Knowledge Perspectives on Advancing Dynamic Capability

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Knowledge Perspectives on Advancing Dynamic Capability

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Preface

When I finished secondary education in 2000, I was certain that I would never pursue an academic career because I wanted to be educated in practice. Less than four years later, when I finished studying at the Academy for Digital Communication, my thoughts had turned as I knew I was not yet 'done' with education. After a short search, I enrolled in the Master of Business Informatics and after just 1.5 years, I gained two things: a master's degree in Information Science and an interest in knowledge management. The opportunity to work on a PhD thesis presented itself. In retrospect, I would admit that the motivation that initially pushed me to pursue the PhD project was based on something that Alain de Botton refers to as 'status anxiety'. Somehow, I felt that I had to prove to the world that I was capable of doing this. Now, I am all the more grateful that this itch of 'I'll show them' gradually transformed into an enthusiasm for conducting scientific research.

As quickly as I obtained both my bachelor's and master's degrees, the more time I would eventually require to finish this doctoral thesis. Although a part-time position and several life-changing events demanded their toll on the project, it was only after I realized from one of Matthieu Ricard's teachings what I had been missing to really get the project off the ground: a sense of direction. Luckily, that's what I found soon after and it opened a world of new insights and great discussions with fellow researchers and practitioners that eventually resulted in this work.

I'm grateful for the unparalleled experience and advice that colleagues, relations and friends provided during the course of this work. I wish to express my gratitude to Jan-Willem Witte, Jeroen van Zelst, Paul Ten Holter, Mark McElroy, Carla van den Berg, Menno de Jonge, Diane Etman, Paul van den Brink, Eric van Tol, Chris Textor, Coen Flach, Marlies van Steenbergen, Rogier van de Wetering, Marijn Plomp, Slinger Jansen, Inge van de Weerd, Rik Bos, Wiel Bruls, Nico Brand, Leo Pruijt, Macro Spruit, Jaap Kabbedijk, Kevin Vlaanderen, Ravi Khadka and Michiel Meulendijk.

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Thank you Nienke, for your unconditional love and support that was invaluable for me to realize what life is all about and to put this work in the right context.
A special word of thanks to Ronald Batenburg and Ralph Foorthuis, who are co-authors of many of the articles in this dissertation and to whom I am very grateful for their brilliant expertise on statistical analysis that they were willing to share and that helped me to understand statistics as I could not have done without them.
Of course, I am very grateful to Sjaak Brinkkemper and Remko Helms, without whom this dissertation would never have been possible. Thank you Sjaak for your valuable teachings and your continuous trust and support that allowed me to finish this work. Thank you Remko for your rigorous teachings, advice and reviews and of course for your willingness to publish together.
It saddens me to know that René Jorna has suddenly passed away, just moments before I finished writing this work. He has been my great source of inspiration to pursue this research and it was his guest lecture in 2005 at Utrecht University that sparked my interest in knowledge management and sustainability.
Finally, I wish to dedicate this entire work to two gentlemen who unfortunately are no longer among us and to whom science was their life. Whenever I felt myself lacking in energy whilst doing research, the thoughts of their vigorous dedication and vision sustained me. To my grandfather Gerrit van Breevoort and to my schoolmate Chrys Grykień.

Jurriaan van Reijsen, January 2014

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Part I

Introduction

Chapter 1

Introduction

1.1 Motivation

The importance of Dynamic Capability
Every organization is faced with the challenge to stay competitive in order to survive. Yet true firm survival does not lie in a singular competitive advantage, but in the capability to *continuously* create new competitive advantages (Eisenhardt & Martin, 2000; Cepeda & Vera, 2007), since organizations are prone to changes in their market environment. Dynamic Capability (further abbreviated as "DC") is an expression of the ability of organizations to timely and continuously change their resources and routines (Teece et al., 1997; Winter, 2003), allowing them to cope with changing environments (Barreto, 2010) and gain competitive advantage (Teece, 2007). In practice, organizations are continuously confronted with changing conditions, both internally and in their external environment, such as by changes in market demands, competition, technology or regulations. A practical example is the challenge that product managers are faced with regarding continuously changing software requirements, stakeholder demands and product-strategy alignment (Bekkers, 2012). The ability to timely sense those changes and to adequately respond by adjusting processes, operations and resources, such as financial capital, human and technology capital and knowledge-based capital, allows organizations to co-evolve with those changes and develop sustainable competitive advantage. DC is therefore considered the ultimate source of sustained competitive advantage (Teece et al., 1997) and the Holy Grail of strategic management (Helfat et al., 2009). The importance of DC has increased in the last decades, since environments have become increasingly complex (Faber et al., 2005; Barreto, 2010) and the average time that firms can gain benefits from a competitive advantage has decreased (Wiggins & Ruefli, 2005).

The issue with Dynamic Capability
At the same time, scholars and practitioners struggle to grasp let alone advance DC. The concept has been denoted as elusive (Kraatz & Zajac, 2001), abstract and intractable (Danneels, 2008). This is attributable to the fact that DC is difficult to identify in organizations, since it remains hidden until it is exercised

(Easterby-Smith et al., 2009). Moreover, it has been studied from a wide variety of angles, resulting in many definitions and interpretations (Barreto, 2010). Additionally, DC has mainly been an important object of focus in the strategic management domain (e.g. Teece et al., 2007; Helfat et al., 2009) and although there is ample recognition of its importance, an explicit connection has been lacking to another domain on which DC is highly dependent: the knowledge management (KM) domain (Easterby-Smith & Prieto, 2008).

The role of knowledge for Dynamic Capability

Knowledge is the primary asset of the organization (Alavi & Leidner, 2001) and therefore an important resource in itself. In practice, the development and renewal of resources and routines, which constitutes DC, is induced by knowledge and learning (Zollo & Winter, 2002; Cepeda & Vera, 2007). Since DC deals with mechanisms for change (Easterby-Smith et al., 2009), learning is considered a central element in its creation and acts as its source (Zollo & Winter, 2002; Easterby-Smith & Prieto, 2008). It is through learning and knowledge that organizations can adequately adjust resources and routines and respond to changes. This underscores the role of KM, which concerns the management of knowledge processes such as the identification, development and use of knowledge (Alavi & Leidner, 2001). These processes can in fact be regarded as learning processes (Vera & Crossan, 2003) and therefore, KM can be considered as the *"management of learning processes"* (Huysman & De Wit, 2004) or *"managed learning within organizations by providing solutions to these knowledge-associated processes"* (Prieto, 2003; Vera & Crossan, 2003). Since knowledge constitutes the core component of DC (Augier & Teece, 2007) it is considered the most significant resource for the sustainable competitive advantage of firms (Grant, 1996). Also, the increased complexity of and pace in which environments change makes organizations even more dependent on knowledge and learning to respond adequately (Jorna et al., 2004; McElroy, 2008).

The rationale for this research

Surprisingly, although DC's dependency on knowledge has thus been clearly recognized, little effort has been undertaken to elaborately study antecedents of DC from a KM perspective (Easterby-Smith & Prieto, 2008). Research that examines how knowledge may facilitate DC may bridge this gap and shed new light on antecedents of DC, thus uncovering how DC may be advanced from a KM perspective. In doing so, it is important to recognize that various lenses exist through which the link between knowledge and DC can be studied. In one approach, DC may be facilitated by KM policies. The adoption of such policies by

organizations may streamline knowledge processes and learning, thus enabling organizations to improve their DC. But there is another side to knowledge, which recognizes that knowledge is not just an asset that can be codified and managed but is mostly tacit in nature (Polanyi, 1976; Snyder, 1996) and resides in the minds of individuals. In this view, knowledge is also not the sum of individual cognition but it is through the exchange of knowledge in a social process that knowledge is sustained (Lave & Wenger, 1991). Knowledge is therefore understood as a socially constructed and shared resource (Ibid.; Kianto & Waajakoski, 2010). Such social processes are inherently emergent in nature (Van den Hooff & Huysman, 2009) and take place in organizational networks (Brown & Duguid, 1991) or knowledge networks (Cross & Parker, 2004; Back et al., 2006; Helms, 2007). The structural, relational and cognitive conditions of such networks build up the social capital of the organization (Lin, 2001). The condition of these networks will allow or constrain their effectiveness in terms of the performance of knowledge processes (e.g. Teigland, 2003; Wasko & Faraj, 2005; Faraj & Johnson, 2010). Hence, through the quality of social capital and the performance of knowledge networks, DC may be either limited or advanced. Therefore, studying the effect of social capital and the condition of knowledge networks is another lens on knowledge that may shed new light on antecedents that limit or advance DC.

1.2 Key Concepts

The key concepts that are mentioned above and further addressed throughout this dissertation are discussed more elaborately below.

1.2.1 Dynamic Capability

The term Dynamic Capability was coined by Teece et al. (1997) and originally defined as *"a firm's ability to integrate, build and reconfigure internal and external competences to address rapidly changing environments"*. The definition addresses the ability of organizations to change their resources and routines and acknowledges the fact that organizations are confronted with a dynamic and changing market environment. DC seeks to explain why some organizations are better able to survive than others (Teece et al., 1997; Eisenhardt & Martin, 2000). The underlying assumption is that different organizations have varying resources and capabilities and that differences in competitive advantage between organizations are explained through this variation. This notion is derived from the Resource-Based View of the firm (RBV) (Barney, 1986, 1991) and the DC's view is an extension of that view. Easterby-Smith and Prieto (2008) explain that

the RBV was criticized for a focus on internally available resources and routines, lacking an external orientation (Teece et al., 1997). Priem & Butler (2001) noted that the RBV cannot explain competitive advantage in changing environments. The Knowledge-Based view of the firm (KBV), another evolution of the RBV, emphasized the importance of knowledge and focuses of the role of knowledge for competitive advantage. Still, the KBV too assumes that knowledge is yet available in the organization and focuses on its distribution. The DC's view regards organizational resources and routines in context of market dynamism. Therefore, organizations are highly dependent on knowledge of their external environment to timely and justly adapt their resources and routines (Barreto, 2010). Regarding knowledge-based resources and routines, the role of learning for DC is underscored by Zollo & Winter (2002), stating that DC's are the result of learning.

Critiques on DC

DC as a concept has been criticized for being tautological (e.g. Williamson, 1999) in its link to performance (competitive advantage), both because it defines a capability as an ability (Winter, 2002) and because it fails to differentiate between the concept itself and its main promise (Priem & Butler, 2001). However, a solution is provided by Winter (2003) who places DC in context to competitive advantage. Winter (Ibid.) underscores that DC does not reside in the resources and routines themselves but rather in the distinct ability to modify them. Hence, DC should be interpreted as a higher-order capability that influences a zero-level capability, being the operational capabilities. Operational capability is *"how you earn your living"* and DC is *"how you change your operational routines"* (Cepeda & Vera, 2007). An addition to this hierarchy is provided by Helfat & Peteraf (2003) who add learning as a second-order capability that leads to DC. DC was furthermore criticized for a lack of unification of its concept (e.g. Williamson, 1999; Kraatz & Zajac, 2001; Danneels, 2008), which makes it a concept that is difficult to measure.

Unification of views on DC

In a review article on the concept of DC, Barreto (2010) argues that DC is not yet a theory. Contemplating the nature of the concept, he suggests a new and unifying definition for DC: "*the firm's potential to systematically solve problems, formed by its propensity to sense opportunities and threats, to make timely and market-oriented decisions, and to change its resource base*". With this definition, Barreto (Ibid) underscores the multidimensionality of the construct and furthermore shows that DC is not just about building and adjusting a resource base, but more generally about a (generic) problem-solving capability that is

induced by the ability to sense, decision-making and resource reconfiguration. Likewise, Teece (2007) disaggregated DC into sensing, seizing and asset maintenance. Also, the promise of DC has been stretched over time as e.g. Zollo & Winter (2002) mention the pursuit of improved *effectiveness* and Zahra et al. (2006) relate to any goal *deemed appropriate* by management. In sum, DC may be seen as the ability of organizations to cope with changing environments that has learning as its input and sustainable competitive advantage as its output, impacting the organization's operational processes.

1.2.2 Sustainable Innovation

A concept closely related to DC is sustainable innovation. Founding authors of this concept are Jorna, van Engelen and Hadders (2004) and McElroy (2003). Sustainable innovation may be defined as "*a pattern of rules or requirements for organizational learning and problem solving which helps its practitioners to adapt*[1]*"* (McElroy, 2006). Its link with DC becomes apparent as sustainable innovation too relates to the capability of organizations to solve problems (just as with DC) (Barreto, 2010), the capacity to adapt to changing conditions and the role for learning. A key distinction between DC and sustainable innovation is that the former concept focuses on competitiveness while the latter concept explicitly considers sustainability. This is evident from the notion that sustainable innovation *"produces solutions that solve current knowledge problems without side effects"* and that it maintains (and not drains) the capacity of the system (the organization) (Jorna et al., 2009). Sustainability can be compared to sustainable competitive advantage in the DC view, since both concern firm survival. However, while competitiveness is a main goal in the DC view, sustainable innovation alternatively goes beyond firm survival and additionally includes the sustainability of the environment that the firm interacts with. This makes sense, since in an unsustainable environment there is no soil for organizations to survive either.

Dimensions of Sustainable Innovation

Notwithstanding, sustainability would require an organization to have two things: 1) knowledge of its impact on the world and 2) the capacity to learn and adapt in response (McElroy, 2006). The former aspect is referred to as *Knowledge of Sustainability* (*KoS*) and concerns a content view towards knowledge that considers the knowledge required to adequately adapt. This is comparable to the

[1] The full definition of sustainable innovation is: *"a pattern of rules or requirements for organizational learning and problem solving that is more effective than mainstream approaches to innovation management, and which helps its practitioners to adapt"*. This shortened definition emphasizes the role of learning and the ability to adapt.

resources involved in the DC view. The latter aspect is referred to as *Sustainability of Knowledge (SoK)* and takes a process view towards knowledge, underscoring the need for organizations to develop processes for knowledge acquisition and integration (Jorna et al., 2009). This is comparable to the *processes* or *routines* involved in the DC view. In light of sustainable innovation, organizations are regarded as multi actor systems (MAS) (Ibid.), underscoring the role of the adaptive capabilities of humans that governs organizational adaptation. McElroy (2006) developed a KM policy model that organizations can adopt in the aim to advance sustainable innovation. This policy model is referred to as *The Sustainability Code*. Given its close relation to DC, this policy model can serve as an adequate means to advance DC from a KM perspective.

1.2.3 Knowledge and Knowledge Management

Organizations have become increasingly aware of the importance of knowledge for survival (Easterby-Smith & Prieto, 2008). Knowledge is nowadays considered the most important asset of organizations (Alavi & Leidner, 2001). Knowledge management is defined as *"managing the corporation's knowledge through a systematically and organizationally specified process for acquiring, organizing, sustaining, applying, sharing and renewing both the tacit and explicit knowledge of employees to enhance organizational performance and create value"* (Davenport & Prusak, 1998). As discussed, since these processes concern learning processes, KM can in fact be regarded as the management of learning processes in organizations (Vera & Crossan, 2003; Huysman & De Wit, 2004). The importance of knowledge and KM in organizations too, stems from an evolution of the RBV into the Knowledge-Based View of the firm (KBV) (Grant, 1996) that recognizes knowledge as the most strategically significant resource for competitive advantage.

