organization who has an end-to-end solution. *AlphaCore Business Development Manager*
	The real value that Alpha brings to the market, in addition to the components that I've talked about – the best hardware, the best software, the skills and capabilities – is our ability to orchestrate this and co-ordinate this in a meaningful way for clients. *AlphaCore Industry Technical Leader*
	It's very easy to describe a piece of technology […] It's a little harder to talk about the softer issues, because they happen to be the most important part of any solution delivery. The people aspects, the cultural change, the transformation within the business will all be affected by the deployment of the solution. *BetaSuite, Commercial Director*
	We will offer an end-to-end service for the customer. *BetaSuite Product Development Manager*
	We didn't invent these technologies, they weren't new technologies, they existed in the marketplace. Project management isn't new, we didn't invent that. We didn't invent training, we didn't invent docking stations; but the integration piece… there were parts of that that were new to Beta and definitely new to the customer. *BetaSuite Solutions Implementation Manager*
	The technology we will pick and choose what we consider to be most appropriate to meet the need, which is also perhaps a difference between us and many others. So we just don't have a list of products that we attempt to sell, what we try to sell is a solution, an end to a solution, backed by the experience of understanding of what may work and what may not work, and the importance of people, culture, transformation, benefit realization to support that. *BetaSuite Commercial Director*
	There are certain things that you can implement that just by their nature help you to improve efficiency but perhaps affect individuals' behavior. Tracking is perhaps one of those; it's a very emotive thing putting GPS tracking on a vehicle. It has this peculiar effect of ensuring that people do what they're supposed to be doing, because they think they're being watched over all the time. *BetaSuite Commercial Director*
Metaknowledge-based Patterning	
Design rules and principles	Increasingly, we're embedding our methods into software tools. *Alpha New Product Development Global Expert*

Any technology decisions we take in terms of modelling tools, it's done once through AlphaCore, and the content effectively becomes packages that come within it. So the two [technology, and models], while integrated, should be separated. Technology should not take into account whether that's for banking insurance, or whatever. *Alpha Client Technical Advisor*

It's come out, obviously, in analyses over quite a few years. It's consistent over a number of years and with a number of clients. It's that 80/20 rule. *AlphaCore Services Manager*

The 80/20 rule refers to the rising line of commoditization in Alpha's projects. New application sets for first-of-a-kind projects, 1st or 2nd project with a client, use components which are 50-60% standardized. So at the start its 40/60. By the time [we] move to the 3rd project, it tries to achieve the 80/20 rule. *Alpha Chief Technology Officer*

Processes can be standardized to handle multi-channel, multi-customer segments, so that no matter what kind of process you want to implement, it doesn't really matter what the technology is behind it, the models are still valid. *AlphaCore Project Consultant*

If it was complex, we would take the simple version of that product to standardize it. *BetaSuite Commercial Director*

You get far greater return if you have a far larger, more company-wide deployment of a solution, rather than pockets of 25 or 30 [workers]. *BetaSuite Commercial Director*

I think we should probably stick to 70% common, kind of, generic solution and maybe 30% bespoke. The services are probably more like 80% common. *BetaSuite Commercial Director*

The project management component of the solution is a key activity. It has to be there. *BetaSuite Project Manager*

They're looking at the 70:20:10 rule, which means 70% of everything is standard, 20% is a little bit non-standard and 10% is bespoke; which obviously then increases our ability to match customer requirements. [...] It's formalized in [a document]. *BetaSuite Sales Manager*

Patterns of organizing

You want your best and brightest people not concentrated in development labs, but out there in the field, at the customer's site. *Alpha Senior Strategy Consultant*

In the early part of the sales cycle you want to show all the depth of value that AlphaCore has, but you don't want to give it to the customer, because then you've got nothing to sell. *Alpha Chief Technology Officer*

We are trying to move away from a purely labour-based model to one that's more productive and therefore… we want to make more consistent use of our assets. *Alpha Industry Technical Executive*

So AlphaCore is absolutely open, you can see the whole of it. Do we allow you to see it all before you buy it? No, because that's an IP issue. Do we allow you to see enough of it to be able to take a decision? Absolutely. *Alpha Chief Technology Officer*

We got to a point where the potential number of customers was likely to increase, and therefore we needed a regular forum to discuss the service that we were giving to our customers. *BetaSuite Head of Solutions Implementation*

As we got more customers, with parallel implementations and so on, then you get conflicts in requirements in terms of managing development. So then we needed a more structured approach to decide if it was priorities, and which developments got done. It's a scalability thing, really. *BetaSuite Head of Solutions Implementation*

We had sort of various people in the team potentially going to the supplier, which causes confusion. So we had to stop that and say, no, everything goes through [the unit director]. [...] So, I think we've got that under control now. *BetaSuite Unit General Manager*

We have a really rigorous checklist that says, you know, have we translated the terms and conditions? have we put stuff on the website? have we got enough resources to deliver it? which customers are we expecting to sell this to? what's the forecast? And then when we look at the consultants we'll say, who within the region, or surrounding regions, has the skill sets required to deliver this? *Beta Senior Managing Consultant*

That's a fairly templated approach. We'll do a pre-engagement questionnaire before we go into the workshop, to understand where things are. *BetaSuite Unit Director*

Over the course of the following deliveries, we adopted a much more sort of rigorous requirements capture and scoping process. *BetaSuite Project Manager*