Generations of KM

The way in which organizations have regarded knowledge, has shifted over time. Formerly, knowledge was deemed to be already available in the organization. The primary goal of KM then was to codify and distribute the knowledge throughout the organization whenever required by management. Therefore, focus was mainly put on technology (IT systems) in order to facilitate codification and distribution of knowledge. In a later view, organizations additionally recognized the importance of knowledge creation and evaluation. Moreover, knowledge was no longer regarded as the possession of an individual but more as a collective process that is sustained organization-wide through social interaction. In this approach, the role of human (HR) aspects are recognized, stressing the role of all individuals instead of merely management in knowledge processes and the notion that

knowledge sharing cannot be forced by management but that employees should instead be motivated to participate in knowledge processes. Both former and latter approaches towards KM are typified as first and second generation KM (McElroy, 2003) or as first and second wave KM (Huysman & De Wit, 2004). In the second generation of KM, the IT-focus and human-focus are not exclusive views. Instead they complement each other, e.g. in the contingency view on KM (Hansen et al., 1999) that discusses a mix of the codification and personalization of knowledge. A third wave of KM has been described by Wenger (2006), who recognizes an additional focus of knowledge as a strategic capability. Here, knowledge is regarded as a strategic asset, which is in line with Grant's (1996) and Alavi & Leidner's (2001) view that knowledge is the most important strategic asset and underscores the role of knowledge for DC.

Critiques on KM

KM has been criticized, mainly on the basis of the question if knowledge can actually be managed. It can be argued that knowledge is in fact difficult to manage (e.g. Van Den Hooff & Huysman, 2009; Vera & Crossan, 2003). The primary reason for this notion is that most knowledge is in fact tacit in nature (Snyder, 1996) instead of explicit and therefore difficult to codify. The tacit nature of knowledge makes that knowledge resides in the minds of people, making the individual the focal point for knowledge processes (Nonaka, 1995; Grant, 1996). It is through social interaction and exchange between individuals that knowledge is sustained throughout the organization (c.f. Cook and Yanow, 1993; Nicolini and Meznar, 1995; Nicolini et al. 2003; Laursen & Salter, 2006). This shift in thinking can be characterized as the social dynamics of knowledge and is central to today's thinking about knowledge (Van den Hooff & Huysman, 2009).

1.2.4 New Knowledge Management

The New Knowledge Management (NKM) is a specific second generation approach towards KM and was coined by McElroy (2003). NKM is the theoretical foundation on which *The Sustainability Code* is based (McElroy, 2006); the KM policy model that aims at advancing sustainable innovation in organizations. NKM is pillared by four cornerstones. The theoretical body of these cornerstones is not completely new, but unique through its focus on the evaluation of knowledge and the claim that its application in practice advances sustainable innovation in organizations. First, the *Knowledge-Life-Cycle (KLC)* cornerstone underscores the cyclical flow of knowledge in organizations (i.e. the knowledge processes as defined by Davenport & Prusak, 1998) and stresses the importance of evaluating the fallibility of knowledge. Second is the cornerstone of the *Open Enterprise (OE)*. This cornerstone advocates the separation of knowledge processes from

decision making and opening up participation in knowledge processes to all employees in the organization. Third, the *Knowledge Management (KM)* cornerstone underscores the importance of a distinct KM function in the organization that is separate from the executive function and is independent in its resources. Fourth is the *Complex Adaptive Systems (CAS)* cornerstone that is inspired by the work of Holland (1995) and promotes that organizations should exploit the self-organizing behavior of humans. Humans and collectives of the same are regarded as complex adaptive systems that will intrinsically adapt to changing conditions.

Critiques on New Knowledge Management

The original NKM proposition (McElroy, 2003) has been criticized in the past, mainly for a lack of practical guidelines for organizations to adopt NKM in practice (Connell, 2003; Nowe; 2003; Loan, 2006). This is probably what led McElroy (2006) to develop *The Sustainability Code*, which is a practical approach towards the four cornerstones of NKM. The code comprises a total of 15 KM policies that organizations can adopt in practice, aiming at leveraging sustainable innovation.

1.2.5 Social Capital

Through the shift in thinking about knowledge, it is now understood as a socially constructed and shared resource (Kianto & Waajakoski, 2010). A means to regard and value this resource is through the concept of social capital, which is an expression for the availability of social relations, trust and shared values in organizations (Coleman, 1988; Adler & Kwon, 2000; Lin, 2001). Social capital can be defined as *"resources embedded in social structure that are accessed and/or mobilized in purposive actions"* (Lin, 2001). The social capital view respects the relational view towards knowledge (Brown & Duguid, 1991; Lave & Wenger, 1991; Nahapiet & Ghoshal, 1998; Cohen & Prusak, 2001) and considers social capital to consist of both the network of individuals and the assets that may be mobilized through it (Van den Hooff & Huysman, 2009).

Dimensions of Social Capital

Social capital can be divided into several dimensions. One way to distinguish distinct forms of social capital is through a *structural*, *relational* and *cognitive* dimension (Nahapiet & Ghosal, 1998). The structural dimension represents the organizational network of individuals that exchange knowledge. The relational dimension concerns the extent of shared values and trust among the network members and the cognitive dimension regards the extent to which network members have a common context and language. A different way to dimension social capital is to distinguish between the benefits of social capital for the

individual network member, referred to as ego-centric social capital and the benefits of social capital for the network as a whole (socio-centric social capital) (Adler & Kwon, 2002). Finally, a distinction can be made between internal and external social capital (Kianto & Waajakoski, 2010) where the availability of social capital is addressed within the organization and between the organization and other organizations respectively.

The availability of social capital is important for organizations, since it provides the infrastructure for employees in organizations to exchange knowledge and the conditions for employees to connect (Adler & Kwon, 2002). Outcomes of social capital such as improved knowledge flows and collaboration have been recognized by the same authors.

1.2.6 Knowledge Networks

A related way to regard the social dynamics of knowledge in organizations is by further zooming in on the network perspective of knowledge. In a related stream of literature, knowledge processes have been studied by means of exchange patterns between knowledge workers in social networks. A social network is defined as *"a finite set or sets of actors and the relation or relations defined on them"* (Wasserman & Faust, 1994). In the context of knowledge in organizations, these social networks represent the *structural* dimension of social capital. Organizational networks exist in a variety of forms, such as communities of practice (Wenger & Snyder, 2000), networks of practice (Brown & Duguid, 2000; Teigland, 2003) or knowledge networks (Helms & Buysrogge, 2006; Back et al., 2006; Helms, 2007). Such forms differ in their purpose and dimensions. A community of practice for example, thrives on the passion and interest of members to participate and may fall apart if members lose interest in maintaining the group (Wenger & Snyder, 2000), while a knowledge network denotes more generally a group of employees that exchange knowledge regarded from a network perspective and may thus be represented by means of an organizational department or business unit.

Two forms of exchange that closely relate to knowledge are found in advice-seeking relations (Rhee, 2004; Faraj & Johson, 2010) and learning relations (Škerlavaj et al., 2010). The former form of exchange concerns knowledge that helps individuals to complete their daily activities and contain e.g. solutions to problems or validations of ideas (Cross et al., 2001) and is ad hoc in nature. The latter form concerns more long-term exchange e.g. in the form of a master-apprentice relation (Helms, 2007).

Linking knowledge networks to outcome
The structural make-up of knowledge networks will vary among organizations and like differences in social capital, differences in the composition of knowledge networks may limit or advance effective knowledge exchange in those networks (e.g. Teigland, 2003; Wasko & Faraj, 2005; Helms & van Reijsen, 2008; Faraj & Johnson, 2010). Ample studies have investigated how the structure of organizational networks influences the performance of those networks (e.g. Sparrowe et al., 2001; Teigland, 2003; Ashworth & Carley, 2006), either through a conceptual or an empirical approach. A comprehensive overview of network studies is provided by Nieves & Osorio (2012). In order to study organizational networks, scholars and practitioners have adopted measures of structural properties from the sociology domain. Examples are *density* that expresses the degree to which actors in a network are linked to one another (Hanneman & Riddle, 2005) or *centrality* (Wasserman & Faust, 1994) that expresses differences in the relative position of individuals and the effects that these differences yield towards the individual and the network as a whole. In network analysis, such network structure variables are applied to study the condition of the network.

1.2.7 Absorptive Capacity

Another key concept in this dissertation is Absorptive Capacity (further abbreviated as "ACAP"). ACAP is incorporated in this study since it is closely related to DC, KM and learning. The term ACAP was coined by Cohen & Levinthal (1990) and was defined as *"the capacity to recognize the value of new external information, assimilate it and apply it to commercial ends"*. This definition underscores the close link between ACAP and DC and highlights both the sensing and seizing aspects of DC and the importance of external knowledge. ACAP is moreover regarded as the DC that is related to learning (Noblet et al., 2011). Likewise, Camisón & Forés (2010) define ACAP as the DC that allows organizations to gain and sustain competitive advantage through the management of external knowledge. The concept of ACAP is embedded in the debate on DC (e.g. Zollo & Winter, 2002; Helfat et al., 2007; Teece, 2007) and is regarded as a specific form of DC by Zahra & George (2002).

Dimensions of Absorptive Capacity
These latter authors stipulate that ACAP is a multidimensional construct and distinguish four dimensions:

1) *acquisition*, which refers to recognizing and acquiring external knowledge (Lane & Lubatkin, 1998; Zahra & George, 2002);

2) *assimilation*, which refers to integrating external knowledge through knowledge routines (Zahra & George, 2002);
3) *transformation*, which expresses the ability to combine new external knowledge with existing knowledge (Noblet et al., 2011); and
4) *exploitation*, that focuses on the ability to utilize the external knowledge to achieve organizational goals (Lane & Lubatkin, 1998).

The recognition of these dimensions underscores the relation of ACAP with learning, since the four dimensions are corollary to the processes of exploratory, assimilative, transformative and exploitative learning (Lane et al., 2006; Gebauer et al., 2012). The importance of ACAP for organizations has been underscored by various authors and may result in benefits such as innovation (Tsai, 2001), business performance (Gupta & Govindarajan, 2000), competitive advantage (Lichtenthaler, 2009), innovation and strategic flexibility (Zahra & George, 2002) and the ability to innovate, adapt to changes and be competitive (Daghfous, 2004; Escribano et al., 2009; Jiménez-Barrionuevo et al., 2011). Of special relevance is the focus that ACAP puts on external knowledge, since especially external knowledge is relevant for organizations to gain competitive advantage (e.g. Camisón & Forés, 2010).

The link between ACAP and DC

ACAP can be seen as an embodiment of DC and is incorporated in this study for two reasons. First, through its relation with DC, learning and knowledge, it helps to better understand the role of knowledge for DC and to put the various concepts in context. Secondly, the Concept of ACAP is currently better operationalized than the concept of DC. Although earlier operationalizations of both concepts have criticized (c.f. Barreto, 2010 for DC and Flatten et al., 2011 for ACAP), to date, a comprehensive operationalization of DC does not yet exist (Easterby-Smith & Prieto, 2008; Barreto, 2010). An exception is the work of Cepeda & Vera (2007), although even in their approach, objective proxies have been applied. On the other hand, recently, several operationalization initiatives for ACAP have been employed (e.g. Camisón & Forés, 2010; Flatten et al., 2011; Noblet et al., 2011; Jiménez-Barrionuevo et al., 2011). Given the close relation between DC and ACAP, such operationalizations facilitate research efforts that study both concepts alike.

1.2.8 Integration of the key concepts

Now that the key concepts of this dissertation are introduced in more detail, an integration of the concepts is proposed. A key fundament for this integration is the notion by Winter (2003) of the *capability hierarchy*. This notion describes how *learning* as a second-order capability leads to *dynamic capability* as a first-order

capability. The result of DC then results in *operational capability* as the zero-order capability. Eventually *operational capability* results in competitive advantage. In figure 1.1 below, we propose a model that visualizes this hierarchy of capabilities and places the other concepts discussed in this chapter in context of that hierarchy. As a basis for this model, a previous model by Easterby-Smith & Prieto (2008) is adopted that they simply referred to as an "integrative framework". Their model depicts the interplay between learning, KM and DC and puts these concepts in context to operational capabilities and the anticipated outcome of sustained competitive advantage. However, we adjusted the original model, given a note of critique. In the original model, DC is modelled as an explicit entity, identical to KM (i.e. KM being an explicit entity in the model). DC, however, differs from KM in the sense that DC is not a tangible process or discipline, but rather a *"potential to do certain things"* (Dougherty et al., 2004). Likewise, operational capability should not be modelled as a distinct entity, but rather as a *potential* as well. Cepeda & Vera (2007) explain that *operational* capability is *"how you earn your living"* and that *dynamic* capability is *"how you change your operational routines"*. Therefore, the former capability resides in the *application* of operational routines and organizational resources and the latter capability resides in the *reconfiguration* of the two. This idea is reflected in our adjusted model below that we coin as the "Knowledge-Based Dynamic Capability Model" (KDC model).

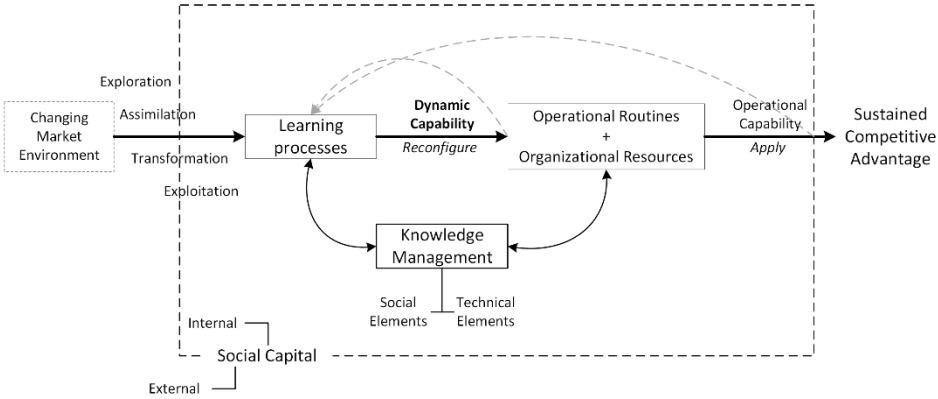


Figure 1.1. The Knowledge-based Dynamic Capability Model

Furthermore in the KDC model, KM is modelled as the discipline that *engineers* the learning processes. The contribution of KM is its differentiation between knowledge as an asset and knowledge as a social process and its contribution of strategy and tactics. The arrow between learning and KM is bi-directional, since the result of learning can in turn improve the KM practice. KM additionally links

to the operational processes and routines for two reasons. First, because knowledge is a resource in itself and may therefore reinforce the organizational resources. Secondly, KM not only plays a role in managing learning processes, but additionally has a responsibility to support operational routines where knowledge is involved.

The major square represents the organization and at the same time, it represents the social capital of the organization. Social capital is the *infrastructure* in which all of the modelled processes take place and in which all of the organizational resources and routines reside. It is through the availability of the structure, shared values and mental models in the organizational network that these processes are performed and these resources are made available. Besides internal social capital, the organization can also leverage external social capital, i.e. the resources that reside in the social structure with external partners, which is also incorporated in the model.

ACAP is also present in the KDC model and resides in the learning processes that manifest between the changing market environment and the organization itself. Through these learning processes, the organization is enabled to explore external knowledge and exploit it in the reconfiguration (and application) of its routines and resources. It is the effectiveness of these learning processes that shapes the ability to reconfigure resources and routines and to apply them further down the capability hierarchy in the model with the aim to achieve sustained competitive advantage.

Furthermore, the KDC model contains two feedback loops: from the reconfiguration and the application of routines and resources back to learning. This reflects the fact that organizations not only learn based on new (external) knowledge from their market environment, but also based on internal feedback such as the results of their operational processes. The result of the application and reconfiguration of routines and resources feeds back as learning in the organization.

Some final thoughts about the KDC model deserve attention. One is that the model fits a differentiation between an asset, capability and relational approach that Kianto & Waajakoski (2010) describe as approaches towards competitive advantage. All three approaches are captured in the model and feature as determinants for competitive advantage. Another thought is that the *reconfiguration* and *application* of routines and resources are not per se a guarantee for sustained competitive advantage. It is only when reconfiguration and application based on learning are performed *successfully* and indeed lead to sustained competitive advantage that an organization is said to have a DC.

1.3 Research Questions

With the KDC model in place, a link is drawn between various perspectives on knowledge and their role as antecedents for DC. This link, however, is understudied, especially empirically. Prior empirical research that investigated antecedents of DC mainly stem from the strategic management domain. Examples are Rindova & Kotha (2001), King & Tucci (2002), Lampel & Shamsie (2003), Kor & Mahony (2005), Pil & Cohen (2006), Karim (2006), Rothaermel & Hess (2007), Danneels (2008) and Van der Weerdt et al. (2012). A more evident link from this domain to the KM domain is found in Blyler & Coff (2003) who investigate the role of social capital for personal rents in organizations that have a DC. Their research, however, takes an ego-centric approach towards social capital, while in this thesis, a socio-centric approach is adopted in order to study social capital on a multi-actor (e.g. group or organization) instead of a single-actor level. From the KM domain, Cepeda & Vera (2007) investigated the role of KM on the connection between dynamic and operational Capabilities, which is one example of a knowledge-related antecedent study of DC.
Guided by the importance of knowledge and learning for DC, this thesis intends to extent and expand the knowledge-related antecedent research and proposes as its main research question:

MRQ: *How can dynamic capability in organizations be advanced from a knowledge perspective?*

Distinctiveness and overlap between the knowledge perspectives
This main research question is broad in the sense that it encompasses all perspectives on knowledge that were discussed above. In order to make the main research question more concrete, it is broken down into several sub-questions that distinctively address each perspective on knowledge. These perspectives are not completely disjunct to the extent that they all concern knowledge in organizations. However, differentiations exists. One differentiation is that the KM perspective on knowledge is an *engineering* approach towards knowledge, while the social capital and knowledge network perspectives are *emergent* approaches towards knowledge. An engineering approach focuses on management interventions to facilitate knowledge processes, while an emergent approach is concerned with the social nature of knowledge, focusing on the availability of conditions that facilitate knowledge processes (Van den Hooff & Huysman, 2009). The engineering approach acknowledges the emergent nature of knowledge and therefore, both approaches are complementary. Indeed, the engineering approach can support conditions in the emergent approach (Ibid.). In

this dissertation, both an engineering approach (KM) and an emergent approach towards knowledge (social capital and knowledge networks) are studied as antecedents of DC. Social capital and knowledge networks both overlap and differ as perspectives on knowledge. Their overlap is found in the fact that knowledge network analysis studies the *structural* dimension of social capital, i.e. the connections between employees. However, although social capital is mainly concerned with the *availability* of that structure and to what extent it supports or limits organizational goals, the knowledge network approach (i.e. conducting knowledge network analysis) zooms in on the depth of this dimension of social capital and is concerned with the *structural properties* instead of merely the availability of the connections between actors. The knowledge network approach towards knowledge is therefore positioned as a zoom lens on structural social capital.

The knowledge management perspective towards knowledge
The approaches towards knowledge are now captured in three sub-questions.

RQ1: *To what extent can dynamic capability in organizations be advanced through knowledge management?*

The link between KM and DC becomes apparent from the integrative model. Foremost, DC is dependent on knowledge through a learning cycle of exploration and exploitation (Zollo & Winter, 2002). The ability to perform both exploration and exploitation learning processes (Ambidexterity, Raisch & Birkinshaw (2008)) gives rise to DC. Through KM, or the management of learning (Vera & Crossan, 2003), these processes can be enhanced (Swan et al., 2000) so that in turn, they may improve DC. Additionally, Eisenhardt & Martin (2000) argue that learning and KM guide the development of DC, given their nature as organizational routines. In studying the potential impact of KM on DC, a comprehensive approach should be followed that regards how both the technical and social side of KM can impact DC. Hence, an exploration of the link between the adoption of a second generation (McElroy, 2003; Huysman & De Wit, 2004) KM approach by organizations and their DC may appropriately shed light on the role of KM for DC.

The social capital perspective towards knowledge
The second perspective on knowledge is that of social capital. The corollary research question is formulated as follows:

RQ2: *To what extent can dynamic capability in organizations be advanced through social capital?*

By taking a social capital perspective towards knowledge, a relational approach towards competitive advantage is adopted (Kianto & Waajakoski, 2010) that concerns the infrastructure in which knowledge and learning processes take place. This approach acknowledges the emergent and socially embedded nature (Brown & Duguid, 2001) of knowledge. It allows to explore how the structure, quality and cognitive ability of that infrastructure (Nahapiet & Ghosal, 1998) can limit or advance DC. Grant (1996) argues that social capital is a key mechanism for knowledge integration, underscoring the role of social capital for the knowledge and learning processes that are connected to DC. Moreover, Blyler & Coff (2003) argue that social capital is an essential component of DC, since it enables the management of resources (and routines). Also, Prieto & Easterby-Smith (2006) underscore that especially social elements of knowledge can activate DC. Hence, studying the availability of social capital in organizations and their DC may shed light on the role of social capital for DC.

The knowledge network perspective towards knowledge

Finally, the knowledge network perspective is adopted that zooms in deeper on the infrastructure in which knowledge, learning and dynamic processes take place. Since these processes primarily take place in organizational networks (e.g. Brown & Duguid, 2001; Teigland, 2003; Back et al., 2006; Helms, 2007; Agterberg et al., 2010), it is relevant to dive deeper into the fabric of social capital and more explicitly study the properties of such networks, allowing for a closer exploration of their role for DC. At the same time, since the analysis of knowledge networks can be performed in various ways, through various sources of network data (e.g. Culotta, 2004; Tyler et al., 2005; Helms, 2007; Johnson et al., 2012) and is an intensive and time-consuming process (Teigland, 2003; Škerlavaj et al., 2010) it also makes sense to explore the available tools and techniques to conduct knowledge network analysis in order to select a best suitable means to study knowledge networks and their role for DC. Therefore, an intermediate research question is formulated:

RQ3: *What knowledge network analysis tools and techniques are available and how to they relate?*

Guided by an appropriate approach to study knowledge networks in organizations, their role for DC can be further examined. Driven by the notion that knowledge and learning processes take place in organizational networks, the role of such networks for knowledge processes has been extensively studied in literature, for example their role for team performance, as mentioned earlier (e.g. Sparrowe et al., 2001; Teigland, 2003; Ashworth & Carley, 2006). But their role

for learning processes has also received a lot of attention. Rhee (2004) for example, mentions that social networks are the locus of learning. Moreover, Capaldo (2007) illustrates that as learning takes place in the social network of an organization, this enhances its ACAP, which in turn increases its capability to innovate. In fact, the socialization of knowledge affects all learning processes (Gebauer, 2012) and Jansen et al. (2005) empirically found that socialization capabilities will strengthen the learning processes of ACAP. As discussed, many authors illustrated that the structure, i.e. the condition, of knowledge networks will influence the extent to which such networks are capable to learn effectively. Since the effectiveness of learning will influence DC either as a *process* (the result of learning influences DC) (Zollo & Winter, 2002; Easterby-Smith & Prieto, 2008) or because learning is a DC in itself (Zahra & George, 2002; Noblet et al., 2011), the structure of knowledge networks may advance or limit DC in organizations. Therefore, a final research question is proposed:

RQ4: *To what extent can dynamic capability in organizations be advanced through the structure of their knowledge networks?*

With regard to this question, it is especially important to consider the type of network under examination, for example in terms of level of focus (individual actors versus groups). Various authors (e.g. Ahuja, 2000; Koka & Prescott, 2008) stress that an optimal network structure for knowledge creation may be different for individuals than for groups, similar to the differentiation between the benefits of ego-centric and socio-centric social capital. Likewise, recent authors (Mors, 2010; Rost, 2011; Nieves & Osorio, 2012) stress that the context of whether knowledge is internally available or externally accessed and integrated may determine what network configuration optimally contributes to learning. In the context of DC, external knowledge plays a dominant role (Blyler & Coff, 2003; Barreto, 2010) since DC is concerned with the adaptability of the organization based on changing environments. Therefore, by taking into account the type and context of knowledge networks, their role for DC can be appropriately studied.

1.4 Research relevance

Although the importance of the KM domain for DC is recognized, little attempt has been undertaken to study its role in detail (Easterby-Smith & Prieto, 2009). This research intends to bridge that gap by empirically investigating how DC can be advanced from the discussed knowledge perspectives: through a 1) KM, 2) social capital and 3) knowledge network lens. By connecting DC to knowledge

perspectives in detail, theory on the antecedents of DC is advanced and the gap between DC and the KM domain is narrowed. To this extent, this dissertation answers the call to better integrate knowledge concepts into the research agenda of DC (Easterby-Smith & Prieto, 2008). For example, Majchrzak (2009) calls to connect communities (a form of organizational networks) to better understand their role for DC. Also, Nieves & Osorio (2012) call for additional research on the role of social networks for knowledge creation, one of the processes that underlie learning (Vera & Crossan, 2003). Explicitly linking DC and the three perspectives on knowledge may contribute to theory on all research strands: it may strengthen the available body of knowledge on the role of KM, social capital and knowledge networks for DC that allow it to prosper. Furthermore, this research intends to contribute to the theory on these four research strands by operationalizing their constructs and developing tools and techniques that (better) allow empirical exploration of their underlying concepts. For some concepts, adequate operationalizations already existed, such as for the measurement of social capital (Kianto & Waajakoski, 2010). For other concepts, this research proposes new operationalizations. An operationalization is proposed for the measurement of The Sustainability Code, i.e. the adoption of these KM-related policies by organizations. Furthermore, in co-development with other authors (Noblet et al., 2011) an operationalization is proposed for the measurement of ACAP in organizations. From a practical stance, organizations can be benefitted by this research for multiple reasons. First, the research provides insight in ways that organizations can leverage knowledge, which is their most important asset (Alavi & Leidner, 2001) to develop and improve DC, which in turn allows organizations to develop and sustain competitive advantage. In doing so, this research aims to provide organizations with multiple approaches towards knowledge, in the form of both KM policies and an insight in how they can influence their social capital. Guided by the right KM interventions and the right ways to stimulate their social capital and organizational networks, organizations may, through this research, be better able to develop DC and advance their competitive edge. Moreover, the proposed operationalizations for key concepts of this study may allow organizations to test and benchmark their current condition of knowledge, DC and ACAP, enabling them to draw a starting point and, through the results of this research, devise a strategy for improving their DC.

1.5 Methodology

This section provides an overview of the applied research methodology throughout this dissertation. Various research methods are applied throughout the chapters of this work, such as survey research and social network analysis.

Survey research and statistical analysis

One of the main methods applied throughout this dissertation is survey research. Multiple surveys have been conducted in various organizations to acquire data for statistical analysis. In chapters 2, 3, 4 and 8 one or multiple surveys were conducted. Through two surveys, the extent to which organizations adopted KM policies and their current state of DC was explored (n_1=30 and n_2=55 organizations, applied in chapter 2 & 3 and 4 respectively). The latter survey additionally functioned to assess the availability of social capital in organizations (n_2=55 organizations, applied in chapter 4). In a third survey, levels of ACAP in organizations were explored (n_3=48 knowledge networks, applied in chapter 8). The tool that was applied for conducting these surveys is LimeSurvey 2.0.

In the chapters were survey research was applied, the output of those surveys was used in statistical analysis to process the data into research findings and conclusions. In chapters 2, 3 and 7, first generation statistical analysis techniques were applied such as correlations and t-tests. In this case, a reflective approach was adopted towards the formulation of the constructs and the development of the research model. Reflective indicators are determined by their construct so that changes in the construct will cause changes in all associated indicators of that construct (Diamantopoulos & Siguaw, 2006). Therefore, its indicators are expected to covary. The reflective approach thus requires standard validity tests such as tests for convergent validity and reliability, which were applied in these chapters. Furthermore, basic statistical analysis techniques are applied in chapter 5 to compare different social network analysis data capturing techniques. The tool that was used for the validation and analysis of the data here, is SPSS.

In chapters 4 and 8, a formative approach towards construct and model formulation and evaluation was applied. In a formative approach, indicators represent different aspects of a construct and together cause changes in the construct. A formative approach is thus more appropriate when studying constructs that are multidimensional in nature, such as ACAP (Zahra & George, 2002; Noblet et al., 2011). In both chapters, the formative models were designed and tested using the second generation technique PLS-SEM (Hair et al., 2013) and by using formative tests for evaluation such as indicator weights, loadings and Variance Inflation Factors (VIF) (Hair et al., 2011). The tool that was used to model and evaluate the formative models is WarpPLS (Kock, 2012).

Case study research

The advantage of case study research is that it can be applied both for theory building and theory testing (Yin, 2003). In chapter 5, an exploratory case study approach was adopted in order to build theory on the similarities and differences between various methods for social network data capturing techniques in an

organizational setting. In chapter 8, a retrospective case study approach was adopted in the form of several structured interviews with the organizations that participated in the knowledge network analysis surveys. The interviews were intended to confirm the results of the network analysis with the C-level managers of the participating organizations and verify if the knowledge networks (sociograms and properties) could be expected to be true to nature.

Social Network Analysis (SNA)

In chapters 5, 7 and 8 sociometric surveys were conducted in organizations to gather data that enables the formulation of their knowledge networks. Knowledge networks were surveyed in several organizations, varying in size, expressed in the amount of network actors: n_4=41 (applied in chapter 5), n_5=79 (applied in chapter 7), n_6=128, n_7=40, n_8=100, n_9=100, n_{10}=74 and n_{11}=100 (applied in chapter 8). In order to compute structural properties of these knowledge networks, social network analysis tools were applied. The tools that have been applied here are Netminer (Cyram, 2011) and UCINET (Borgatti et al., 2002).

Design-science research

In chapter 6, principles of design-science research (Hevner et al., 2004) were adopted. In design-science, an approach of building and testing artifacts is applied in order to meet business requirements. This is in contrast to the behavioral-science approach that aims at theory building and testing to explain organizational and human phenomena, which is applied in the chapters where statistical analysis was applied. A design-science approach was adopted to develop a new tool that allows capturing data on both the structure and the content of knowledge networks.

An overview of applied research methodology per chapter in this dissertation is provided in table 1.1 below.

Table 1.1. Overview of applied research methodology per chapter

	Chapter						
Research method	2	3	4	5	6	7	8
Survey research	x	x	x				x
Statistical analysis: Reflective / Basic	x	x		x		x	
Statistical analysis: Formative / PLS-SEM			x				x
Case study research				x			x
SNA & Sociometric surveys				x		x	x
Design-science research					x		

1.6 Dissertation Outline

The dissertation comprises six parts. Four parts each cover one of the research questions of this thesis, preceded by an introduction part (this chapter) and complemented by a part that concludes the research. Each part is briefly described in the outline below. Links between the four main parts and the research questions are provided.

I Introduction

Chapter 1. Introduction
This first chapter describes the motivation of this research. Moreover, it elaborates and integrates the key concepts of the study. Research relevance is provided, an overview of applied methodology is provided and the remainder of the thesis is briefly introduced in an outline of the thesis.

II Knowledge Management and Dynamic Capability

Chapter 2. Impact of Knowledge Management on Dynamic Capability
This chapter studies how organizations may advance DC through the adoption of formal KM policies. In doing so, a suitable operationalization for second generation KM policies that relates to DC is found in a KM policy model called *The Sustainability Code* (McElroy, 2006). This policy model is based on the KM perspectives set forward in *The New Knowledge Management* (McElroy, 2003). Through survey research and the statistical analysis of 30 Dutch knowledge-intensive organizations, the impact of KM policy adoption on DC is tested. The chapter concludes with a finding in favor of adoption of this KM policy model to advance DC and therewith provides an answer for RQ1. This work has been presented as "Validation of the New Knowledge Management Claim" at the 15th European Conference on Information Systems in St. Gallen, Switzerland, and is published as a research paper in the Proceedings of ECIS 2007.

Chapter 3. Organizational Conditions for Dynamic Capability
Based on the research conducted in chapter 2, this chapter examines the organizational conditions that could be beneficial for the adoption of the KM policy model in light of advancing DC. Among these conditions are organizational size, hierarchy, value proposition and the active use of a KM IT system. Based on distribution tests in a sample of 30 Dutch knowledge-intensive organizations,

organizational conditions that are related to the cause are uncovered. The chapter concludes by pointing out several organizational conditions that may help organizations to adopt the KM policy model and supports to answer RQ1. This work has been presented as "Organizational Conditions for New Knowledge Management Application" at the 8th European Conference on Knowledge Management in Barcelona, Spain, and is published as a research paper in the Proceedings of ECKM 2007.

For both chapters 2 and 3 we would like add a note about terminology and methodology. First, at the time that this research was conducted (2006) some ambiguity prevailed about the correct use of terminology for the proposed outcome of the adoption of the KM policy model. Later, an article by Jorna et al. (2009) clarified the terminology. Where chapters 2 and 3 refer to '(corporate) sustainability', in fact 'sustainable innovation' should be used instead. This term best describes the outcome of the KM policy model and best aligns with the DC concept, as discussed in this work.
Second, in these chapters, a reflective approach towards the studied constructs was taken. Through progressive understanding, we acknowledge that one construct studied in these chapters (the KM policy model) would prefer a formative approach, due to its multidimensional nature. Although this deviation is primarily decisive for the way in which the validity of the construct should be evaluated, it should not influence the statistical analysis that links this construct to its dependent variable (DC).

III Social Capital and Dynamic Capability

Chapter 4. Impact of Knowledge Management and Social Capital on Dynamic Capability

This chapter continues to explore the potential of KM policy adoption to advance DC but additionally introduces another lens on knowledge through social capital. The research conducted in this chapter sets out to investigate 1) the effect of KM policy adoption on DC, 2) the effect of social capital availability on DC and 3) the relation between the former formal approach and the latter informal approach towards knowledge in their effect on DC. A second-order PLS-SEM model is formulated with formative constructs that represent the inner dimensions of both the KM policy model and of social capital. Based on a sample of 55 Dutch knowledge-intensive organizations, the model is tested and analyzed. The study resulted in a fortified role for the KM policy model in favor of DC, contributing to RQ1. Moreover, the link between social capital and DC is uncovered and a

comparison between both approaches towards knowledge is elaborated, answering RQ2. This work has been accepted for publication as "The Impact of Knowledge Management and Social Capital on Dynamic Capability in Organizations" in the Knowledge Management Research & Practice Journal (ISI 1.069).

IV Knowledge Networks: Techniques

Chapter 5. Knowledge Network Data Capturing Techniques
From this chapter onwards, a third approach towards knowledge is adopted through the investigation knowledge networks. This chapter sets out to explore the various available methods and techniques for collecting the sociometric data required to formulate knowledge networks and questions to what extent these methods are comparable and exchangeable. This question is approached by collecting and comparing sociometric data in a knowledge-intensive organization through several data collection techniques, such as a sociometric survey, email mining and telephony mining. Under the assumption that a survey will yield the most representative knowledge network, two survey networks, a learning network and an advice network, are applied as baseline networks. The networks that were constructed by other data collection methods were then compared to the baseline networks by means of statistical analyses. The chapter concludes with several findings about the comparability of knowledge networks that were constructed by means of data mining techniques with networks constructed through sociometric surveys, therewith providing insights for RQ3. This work has been presented as "Revealing Knowledge Networks from Computer Mediated Communication in Organizations" at the 17th European Conference on Information Systems in Verona, Italy, and is published as a research paper in the Proceedings of ECIS 2009.

Chapter 6. Knowledge Network Email Mining Techniques
In this chapter, the availability of tools for the formulation of knowledge networks in organizations is studied. The chapter introduces various properties and features of such tools that are important to consider during tool selection. Also, the paper identifies a gap between data collection that focuses on the structure of knowledge networks and data collection that focuses on the content of knowledge exchanged within knowledge networks. Consequently, two individual tools are presented that focus on the collection of knowledge network structure and on the collection of knowledge network content respectively. Furthermore, taking a design-science research approach, the integration of both tools in

practice is proposed to serve the ultimate goal of meeting the requirement to capture both knowledge network structure and content through the application of one integrated tool. The findings in this chapter contribute to an answer for RQ3. This work has been presented as "Mining Email to Leverage Knowledge Networks in Organizations" at the 10th European Conference on Knowledge Management in Vicenza, Italy, and is published as a research paper in the Proceedings of ECKM 2009.

V Knowledge Networks and Dynamic Capability

Chapter 7. Impact of Knowledge Networks on Group Performance[2]
Equipped with the experiences from the previous two chapters, this chapter sets out to investigate possible links between knowledge network structure and organizational outcomes. In this chapter, the organizational outcome of team performance is studied. Although this outcome does not directly relate to the ultimate object of focus, DC, the research performed in this chapter is a precursor of that study and helps to clarify and test a suitable research approach and to select knowledge network properties to focus on. In a Dutch knowledge-intensive organization, data is collected about 18 learning knowledge networks and the team performance of the knowledge network members. Through statistical analysis, several knowledge network properties were compared with team performance. The chapter concludes with several findings that were done about knowledge network structure properties that were found to be positively linked to team performance. This work has been presented as "Impact of Knowledge Network Structure on Group Performance of Knowledge Workers in a Product Software Company" at the 9th European Conference on Knowledge Management in Southampton, UK, and published as a research paper in the Proceedings of ECKM 2008.

Chapter 8. Impact of Knowledge Networks on Absorptive Capacity
In this chapter, the role of knowledge network structure for advancing DC is studied in order to uncover and describe preferential network structures to advance DC. In this chapter, DC is studied in the embodiment of ACAP. As elaborated in this chapter, ACAP is the DC related to learning. This embodiment is adopted since it offers a better means to operationalize and measure extents

[2] Please note that this chapter represents a work of which the candidate is not the first author. However, we decided to include this paper in this PhD dissertation for means of a complete and logical flow of the chapters in the dissertation.

of DC in organizations. The research is approached by the introduction of a PLS-SEM model that links various structural properties of knowledge networks to the various dimensions of ACAP. In a sample of 4 knowledge-intensive organizations, data was acquired via survey research in 48 knowledge networks. From these networks, both their knowledge network structure was captured through sociometric surveys and the extent of ACAP was captured. Based on that data, the PLS-SEM model was validated and links between various knowledge network properties and distinct learning dimensions of ACAP were tested. The chapter concludes with several findings that describe how knowledge networks may limit and advance ACAP and provides suggestions about how organizations may stimulate their knowledge networks in light of advancing ACAP. Herewith, the findings and conclusions in this chapter provide an answer for RQ4. This work has recently been submitted as "The Impact of Knowledge Network Structure on Absorptive Capacity in Organizations" to a Journal in the Information Systems domain.

VI Conclusion

Chapter 9. Conclusion and Outlook
In this final chapter, the main research question and its derivative research questions are answered and reviewed. Moreover, the contribution of this dissertation is discussed. Limitations are reviewed and an outlook is provided for future research based on the studies conducted in this work. The chapter is complemented by personal reflections on this work.

1.7 List of concept definitions

The following list provides an overview of definitions of key concepts as applied throughout this work.

Dynamic Capability
The firm's potential to systematically solve problems, formed by its propensity to sense opportunities and threats, to make timely and market-oriented decisions, and to change its resource base (Barreto, 2010).

Sustainable Innovation
A pattern of rules or requirements for organizational learning and problem solving that is more effective than mainstream approaches to innovation management, and which helps its practitioners to adapt (McElroy, 2006).

Knowledge Management
Managing the corporation's knowledge through a systematically and organizationally specified process for acquiring, organizing, sustaining, applying, sharing and renewing both the tacit and explicit knowledge of employees to enhance organizational performance and create value (Davenport & Prusak, 1998).

Social Capital
Resources embedded in social structure that are accessed and/or mobilized in purposive actions (Lin, 2001).

Social Network
A finite set or sets of actors and the relation or relations defined on them (Wasserman & Faust, 1994).

Knowledge Network
A generic form of social network that typically resides within or between organizations where knowledge workers are primarily engaged in exchanging knowledge for the purpose of learning or advice-seeking (this work).

Absorptive Capacity
The capacity to recognize the value of new external information, assimilate it and apply it to commercial ends (Cohen & Levinthal, 1990).

Part II

Knowledge Management and Dynamic Capability

Chapter 2

Impact of Knowledge Management on Dynamic Capability

Recently, a new theory emerged in the field of Second Generation Knowledge Management. This theory is labeled 'New Knowledge Management' and was introduced by McElroy (2003). The theory is new to the extent that it brings together several known concepts concerning knowledge management in a unique combination. In its essence, the theory consists of fourteen policies that organizations should apply to improve performance. More precisely, the theory claims that application of the fourteen policies leads to corporate sustainability and sustainable innovation. However, this claim has not been empirically validated yet. In this paper, we present a research model for validating this claim. The empirical validation of the claim has been conducted using survey data collected from 30 organizations. Results from statistical analysis indicates that application of New Knowledge Management indeed is present in more sustainable organizations, but not in innovative organizations, as proposed by its claim. In addition, it was found that corporate sustainability also heavily depends on the external orientation of organizations. This implies that the application of NKM theory is an important but not the only critical condition for organizations to obtain a sustainable position.[1].

2.1 Introduction to the claim

The importance of knowledge as an organizational asset in the knowledge driven economy of recent years is no longer a new topic of discussion (Alavi & Leidner, 2001). Also, the important role of Knowledge Management as the discipline that intends to structure knowledge processes is not a new concept (Hansen, Nohria & Thierney, 1999). The value of knowledge and knowledge management in order to stay on top of the innovation process and to outlearn competition may explain the existence of the continuum in which new thoughts and ideas regarding knowledge management emerge, dominate and disappear. Looking back, one

[1] This work has been published as: Reijsen, J. van, Helms, R. and Batenburg, R. (2007a). Validation of the New Knowledge Management Claim. In Osterle H., Schelp J. and Winter R. (Eds.), *Proceedings of the 15th European Conference on Information Systems*, 552-564.

could say that there has been a paradigm shift from first generation to second generation knowledge management. During the first generation, knowledge management was focused on capturing existing knowledge (from experts) and distributing it to those who need at the right time and at the right place. This approach is reflected by the knowledge management lifecycles as defined by Meyer and Zack (1996) and Liebowitz (2001). These approaches typically assume that valuable knowledge is already present inside the organization.
The second generation focuses on the human aspects of knowledge management and underlines the important role of knowledge creation that is neglected in first generation knowledge management. Through the knowledge creating role of the individual in an organization, knowledge is gained and developed. One of the best known theories in second generation knowledge management is perhaps Nonaka's Dynamic Theory of Organizational Knowledge Creation (Nonaka, 1994). Another, more recent theory is referred to as 'New Knowledge Management' (NKM) and was proposed by McElroy (2003). As with previous theories, the goal of this theory is also to apply knowledge management to develop and use the intellectual asset in the organization and to improve organizational performance. In this context, organizational performance is defined as 'corporate sustainability' and 'sustainable innovation'. It is based on a bottom-up view with respect to knowledge management in which humans are able "to self-organize around the production, diffusion and use of new knowledge" (McElroy, 2005). In other words, he claims that knowledge management cannot be effectively managed top-down as proposed by the other theories. This self-organization will result in a process that is capable of continuous or sustainable innovation. To achieve this state of business, McElroy defines a number of policies. He claims that organizations that apply these policies can achieve corporate sustainability and sustainable innovation. This may be regarded as a very promising and interesting claim. However, no proof yet exists that provides a foundation for this claim. This paper intends to determine the extent to which this claim is justifiable.

The structure of the remainder of this paper is as follows: In section 2.2, the cornerstones of the NKM theory are presented. Section 2.3 presents our research model for testing the theory's claim. The results of our empirical validation are presented in section 2.4 and provide an insight in the extent to which the claim is justifiable. Finally, in section 2.5 we present our conclusions and our general thoughts and ideas about NKM are elaborated.

2.2 Cornerstones of New Knowledge Management

This section discusses the four cornerstones of McElroy's NKM theory. The cornerstones are not completely new and we will demonstrate this by referring to related work where appropriate. After discussing the cornerstones, we present the fourteen policies that have been derived from these cornerstones. The policies are indicators for the level of NKM application by an organization.

2.2.1 Knowledge Lifecycle

The Knowledge Lifecycle is the first cornerstone. It concerns the different knowledge processes that are interconnected: knowledge production, knowledge integration and a knowledge processing environment. Together, the processes should result in the creation of new knowledge (i.e. knowledge production) that is transferred to the right employees in the organization (i.e. knowledge integration). Finally, the employees should apply the newly received knowledge in their activities in order to create added value for the organization. The idea of a knowledge lifecycle in itself is not completely new. Also other authors, such as (Wiig, 1993; Weggeman, 1997), describe the notion of a knowledge lifecycle consisting of more or less similar knowledge processes. What distinguishes the knowledge lifecycle model of McElroy is the role of knowledge evaluation in the lifecycle, which is lacking in other models. In his view, individual agents (employees) acquire new knowledge from learning and practice and define their new knowledge in knowledge claims. In order to acquire support for a knowledge claim, the claim is first discussed on a group level. Finally, the knowledge claim is discussed at an organizational level and after acceptance it is integrated in the existing knowledge base.

2.2.2 Complexity Theory

As stated in the introduction, the claim of NKM is to achieve corporate sustainability and sustainable innovation. According to McElroy, this can be achieved through self-organization and organizational learning. Self-organization and organizational learning enable an organization to adapt itself based on experiences in the execution of activities or based on internal and external changes. In NKM, the self-organizing and learning capabilities are introduced by applying the theory of Complex Adaptive Systems (CAS) (Holland, 1995). Consequently, every employee is considered a Complex Adaptive System, which has an intrinsic motivation to detect changes and adapt to them (self-organization). However, not only individual agents may be interpreted as CAS, but also groups and the organization itself are regarded as CAS. So besides

individual learning, there is such a thing as group learning and organizational learning. This way, not only individuals, but also groups and the organization itself tend to track and adapt to organizational changes and to achieve corporate sustainability and sustainable innovation.

2.2.3 Open Enterprise

McElroy rejects the idea that decision making and knowledge making are the privileges of upper management only, as is typically the case in bureaucratic organizations. Knowledge making should be decoupled from decision making and should be a privilege of all employees and therefore be promoted by management. Furthermore, the created knowledge should be transparently available to all employees as long as it does not violate privacy considerations. Finally, all employees should always try to detect and report flaws in current knowledge claims during the process of applying this knowledge in action. This results in a continuous learning process in which knowledge is revised and updated.

To further stimulate the innovative capabilities of employees, organizational policies should be aligned with current behavior and practices of employees and not the other way around. In traditional, bureaucratic organizations, desired behavior is typically enforced top-down using policies. However, this constrains the innovative capabilities of employees instead of stimulating the capabilities. Therefore, all employees are motivated and empowered to formulate any new knowledge process related rule or policy. Finally, McElroy states that all employees should adhere to the rules and policies. Employees that cannot identify themselves with the rules and policies should be excluded from the organization.

The concept of the Open Enterprise is not completely new. From organization theory, it is already known that bureaucratic or mechanistic structures are no longer applicable to today's fast changing environment and have been replaced by more organic structures that foster learning and innovation (Daft, 2006). Furthermore, from the field of Human Resource Management it is already known that empowerment, i.e. providing employees with more control and resources (Thomas & Velthouse, 1990), will result in more innovative behavior of employees.

2.2.4 Epistemic Hierarchy

The last cornerstone is the epistemic hierarchy of knowledge management, in which the relative position of knowledge management with respect to knowledge processing and business processing is sketched. The main thought behind the

epistemic hierarchy is the fact that knowledge management cannot directly influence business processes, but that it can only influence the knowledge processes of the knowledge lifecycle that in their turn have an impact on business processes. This hierarchy is addressed in order to indicate the non-linearity that exists between knowledge management investments and interventions on the one hand and business outcomes on the other hand.
Based on this idea, McElroy states that KM should be a separate business function and should not be integrated with for example IT, R&D or HR and not be rooted in the executive function. The KM function should have enforceable authority to allocate resources that enhance knowledge processes. The executive function should only have coordinating responsibilities to the KM business function. This is in line with Davenport & Prusak (1998), Smith & McKeen (2003) and Awad & Ghaziri (2004), who also identify that many organizations create a separate KM business function. However, they also state that "knowledge management is part of everyone's job" (Davenport & Prusak, 1998). Therefore, it cannot be made the sole responsibility of a KM business function.

Table 2.1. Policies of the Sustainability code

Policies	NKM Cornerstone	Description
McElroy's policies		
Fallibility	Knowledge lifecycle	The extent to which knowledge is regarded as fallible
Fact / Value	Knowledge lifecycle	The extent to which knowledge is evaluated: not, on a basis of factuality or on a basis of factuality and value
Fair Comparison	Knowledge lifecycle	The fact whether new knowledge is evaluated before it is integrated
Transparency	Open Enterprise	The extent to which knowledge is transparent to all employees
Inclusiveness	Open Enterprise	The extent to which employees are included in learning & training programs
Looking for Trouble	Open Enterprise	The fact whether employees are stimulated to detect flaws in knowledge
Growth of Knowledge	Open Enterprise	The fact whether employees are allowed to change knowledge processes

Policy Synchronization	Open Enterprise	The way in which policies are formulated: resulting from behavior or resulting in behavior
Enforcement	Open Enterprise	The fact whether employees that do not abide to the knowledge processes and rules are excluded from the organization or not
Knowledge Management	Epistemic hierarchy	The extent to which the knowledge management function is controlled by the executive function

2.2.5 NKM policies

The four cornerstones are the theoretical pillars of McElroy's NKM theory. He derived 10 policies from these four cornerstones, which he refers to as the Sustainability Code (McElroy, 2005). A policy is a practical guideline that an organization should adhere to if it wants to adopt NKM. A complete overview of the policies of the Sustainability Code is shown in table 2.1. For each policy a short description is provided and it is indicated from which cornerstone the policy is derived.

Table 2.2. Policies derived from Complexity Theory

Holland's policies	
Embryology	The extent to which employees are allowed to have own personal learning agenda's
Politics	The fact whether knowledge creation is limited to the executive function
Ethodiversity	The fact whether employees are expected to have convergent or divergent worldviews
Connectedness	The extent to which resources for IT based and social connectivity is adequate

2.3 Research Model for claim validation

The goal of this research is to justify the claim that application of the 14 NKM policies will yield in corporate sustainability and sustainable innovation. In this section, we present the research model for justifying this claim. We start with presenting the individual constructs of our model: level of NKM application, performance indicators, and external orientation. Finally, we close the section by presenting our complete research model.

2.3.1 Level of NKM application

The cornerstones of NKM theory have been discussed in the previous section. Furthermore, it was shown that the major concepts behind these cornerstones can be expressed in fourteen policies as defined by McElroy (table 2.1 and 2.2). Some of these policies are more practical in nature than others. We have built an assessment method for measuring the level of NKM application that is based on these fourteen policies (Van Reijsen, 2006). In our assessment method, each policy is measured by one question. Hence, in total there are fourteen questions and together they measure the level of NKM application of an organization. The scales for each question are shown in Appendix A. The measurement of the level of NKM application is further elaborated in section 2.4.2.

We thoroughly validated the assessment method by using three different validation methods: an expert review, a non-expert pre-test, and a case study. An expert review has been conducted to test the construct validity of the assessment method (Yin, 1994). In the expert review, the method and the corresponding survey has been reviewed by an expert from a Dutch consultancy organization specialized in knowledge management. This review resulted in optimization of the assessment method in the form of rephrased questions and an altered chronology of the survey.

Secondly, face validity of the assessment method was tested by performing a non-expert pre-test. The method for conducting the face validity assessment is based on Walonick (2006). The pre-test consisted of ten individuals that were not knowledgeable about the content of the assessment survey, i.e. non-experts. The ten non-experts were asked to take the survey and think aloud while reading and answering the questions. By capturing all questions and remarks, revisions were made to the survey, i.e. rephrasing some questions.

Finally, a case study has been conducted at a Dutch based non-profit healthcare organization. Six respondents of this organization filled in the survey. Because all respondents work for the same organization, it was assumed that the respondents would provide similar answers. However, the results showed that the answers of the respondents were not consistent. An interview with the respondents as well as a document study was performed in order to provide more insight. These examinations resulted in an important insight. Respondents provided a desired situation rather than the actual situation in their answers. Analyzing the survey questions revealed that the questions encouraged respondents to indicate the desired situation. As a result, the survey has been extended with supporting texts such that respondents only provide answers that refer to the actual situation.

2.3.2 Performance Indicators

Performance indicators that measure the degree of corporate sustainability and sustainable innovation could not easily be derived from McElroy's theory, because it does not provide clear and complete definitions of the concepts of corporate sustainability and sustainable innovation. In order to capture the essence of corporate sustainability, a literature study has been conducted regarding the foundation of the sustainability concept. A good insight into the notion of sustainability is provided by Faber, Jorna & Van Engelen (2005), which has been used as the basis for our definition of corporate sustainability. Furthermore, NKM theory does not provide a consistent definition of sustainable innovation either. Therefore, only a performance indicator for the concept of innovation could be formulated. The assessment method is therefore only capable of assessing the extent to which the theory's application influences the corporate sustainability and innovative capability of an organization, while the sustainability aspect of innovation cannot be measured (presumably, if the theory's application does not add value to the innovative capability of an organization, it also does not add value to the sustainable innovative capability of that organization). Table 2.3 shows the results of the literature study and provides the performance indicators and the definitions that have been used to construct the indicators in this research.

Table 3. The performance indicators of corporate sustainability and innovation

Indicator	Definition
Corporate sustainability	The extent to which an organization is capable to track changes, internally as well as in the external environment, and is capable to adapt to these changes.
Innovation	The extent to which an organization is capable to introduce new ideas, products, services and practices, and is capable to apply them.

It can be argued that a gap exists between the concept of knowledge management on the one hand and the concepts of corporate sustainability and innovation on the other hand. However, the definition that was found for the concept of corporate sustainability closely aligns with NKM theory. This is best reflected from the indicators of its measurement. The "transparency" rule e.g. increases the potential of changes that can be tracked and the "looking for trouble" rule stimulates employees to track changes. In the case of innovation for example, the "fallibility" and "fact/value" rules stimulate evaluation of knowledge and yield shorter development cycles of new knowledge and hence new ideas and products.

2.3.3 External orientation

As indicated in section 2.3.2, the definition of corporate sustainability provided by the NKM theory (McElroy, 2003) itself is incomplete and ambiguous. Therefore, we developed our own definition of corporate sustainability, which is based on the work of Faber et al. (2005). This definition considers both internal and external orientation. However, almost all of the NKM policies are internally oriented. This leads to the assumption that application of the NKM policies is not the only condition to obtain corporate sustainability. Furthermore, we assume also that external orientation increases the corporate sustainability of organizations.

Table 2.4. The business dimensions (Scheper, 2002) and the maturity levels (Boot, 1997) that build the framework for measuring the degree of external orientation.

Business Dimensions
1. Organization & Processes
2. Strategy & Policy
3. People & Culture
4. Monitoring & Control
5. Information Technology

Maturity Levels
1. Ad Hoc Orientation
2. Process Orientation
3. Organizational Orientation
4. Chain Orientation
5. Societal Orientation

To measure the degree of external orientation of an organization, we used a knowledge management framework that has been developed by Boot (1997). The framework has been developed to determine the position of a company with respect to good knowledge management practices, which is measured using a maturity scale. Here, a higher maturity is an indication for better knowledge management practices. The maturity scale from this framework (left side of table 2.4) has been used to define the degree of external orientation, because it provides a good description of how an organization can grow from no orientation to internal orientation to external orientation. The maturity levels are considered to be normative, implying that an organization that is externally oriented is also internally oriented. Furthermore, organizational theory learns that organizations consist of several dimensions that should be considered when describing or designing an organization (Daft, 2006). Therefore, we assume that an organization is only truly externally oriented if there is external orientation in all its dimensions. The business dimensions that are used are taken from Scheper (2002) and are also shown in table 2.4 (right side). The use of this model for measuring the degree of external orientation is further elaborated in section 2.4.3.

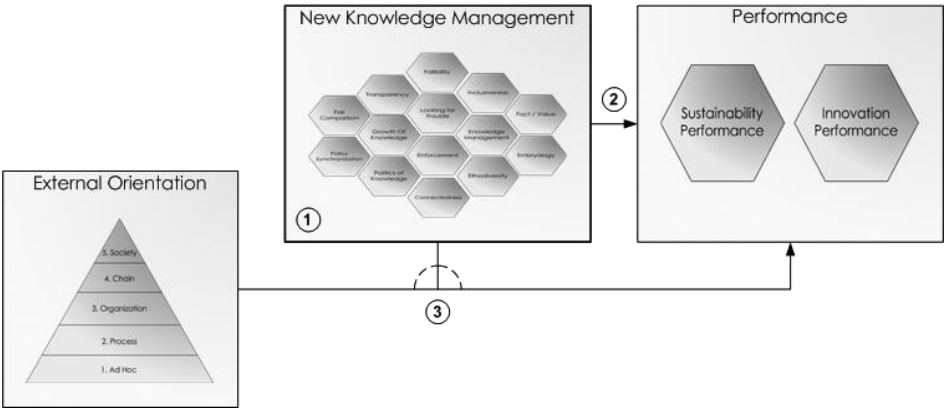


Figure 2.1. Outline of the research model.

2.3.4 Outline of the research model

The three constructs of our research model have been discussed in the previous sections. Figure 2.1 shows how the three key constructs of the assessment method are assumed to be interrelated in three different ways labeled as arrows 1, 2, and 3 (number is placed within circles). Arrow 1 represents the central claim in NKM theory, i.e. that NKM application is positively related to Performance. The second arrow represents our own assumption that External Orientation is also positively related with Performance. Finally, the third arrow assumes that the combination of NKM application and External Orientation will have an additional positive relationship regarding to Performance. This last relationship implies that particularly organizations with high assessment scores on *both* variables will have the highest Performance scores.

2.4 Results of the claim validation

2.4.1 Construction of the survey

Data for the empirical validation of the relations in our research model was collected using a survey. The respondents and organizations were selected using convenience random sampling (Triola, 2004). In total, 30 organizations were approached between June and August 2006. Using an on-line survey tool, each respondent was asked to provide answers to 14 questions that measure the application level of the fourteen policies. Each question consisted of 2 to 4 answer options (see Appendix A for the questions and answer options). The answers represented the degree to which an indicator is applied, expressed as a percentage. Answers from questions with 2 answer options were expressed as

either 0% or 100%, 3 answer options are expressed as 0%, 50% and 100% etc. All answers were then averaged and treated as ratio level scale measurements (Stevens, 1946). In addition, 15 questions were posed to measure the organizations' External Orientation, based on the items as presented in section 2.3.3. Here, for each question, a 5-pointscale answer system is applied, were each answer represents a maturity level for external orientation. The answers were treated as interval level scale measurements. Finally, at the end of the survey, the Performance concept was measured by 2 questions, i.e. one question for the extent of performance of each of the two indicators presented in section 2.3.2. Here, both questions were answered on a 5-pointscale ranging from bad to excellent that was treated as an ordinal level scale measurement. In total, the survey consisted of 31 questions.

2.4.2 Measurement of the level of NKM application

The extent to which a particular policy is applied is measured using different scales, i.e. two, three or four answer options (see section 4.1 and Appendix A). Reliability analysis over these 14 indicators resulted in a Cronbach's alpha of 0.80. Although this indicates that a reliable scale can be constructed by aggregating all 14 indicators, inspection of the inter-correlations and principal components showed that one indicator has a weak contribution to one latent factor solution. This is the question regarding 'Fact/Value'. Excluding this question does not improve the Cronbach's Alpha significantly, however. Hence, the complete set of indicators is used to measure the level of NKM application by computing the average scores over the 14 indicators.

2.4.3 Measurement of External Orientation

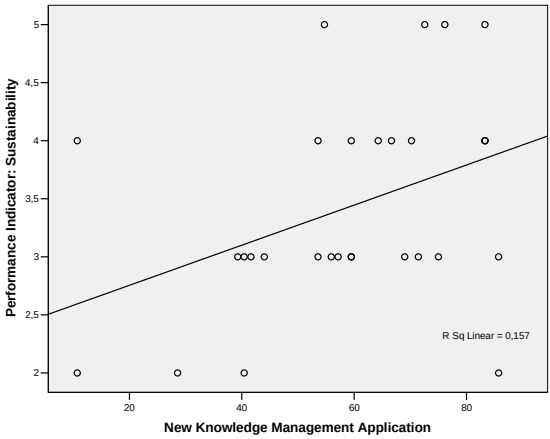
The degree of external orientation is measured by 15 questions with answer options ranging from 1 to 5 as maturity levels cumulating from 1 to 5. Each of the five business dimensions (strategy & policy, monitoring & control, organization & processes, people & culture and information technology; see section 2.3.3) is represented by three questions. Here, the measurement strategy is to aggregate all 15 answers (i.e. maturity levels) into one single maturity level. Reliability analysis resulted in a satisfactory Cronbach's alpha value of 0.80. Correlation analysis indicates that the 15 variables are all positively interrelated. In addition, principal component analysis supported a one-dimensional latent factor solution. Hence, the 15 variables were averaged into a single factor being the External Orientation concept.

2.4.4 Measurement of Performance

Both performance indicators, corporate sustainability and innovation, were formulated using a 5-point Likert scale. The scales vary from an organization is performing 'bad' (1), 'weak' (2), 'average' (3), 'good' (4) to 'excellent' (5). A bivariate correlation coefficient is computed to explore if both can be aggregated into one single (Performance) concept. It appears that corporate sustainability and innovation do not correlate significantly (r=.30, p=.11). Consequently, we keep both variables as separate indicators, i.e. two different dimensions of the Performance concept within our assessment method.

2.4.5 Validation of the assumed relations in our research model

Our first validation test concerns the assumed positive correlations between level of NKM application on the one hand, and corporate sustainability and innovation as performance indicators on the other hand. As figure 2.2 depicts, this relationship is found for corporate sustainability, supported by a significant correlation coefficient (r=0.40; p=.03), but not for innovation (r=0.15; p=0.44). This result is supported by correlations computed with the fourteen different policies of the NKM concept. Five of the policies are significantly correlated with corporate sustainability, while none are significantly correlated with innovation. This confirms the claim that organizations with a higher level of NKM application also have higher scores on the corporate sustainability, but not on innovation.



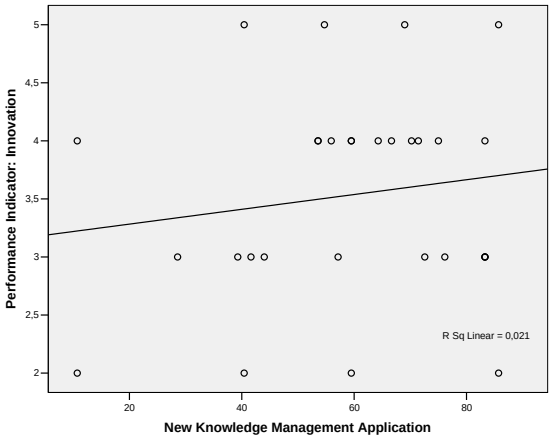


Figure 2.2. Scatter plot of the relation between NKM application and the performance indicators of corporate sustainability (top) and innovation (bottom)

The second test concerns the relation between the extent of external orientation on the one hand, and the performance indicators corporate sustainability and innovation on the other hand. Depicted in Figure 3, the relation between external orientation and corporate sustainability is positively significant (r=.59; p=0.00), according to the expectation. The relation between external orientation and innovation, however, is not significant (r=0.29; p=0.12). Similar to the previous analysis, much more of the 14 policies are significantly correlated with corporate sustainability then with innovation. The claim can therefore be validated that a higher maturity of external orientation by organizations indeed yields a higher score on their corporate sustainability, but not the claim that external orientation coincides on innovation.

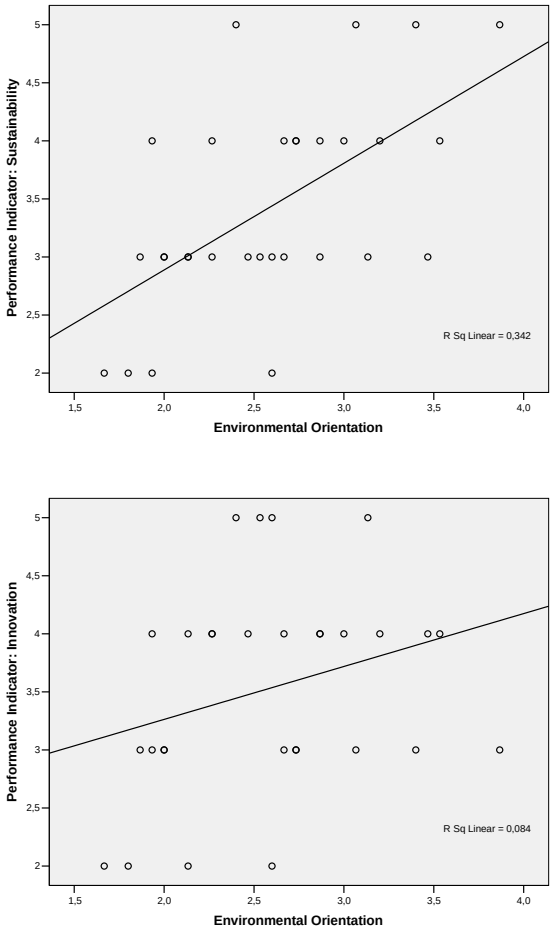
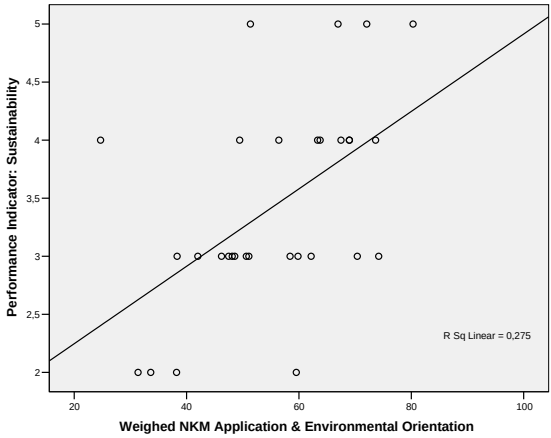


Figure 2.3. Scatter plot of the relation between external orientation and the performance indicators of corporate sustainability (top) and innovation (bottom)

The third and final analysis concerns the expected interaction effect of the relationships in our research model. The interaction effect actually builds upon the main effects of NKM application and external orientation that were investigated above. It is hypothesized that in particular the *combination* (i.e. interaction) of external orientation and NKM application significantly improves an organizations' corporate sustainability and innovation. Figure 2.4 below illustrates the correlation analysis performed to validate this claim. With respect to corporate sustainability, the interaction effect is indeed significant. Corporate

sustainability significantly increases with the combined increase of an organizations' NKM application and external orientation (r=.52; p=0.00). As for the relation with innovation, no significant interaction effect (i.e. correlation) was found (r=.22; p=0.24). Our third claim is therefore, again, partly supported.



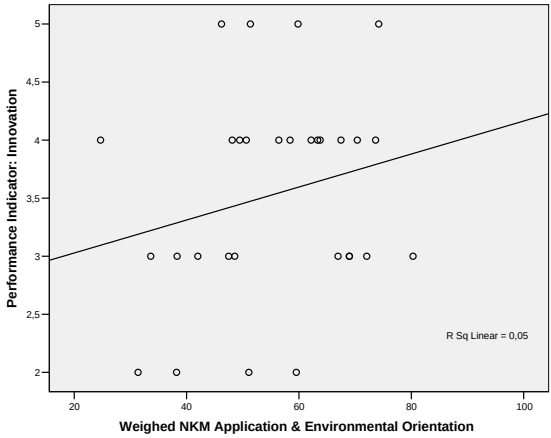


Figure 2.4. Scatter plot of the interaction effect of external orientation on the relation between NKM application and the performance indicators of corporate sustainability (top) and innovation (bottom)

2.5 Conclusion and discussion on the claim

In this paper, we wanted to discover to what extent the NKM claim of corporate sustainability and sustainable innovation is justified. This has been realized by creating an assessment method, containing constructs that enable the measurement of the relation between the level of NKM application and organizational performance with respect to corporate sustainability and innovation. In addition, a construct was developed to measure the degree of external orientation. The constructs and assumed interrelationships within the assessment method were validated using a survey among 30 organizations.

The research revealed that application of the policies as defined in the NKM theory indeed yields a higher performance for corporate sustainability. This relation does, however, not apply to the performance of innovation. As a result, one has to conclude that the claim is only partially justifiable. Moreover, it appeared that NKM application as well as external orientation influences the performance of corporate sustainability. Insights in the interaction effect of external orientation on the relation between application and the performance of sustainability provided the argument that application of the theory is not the only condition for an organization in order to perform sustainable. Moreover, the research results provide the argument that the theory is not a suitable theory for organizations that want to increase their level of innovation. Furthermore, it is apparent that neither external orientation nor the interaction effect of external orientation on NKM application yields an increase in the performance of innovation.

Future research could further validate the insights that were provided by this research. For example, an additional assessment of more organizations would provide more reliability for the findings of this research. Another interesting agenda item for a future research initiative may be to explore how the individual indicators from NKM application or from the external orientation framework add performance value to sustainability and innovation. Also, the relation between external orientation and the organizational characteristics from our original assessment method is an item that needs further research. Future research may provide answers to these questions. For now, the NKM theory should only be applied as a reference model for organizations that aim for corporate sustainability including an internal and external focus.

Chapter 3

Organizational Conditions for Dynamic Capability

Recently, a new theory emerged in the field of Knowledge Management. This theory is referred to as 'New Knowledge Management' and was introduced by McElroy. The theory is new to the extent that it brings together several known knowledge management concepts in a unique combination. In its essence, it consists of 14 policies that an organization should apply to improve its sustainable and innovative edge. This paper describes a scientifically validated assessment method that we developed to measure the level of New Knowledge Management application in an organization. The goal of developing this assessment method was twofold. First of all, organizations can use the method to determine to what extent they apply the principles of New Knowledge Management. Consequently, organizations can use the method to improve their knowledge management practices. Secondly, we used the assessment to conduct a survey under 30 Dutch companies to study the adoption of the New Knowledge Management principles in these companies. The results have been used as a benchmark for the organizations that participated in the research. Furthermore, we statistically analyzed to what extent adoption is influenced by organizational characteristics, such as size and structure of the organization. In the paper, we present the results of the survey and our analysis. The results show that an average organization applies about 60% of the principles. Moreover, analysis reveals that hierarchical structure, B2B/B2C orientation, and KM system usage tend to significantly relate to the level of New Knowledge Management application.[1].

3.1 Introduction to New Knowledge Management

The importance of knowledge as an organizational asset in the knowledge driven economy of recent years is no longer a topic of discussion (Alavi & Leidner, 2001). Consequently, Managing knowledge in the organization and the creation

[1] This work has been published as: Reijsen, J. van, Helms, R., and Batenburg, R. (2007b). Organizational Conditions for 'New Knowledge Management' Application. In Martins B. (Ed), *Proceedings of the 8th European Conference on Knowledge Management*, 1040-1047, Academic Conferences.

of new knowledge is considered as crucial for the survival of the organization in the competitive market place. This thinking has become known as the knowledge-based view of the firm by Grant (1996), which is an outgrowth of the resource-based theory of the firm as defined by Penrose (1959), Wernerfelt (1984), and Barney (1991) in strategic management literature. The knowledge-based view of the firm is a confluence of a number of streams and studies the role of knowledge in the organization and its implications for management. One of the most cited knowledge management theories in this field is Nonaka's dynamic theory of Organizational Knowledge Creation (Nonaka, 1994; Nonaka & Takeuchi, 1995). A more recent and new contribution is the New Knowledge Management theory by McElroy (McElroy, 2003). In line with other theories, the goal of this theory is also to apply knowledge management to increase the intellectual asset and to increase organizational performance. In his view, knowledge management should be aimed at ultimately achieving 'sustainable innovation'. The core of McElroy's theory consists of a number of policies. He claims that organizations that apply these policies can achieve sustainable innovation.

In this research, we collected empirical data of 30 Dutch companies to study to what extend they apply the principles of the New Knowledge Management. This provides insight in the adoption of New Knowledge Management in the Dutch industry. Secondly, we collected data on certain organizational characteristics (e.g. size, structure), which enables us to study the relation of these characteristics to the application of the NKM principles. Finally, the empirical result can be used as a benchmark by the organizations that participated in the research as well as by other organizations that fill in the on-line questionnaire-based NKM assessment tool.

The structure of the remainder of this paper is as follows. The four cornerstones of the New Knowledge Management theory are elaborated in section 3.2. In section 3.3, the NKM assessment method is discussed that has been developed for measuring the application of NKM principles in organizations. Furthermore, section 3.4 presents the results of the application of the NKM assessment among 30 Dutch firms. Finally, the conclusion and discussion is presented in section 3.5.

3.2 Theoretical background

This section discusses the four cornerstones of McElroy's NKM theory. After discussing the cornerstones, we present the fourteen policies that have been derived from these cornerstones. The policies are indicators for the level of NKM application by an organization.

3.2.1 Knowledge Lifecycle

The Knowledge Lifecycle is the first cornerstone and defines the different knowledge processes: knowledge production, knowledge integration and a knowledge processing environment. Together, the processes should result in the creation of new knowledge (i.e. knowledge production) that is transferred to the right employees in the organization (i.e. knowledge integration). Finally, the employees should apply the newly received knowledge in their activities in order to create added value for the organization. What distinguishes McElroy's knowledge lifecycle model from others, such as (Wiig, 1993; Weggeman, 1997), is the explicit evaluation of knowledge claims, which is lacking in other models.

3.2.2 Complexity Theory

The claim of NKM is to achieve corporate sustainability and sustainable innovation. According to McElroy, this can be achieved through self-organization and organizational learning. This enables an organization to adapt itself based on experiences in the execution of activities or based on internal and external changes. In NKM, the self-organizing and learning capabilities are introduced by applying the theory of Complex Adaptive Systems (CAS) (Holland, 1995). Consequently, every employee is considered a Complex Adaptive System, which has an intrinsic motivation to detect changes and adapt to them (self-organization). Also the organization itself is regarded as a CAS. Hence, also the organization is believed to track and adapt to organizational changes to achieve corporate sustainability and sustainable innovation.

3.2.3 Open Enterprise

The concept of the Open Enterprise implies that everybody in the organization is allowed to participate in the knowledge processes. Furthermore, knowledge in the organization is accessible (i.e. transparent) for all employees and they are encouraged to apply it and to detect flaws in existing knowledge claims. To further stimulate the innovative capabilities of employees, organizational policies should be synchronized with current behavior and practices and not be enforced top down. Additionally, employees should be motivated and empowered to formulate any new knowledge process related rule or policy. As such, the concept of the Open Enterprise is similar to that of organic structures that foster learning and innovation and enable an organization to adapt to its environment (Daft, 2006). Furthermore, from the field of Human Resource Management it is already known that empowerment will result in more innovative behavior of employees (Thomas & Velthouse, 1990).

3.2.4 Epistemic Hierarchy

The last cornerstone is the epistemic hierarchy of knowledge management, in which the relative position of knowledge management with respect to knowledge processing and business processing is sketched. Based on the idea of an epistemic hierarchy, McElroy states that KM should be a separate business function and should not be integrated with for example IT, R&D or HR and not be rooted in the executive function. The KM function should have enforceable authority to allocate resources that enhance knowledge processes. The executive function should only have coordinating responsibilities to the KM business function. This is in line with Davenport & Prusak (1998), Smith & McKeen (2003) and Awad & Ghaziri (2004), who also identify that many organizations create a separate KM business function.

3.2.5 NKM policies

The four cornerstones are the theoretical pillars of McElroy's NKM theory. He derived 10 policies from these four cornerstones, which he refers to as the Sustainability Code (McElroy, 2005). A policy is a practical guideline that an organization should adhere to if it wants to adopt NKM. A complete overview of the policies of the Sustainability Code is shown in table 3.1. For each policy a short description is provided and it is indicated from which cornerstone the policy is derived.

Table 3.1. Policies of the Sustainability code

Policy	Description
NKM Cornerstone: Knowledge lifecycle	
Fallibility	The extent to which knowledge is regarded as fallible
Fact / Value	The extent to which knowledge is evaluated: not, on a basis of factuality or on a basis of factuality and value
Fair Comparison	The fact whether new knowledge is evaluated before it is integrated
NKM Cornerstone: Open Enterprise	
Transparency	The extent to which knowledge is transparent to all employees
Inclusiveness	The extent to which employees are included in learning & training programs
Looking for Trouble	The fact whether employees are stimulated to detect flaws in knowledge
Growth of Knowledge	The fact whether employees are allowed to change knowledge processes

Policy Synchronization	The way in which policies are formulated: resulting from behavior or resulting in behavior
Enforcement	The fact whether employees that do not abide to the knowledge processes and rules are excluded from the organization or not
NKM Cornerstone: Epistemic hierarchy	
Knowledge Management	The extent to which the knowledge management function is controlled by the executive function

Table 3.1 does not contain policies that are derived from CAS theory (NKM Cornerstone: Complexity). That is because McElroy derived these four policies directly from the CAS theory following Holland (1995). An overview of the policies from CAS theory is shown in table 3.2. If an organization applies the policies of Sustainability Code and at the same time the policies derived from CAS theory, McElroy claims that an organization will achieve sustainable innovation.

Table 3.2. Policies derived from Complexity Theory

Policy	Description
Embryology	The extent to which employees are allowed to have own personal learning agenda's
Politics	The fact whether knowledge creation is limited to the executive function
Ethodiversity	The fact whether employees are expected to have convergent or divergent worldviews
Connectedness	The extent to which resources for IT based and social connectivity is adequate

3.3 Assessment method

This section describes the assessment method that has been developed to measure the current application of NKM practices among organizations. The assessment method consists of two parts. The first part of the assessment method measures the application of the NKM policies, while the second part measures particular organizational characteristics. By measuring organizational characteristics it can be determined whether the application of NKM is determined by these characteristics. After presenting the assessment method, the validation of the method is discussed. A total of four tests have been conducted to test the validity of the assessment method.

3.3.1 New Knowledge Management application

The goal of the assessment method is to measure the extent to which an organization applies NKM in practice. For measuring the application of NKM, the 14 NKM policies (from the Sustainability code and from Complexity theory) are used as a starting point. Each policy is a guideline that an organization should implement if it wants to achieve sustainable innovation as is promised by the NKM theory.

To measure the application of a policy, each policy is translated into one question that measures the particular policy. Each question measures the application of NKM on several levels. On average, three levels have been distinguished. The levels represent the extent of NKM policy application. Typically, the following coding of the answer categories has been used: the policy is not applied (0), the policy is applied to a certain extent (50), and the policy is fully applied (100). In a number of cases it was not possible to measure NKM policy application on three levels. Therefore, in these cases NKM application was measured on two or four levels instead. All the questions, including the scales, are shown in table 3.3.

Table 3.3. The 14 indicators and their coding

Indicator	Answer category	Coded as
Fallibility	Knowledge is regarded as always valid	0
	Knowledge is regarded as more or less valid	50
	Knowledge is regarded as always fallible	100
Transparency	Hierarchy strongly limits knowledge accessibility	0
	Hierarchy limits knowledge accessibility to some extent	50
	Hierarchy barely limits knowledge accessibility	100
Inclusiveness	Training and learning programs are provided top-down	0
	Training and learning programs are discussed	50
	Training and learning programs are freely accessible	100
Fair Comparison	New knowledge is not evaluated before it is accepted	0
	New knowledge is evaluated before it is accepted	100
Looking for Trouble	Employees are expected to apply knowledge	0
	Employees are expected to apply and evaluate knowledge	100
Growth of Knowledge	Employees are expected to perform knowledge processes	0

	Employees are empowered to alter knowledge processes	100
Fact / Value	Knowledge is not evaluated	0
	Knowledge is evaluated on a basis of factuality	50
	Knowledge is evaluated on a basis of factuality and added value	100
Knowledge Management	The KM function is action controlled	0
	The KM function is result controlled	33
	The KM function is semi-autonomous	66
	The KM function is autonomous	100
Policy Synchronization	Policy results in behavior	0
	Policy and behavior are aligned	50
	Behavior results in policy formulation	100
Enforcement	Employees that do not abide to knowledge rules remain active	0
	Employees that do not abide to knowledge rules leave	50
	Employees that do not abide to knowledge rules are excluded	100
Embryology	Employees are not allowed to have own, personal learning agendas	0
	Employees are provided time for own personal learning agendas	50
	Employees are provided time and resources for own personal learning agendas	100
Politics of Knowledge	Knowledge creation is dedicated to the executive function	0
	Knowledge creation is influenced by employees	50
	Knowledge creation is open to all employees	100
Ethodiversity	Employees are expected to have convergent worldviews	0
	Employees are expected to have divergent worldviews	100
Connectedness	The density of social and IT based connectivity is inadequate	0
	The density of social and IT based connectivity is adequate	100

The questions form the first part of a survey can capture NKM application in organizations. In the next section, the second part of the survey is discussed, which measures the organizational characteristics.

3.3.2 Organizational characteristics

The second part of the survey measures organizational characteristics (e.g.: size, sector). Consequently, it becomes possible to compare NKM application over different organizational characteristics. Table 3.4 provides an overview of the organizational characteristics that are distinguished in this study. The reason for selecting these particular characteristics is briefly discussed in the remainder of this section.

Table 3.4. The organizational characteristics that are captured by the assessment method

Organizational Characteristic	Description
Organizational Size	The number of employees in the organization
Hierarchical Structure	If the organization is hierarchically structured or flat
B2B / B2C	If the organization is dominantly B2B or B2C oriented
Value Proposition	The value proposition of the organization according to Treacy & Wiersma's tristate
KM IT Support	If KM is supported by a specific IT system or not

The size of an organization expressed in the amount of employees is a suitable characteristic, because it captures possible differences in NKM application between small-medium sized organizations (<= 250 employees) and larger organizations (251+ employees). The existing organizational hierarchy (flat, hierarchical) is relevant in the context of NKM because of its philosophy that hierarchy blocks the innovative and sustainable capabilities of Complex Adaptive Systems. Differences in the fact whether organizations that are dominantly business-to-business or business-to-consumer oriented is a deviating characteristic that caught the interest of the research team and is included in the scope in order to explore possible differences in NKM application. Also, the value proposition of the organization as proposed by Treacy & Wiersma (1993) is relevant to measure in order to examine what value proposition relates with what NKM application level. Finally, the intensity of IT support for KM activities can indicate how important IT is to the organization in relation to KM. This factor is relevant to examine, because it can distinguish what the role of IT is in organizations that have a specific low of high NKM application level. These organizational characteristics provide a basis as determinants to NKM application in order to distinguish different types of organizations when analyzing NKM application. Distinction of different organizational characteristics may reveal relations between the intensity of NKM application and the composition of the organization. Each of these characteristics can be assessed in a survey by

formulating questions that capture the characteristics from an organization. These characteristics then form the second part of the NKM Assessment Method.
In order to challenge the question what effect organizational characteristics may have on the extent of NKM application, a few hypotheses are formulated, which can eventually be tested by means of the research result extracted from the survey data. A first hypothesis is that smaller organizations will apply NKM to a larger extent than larger organizations. A supportive rationale for this hypothesis is that the NKM policies are more easily applied in smaller organizations (better controllable) than in large organizations. A second hypothesis is that flat organizations will have a larger extent of NKM application than organizations with a hierarchical structure. In a way, this is a tautology, because the absence of any hierarchy is a structural component of the NKM policies itself. However, it is arguable that flat organizations are also more transparent and inclusive than hierarchical organizations. This hypothesis may test this assumption. A third hypothesis is that organizations with a B2C orientation and a customer intimacy value proposition have a higher rate of NKM application than B2B or non-customer intimacy oriented organizations. This hypothesis may be supported by the argument that B2C and customer intimacy organizations may be more people oriented which may correspond with the people oriented approach of New Knowledge Management.

3.3.3 Assessment method validation

We thoroughly validated the assessment method by using three different validation methods: an expert review, a non-expert pre-test, and a case study. An expert review has been conducted to test the construct validity of the assessment method (Yin, 1994). In the expert review, the method and the corresponding survey has been reviewed by an expert from a Dutch consultancy organization specialized in knowledge management. This review resulted in optimization of the assessment method in the form of rephrased questions and an altered chronology of the survey.
Secondly, face validity of the assessment method was tested by performing a non-expert pre-test. The method for conducting the face validity assessment is based on Walonick (2006). The pre-test consisted of ten individuals that were not knowledgeable about the content of the assessment survey, i.e. non-experts. The ten non-experts were asked to take the survey and think aloud while reading and answering the questions. By capturing all questions and remarks, revisions were made to the survey, i.e. rephrasing some questions.
Finally, a case study has been conducted at a Dutch based non-profit healthcare organization. Six respondents of this organization filled in the survey. Because all

respondents work for the same organization, it was assumed that the respondents would provide similar answers. However, the results showed that the answers of the respondents were not consistent. An interview with the respondents as well as a document study was performed in order to provide more insight. These examinations resulted in an important insight. Respondents provided a desired situation rather than the actual situation in their answers. Analyzing the survey questions revealed that the questions encouraged respondents to indicate the desired situation. As a result, the survey has been extended with supporting texts such that respondents only provide answers that refer to the actual situation.

3.4 Data collection

After validation, the NKM Assessment Method was applied in order to explore the level of New Knowledge Management application in Dutch organizations, and to examine the relations between NKM application and organizational characteristics. This section reports on a survey research among 30 Dutch organizations that was conducted to this end. First, the data collection process is elaborated, continued by the presentation of the findings of the research.

3.4.1 Data Collection

Data was acquired by inferential research, using convenience random sampling to recruit organizations and their respondents (Triola, 2004). After 30 suitable respondents from an equal number of organizations were mobilized from the social network of the research team, the survey was executed using an online web-survey tool that was hosted between June and August 2006. In the survey, each respondent was asked to judge the current situation of their organization concerning the 14 NKM indicators. In addition, they answered questions with regard to the organizational characteristics as defined in the previous theory section.

A first important step in processing the collected survey data is to explore the junction between variables that are assumed to measure a common concept, in this case the 14 New Knowledge indicators. Common methods to do this are (confirmatory) factor analysis and reliability analysis. Conducting a principal components analysis for the 14 variables resulted into a one-factor solution that achieves 30% explained variance. More convincing is the result from reliability analysis, i.e. the Cronbach's alpha value of 0.80 over the set of 14 NKM indicators. As the removal of none of the indicators significantly improves the results of neither the principal component nor the reliability analysis, we can

conclude that all 14 variables/indicators contribute to the (latent) measurement of the level of NKM application within the organizations.

New Knowledge Management Application

We can now present the distribution of the level of NKM application within our response group of 30 Dutch organizations. In line with the data reduction analysis presented above, the aggregated variable 'level of NKM application' was computed as the average score of the 14 NKM indicators. The distribution of this aggregated variable is presented as a histogram in figure 1.

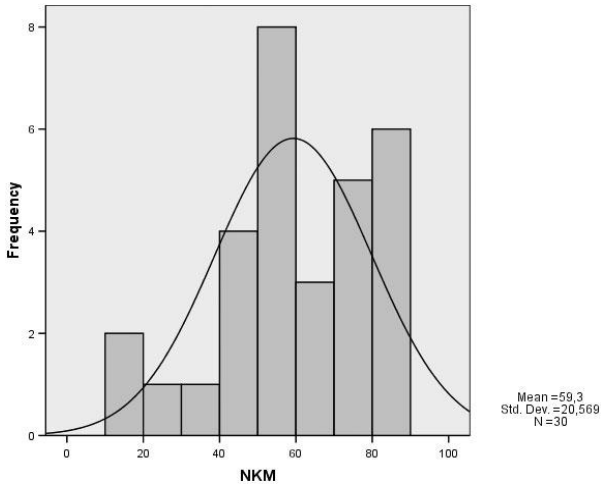


Figure 1: Histogram of NKM Application

It appears that the average NKM application level within our group of 30 respondents is 59.3. This implies that, on average, NKM is applied for about 60% on a 0 to 100 scale. In addition, it should be noted that the standard deviation is 20.6, indicating that organizations considerably deviate from this average score. This obviously challenges the question how the differences in NKM application between organizations can be explained, i.e. how these are related to organizational characteristics, as will be presented in the next section.
The application level of NKM can also be presented per indicator. Table 3.5 provides the frequency distribution for each indicator recapturing their original code categories.

Table 3.5. NKM application levels per indicator

	NKM Application Level				
NKM Indicator	0%	33%	50%	66%	100%
Fallibility	20%	-	57%	-	23%
Transparency	0%	-	40%	-	60%
Inclusiveness	13%	-	77%	-	10%
Fair Comparison	53%	-	-	-	47%
Looking for Trouble	40%	-	-	-	60%
Growth of Knowledge	30%	-	-	-	70%
Fact / Value	20%	-	7%	-	73%
Knowledge Management	33%	23%	-	27%	7%
Policy Synchronization	20%	-	63%	-	17%
Enforcement	33%	-	60%	-	7%
Embryology	17%	-	27%	-	57%
Politics	13%	-	27%	-	60%
Ethodiversity	47%	-	-	-	53%
Connectedness	23%	-	-	-	77%

Note: "-"implies that the code/category is not applicable for this indicator

From the application levels from table 3.5, several values are of interest. The fair comparison and ethodiversity rules e.g. are not applied at all in almost 50% of the sample. On the other hand, the transparency, looking for trouble, growth of knowledge, fact / value, politics of knowledge and connectedness rules are fully applied in 60% or more of the sample.

3.4.2 Organizational Characteristics

In this section, we explore the relationship between the level of NKM application and a limited number of organizational characteristics. From a theoretical point of view, we selected five organizational characteristics: the size of the organization, the hierarchical structure of the organization, the fact whether the organization is dominantly business-to-business or business-to-consumer oriented, the value proposition of the organization and the fact whether a knowledge management supportive IT system is implemented in the organization or not. For these five characteristics, the level of NKM application is broken down in table 3.6 below.

Table 6.3. Proportion of NKM application by organizational characteristics including significant test on category differences

	NKM score			
Organizational Characteristic	Mean	SD	N	T-test / ANOVA on category differences
Organizational Size				Not significant (t=1.3, df=28, p = .200)
Small-Medium (<= 250 employees)	63.6	17.1	17	
Large (251+ employees)	53.7	23.9	13	
Hierarchical Structure				Significant at 5% level (t=2.1, df=28, p=.049)
Flat	64.1	18.1	21	
Hierarchical	48.1	22.8	9	
B2B / B2C				Significant at 10% level (t=2.1, df=28 ,p=.055)
Business-to-Business	65.9	14.7	18	
Business-to-Consumer	49.5	24,6	12	
Value Proposition				Not Significant (F=1.1, df=2, p=.331)
Customer Intimacy	63.2	19.0	17	
Operational Excellence	46.1	33.2	4	
Product Leadership	57.9	16.6	9	
KM IT System?				Significant at 10% level (t=1.9, df=28, p=.066)
Yes	66.5	12.9	14	
No, don't know	53.0	24.2	16	
Total	59.3	20.6	30	

The table shows that our hypotheses were tested with varying results. The first hypothesis was positively tested: smaller organizations averagely apply NKM to a larger extent (63.6) than larger organizations (53.7). This difference is, however, not significant. The second hypothesis was both positively and significantly tested: flat organizations averagely apply NKM to a larger extent (64.1) than hierarchical organizations (48.1). The third hypothesis, however, was not tested according to the assumed hypothesis. Indeed, customer intimacy driven

organizations apply NKM to the largest extent (63.2 opposed to 46.1 operational excellence and 57.9 product leadership) but this difference is not significant. Moreover, it is not the B2C (49.5) but the B2B (65.9) oriented organization, that applies NKM to the largest extent. Summarizing, the significant results show that NKM is more comprehensively applied in flat organizations, B2B oriented companies and in companies that have an IT system to support knowledge management.

3.5 Conclusion on organizational conditions

In this paper, we present a validated assessment method for measuring the NKM application of companies. We applied the assessment method in 30 Dutch companies to determine the adoption of NKM principles. From our sample, it can be indicated that generally the following three principles are widely applied (70% or more of the companies fully apply the principles): Growth of knowledge, Fact/Value, and Connectedness. These principles are part of different NKM cornerstones, therefore, it cannot be concluded that one cornerstone is more fully applied than the others. Furthermore, the following three principles are not widely applied (40% or more of the companies do not apply the principles): Fair comparison, Ethodiversity, and Looking for trouble.

On an aggregate level, the results show that the companies apply about 60% percent of NKM, i.e. all the principles are applied to a more or lesser extent. This percentage is considered relatively high considering the fact NKM theory is rather new. A possible explanation is that NKM is, to a certain extent, a combination of existing knowledge management concepts. Consequently, companies might have implemented these concepts already and therefore score relatively high on the application of NKM. Nevertheless, there is still room for further progress with respect to the level of NKM application in Dutch companies. Besides that the data tells something about the level of NKM application among Dutch companies, it can also be used for benchmarking purposes. Companies in the sample can compare their level of NKM application with other companies in the sample. This makes it possible to compare themselves with the best in class.

From the exploration of NKM application, relations were found between the level of application and some organizational characteristics. Most prominent is the distinction between organizations with a flat versus a hierarchical structure. This supports the assumption that NKM actually concerns policies that strive for openness in the organization and hence would be in conflict with hierarchical structures. In addition, we see that it matters if the organization is B2B oriented and has KM systems in place. Having businesses as customers might imply more complex processes that require more efforts from KM. These can be, obviously,

supported by specific KM systems, although we cannot conclude from these data if this is a driver or a consequence of the application of NKM.

Part III

Social Capital and Dynamic Capability

Chapter 4

Impact of Knowledge Management and Social Capital on Dynamic Capability

One of our most pressing challenges nowadays is sustainable development. Key forces impacting our world are organizations and their primary asset is knowledge. Inspired by this link between organizational knowledge and sustainability, this paper extends previous research that aimed to uncover how organizations can foster an organizational capability that is suggested to be a knowledge-related condition for sustainable development: dynamic capability. In an empirical survey among 55 knowledge-intensive organizations, we studied dynamic capability in organizations from two key perspectives on knowledge: formal, through the adoption of knowledge management policies and informal, through the availability of social capital. Our PLS-SEM model shows that while a formal knowledge management approach strengthens dynamic capability, the availability of social capital is less apparently observable. The paper concludes with an outlook on the role of formal and informal knowledge on dynamic capability.[1]*.*

4.1 Introduction to KM and social capital

The importance of knowledge in organizations is not new. Knowledge is regarded as the primary asset of an organization (Alavi & Leidner, 2001). This is the result of a shift in strategic thinking from the resource-based view of the firm (Penrose, 1960; Wernerfelt, 1984; Barney, 1991b) to the knowledge-based view of the firm (Grant, 1996), regarding knowledge as the primary strategic resource of the firm. Consequently, knowledge management, which is regarded as the management of knowledge processes, is widespread in organizations (Davenport & Prusak, 1998; Jashapara, 2004) and is no longer a new principle (Hansen, 1999). The value of knowledge is underscored by the recognition of knowledge as an impacting factor for performance (Wu, 2008; Helms & Van Reijsen, 2008) and competitive advantage for organizations (Cohen & Levinthal, 1990; Drucker, 1991; Kogut & Zander, 1992; Spender, 1996; Ho, 2008). Knowledge is also suggested as the basis for the capability of innovation in organizations (Barlett &

[1] This work is accepted for publication in the Knowledge Management Research & Practice Journal

Ghoshal, 1989; Hedlund & Nonaka, 1993; Doz & Hamel, 1997; Miguel et al., 2008) and suggested to be related to sustainability (Jorna et al., 2004; McElroy, 2008). The importance of knowledge is suggested here due to the increased complexities of the topic of sustainability: organizations need to rely more than ever on knowledge for sustainable development (Faber et al., 2005).

Surprisingly, the potential leverage of knowledge in organizations for sustainable development is less examined. The apparent link between knowledge in organizations and sustainable development has triggered us to question if and how the knowledge (management) domain can contribute to sustainable development by uncovering knowledge-related organizational capabilities that are beneficial to sustainable development. In earlier research, we investigated the concept of sustainable innovation (McElroy, 2006; Jorna et al., 2009) that formulates that for an organization to be sustainable, it should have full knowledge of its impact on the world and the capability to learn and adapt in response. We were triggered by the latter requirement as we identified it as a well-known topic in strategic management: dynamic capability (Barreto, 2010), further elaborated in the next section.

McElroy's concept of sustainable innovation was based on a theoretical foundation that prescribes how organizations may 'implement' sustainable innovation that McElroy had proposed earlier and coined 'The New Knowledge Management' (further referred to as: NKM) (McElroy, 2003). Subsequently, he operationalized NKM by means of 'The Sustainability Code': a policy model consisting of formal knowledge management policies that target sustainable innovation (McElroy, 2006). NKM was criticized for being too theoretical (Connell, 2003; Nowe, 2003; Loan, 2006) and as empirical support for the effect of NKM adoption was lacking, our previous empirical research tested this link and indeed found a positive result (Van Reijsen et al., 2007a; 2007b). Given the exploratory nature of our research then, we now call for a more elaborate investigation.

Furthermore, through advances in the field of knowledge management, it is nowadays a commonly accepted idea, in supplement to formal approaches to knowledge, that knowledge actually remains tacit and is accessed through informal networks in organizations (Brown & Duguid, 1991; Kogut & Zander, 1992; Macdonald, 1995; Cross, Borgatti & Parker, 2001; Cross & Parker, 2004), also referred to as knowledge networks (Helms & Buysrogge, 2006). In this perspective, a relational approach to knowledge is adopted where the main interest in knowledge is in social relationships and interaction (Kianto & Waajakoski, 2010). The suggestion that organizational outcome is influenced by knowledge processes in informal networks was even stated longer ago (e.g. Kotter, 1982, 1985; Kanter, 1983, 1989; Miles & Snow, 1994). These thoughts already underscored that a variance exists between the formal denotation of the

organization and its actual (informal) working (Orr, 1990). In contrast, NKM is formal in nature as it comprises formal policies that are 'implemented' by management. We identify this as an incomplete lens on the potential impact of knowledge on sustainable innovation.

This research offers the following contributions: to retest the potential leverage of adopting formal KM policies on dynamic capability in organizations in a more elaborate study; to test the potential leverage of informal social capital availability on dynamic capability in organizations and to compare the effect of both formal and informal perspectives. Herewith, this research proposes to test the effect of knowledge perspectives on dynamic capability in organizations. However, it does not claim to test the direct impact of these perspectives on sustainable development. Also, this research focuses on the latter aspect of sustainable innovation (i.e. dynamic capability) and not on the former (i.e. building a knowledge base on organizational impact on the world). We take this focus to align with earlier research, where only the link with dynamic capability was tested.

The remainder of this article is structured as follows. In the theoretical background, a comprehensive acknowledgement for the main constructs of our research is provided: sustainable innovation, dynamic capability, NKM and social capital. Next, we propose 3 research questions that guide our research approach. Following, we introduce our PLS-SEM based research model that aims at testing the impact of both KM perspectives on dynamic capability. We then introduce our survey and explain how our data collection process was performed. In the data analysis section, we reveal the results of the survey and discuss both our analysis approach and an elaborate set of validity tests to support the model and its outcomes. Finally, we face our research questions and conclude on the main findings. Lastly, we acknowledge limitations of our research and suggest directions for future research.

4.2 Theoretical Background on key concepts

4.2.1 Sustainable innovation

The concept of sustainable innovation as proposed by McElroy (2006), embodies the knowledge-driven processes and routines in organizations for sustainable development, i.e. to be sustainable, i.e. to sustainably impact ecology, economy and society. McElroy (ibid) claims that in order for an organization to be sustainable, it requires two things: knowledge of its impact on the world and the uninhibited capability to learn and adapt in response with the aim to improve that impact in light of sustainable development. Both requirements are based knowledge processes in organizations (Jorna, 2009) (i.e. building a knowledge

base of its impact and stimulating its capability to learn and adapt). While the goal of sustainable innovation is to boost sustainable development, these knowledge processes cannot directly impact sustainable development. Instead, an indirect relation exists that is referred to as the three-tier model (McElroy, 2008): the output of knowledge processes is the input for business (operational) processes (i.e. action is knowledge in use). That output, in turn impacts the organization and its environment and hence affects sustainable development. Through this relation, it can be argued that knowledge processes can impact sustainable development. Sustainable innovation is then defined as follows:

"Sustainable innovation embodies knowledge management and practices that provide an organization with knowledge of its impact on the world and the capability to learn and adapt in response, aiming at sustainable development".

It should be noted, however, that there is no guarantee that organizations will actually apply that knowledge base and capability to learn and adapt to improve their sustainability performance (Loan, 2006). However, as argued above, the concept of sustainable innovation does suggest an important role for knowledge in organizations with regard to sustainability.

This role is further illustrated by the notion that sustainability is an increasingly complex concept due to the scale on which sustainability is nowadays regarded (Faber et al., 2005). While sustainability was originally approached in practice as a problem on a world scale (i.e. sustainability of the world), it is now also regarded from a local perspective (i.e. sustainability of a region). These *local specificities* increase the complexity of sustainability and underscore that sustainability has become more dependent on a process of continuous learning. Therefore, organizations need to rely more than ever on knowledge when addressing their sustainability performance (Jorna et al., 2004; McElroy, 2008).

Since this evident link between knowledge and sustainability (i.e. the condition), it is worthwhile to investigate exactly how knowledge can contribute to sustainable innovation (i.e. the process). We therefore propose to examine the link between knowledge in organizations and sustainable innovation. But since sustainable innovation in the way that McElroy postulates it is not a widely recognized nor researched concept, we firstly drill down on its properties to seek more commonly recognized attributes and to thus better embed the concept of sustainable innovation in literature and practice.

The first property of sustainable innovation is the effort to acquire knowledge about the impact that a system (e.g. an organization) has on its environment. It thus refers to a mechanism that allows for the tracking and reporting on the sustainability impact (of an organization). In practice, various sustainability (or corporate social responsibility) principles and reporting frameworks exist nowadays (c.f. Hall (2011), COM (2011), ISO 26000:2010, ISO, 2010,

SA8000:2008, AccountAbility (2008)). While most frameworks focus on the process of addressing sustainable development, an exception is the Global Reporting Initiative framework (GRI, 2011) that additionally provides an extensive set of indicators (KPI's) per sustainability topic (e.g. environment, society, labor) which allows for tangible measurement. Measuring such KPI's could very well operationalize this property of sustainable innovation.
The second property of sustainable innovation concerns the capability of a system (i.e. organization) to learn and adapt in response to the current state of sustainable development. This notion resembles a more widely studied phenomenon, namely dynamic capability. Since dynamic capability is a well-known topic in knowledge management research, it pays off to investigate the components of dynamic capability as it will help to understand its inner working and how it can be measured in empirical research. We will do so in the next section.

4.2.2 Dynamic Capability

The concept of dynamic capability was coined by Teece et al. (1997). These authors referred to this concept as "*a firm's ability to integrate, build and reconfigure internal and external competences to address rapidly changing environments*" (ibid). The authors regard dynamic capabilities as an extension of the resource-based view of the firm (RBV) as the RBV explains firm success or failure based on their resources and capabilities. Moreover, they proposed the capabilities framework that allows examination of the underlying dimensions of dynamic capabilities. In light of this framework, Barreto (2010) underscores that dynamic capabilities have been regarded from a wide variety of perspectives and in an attempt to provide focus, he summarizes the various ways in which dynamic capabilities have been regarded until now. For example, the nature of dynamic capabilities of an organization has been regarded as an ability or capacity (e.g. Zahra et al., 2006; Helfat et al., 2007), but also as a process (Eisenhardt & Martin, 2000) and as a collective activity (Zollo & Winter, 2002).
The anticipated outcome of dynamic capabilities varies: it has been ascribed to benefits such as performance (Teece et al., 1997), economic profit (Makadok, 2001) and competitive advantage (Teece, 2007). These anticipated outcomes have in common that they all regard benefits for the organization itself. This is also reflected in the various definitions that have been opted for dynamic capabilities over the years. Teece (2000) for example refers to "*seizing opportunities quickly and proficiently*" and in another article, Teece (2007) depicts dynamic capabilities as beneficial to "*maintain competitiveness*". However, definitions that are less strictly tied to direct organizational benefits exist as well.

A more relaxed definition is postulated by Zollo & Winter (2002), who relate dynamic capabilities to the "*pursuit of improved effectiveness*". Even more relaxed is the notion of Zahra et al. (2006) who regard dynamic capabilities as the ability to "*reconfigure a firm's resources and routines in the manner envisioned and deemed appropriate*". Also, Eisenhardt & Martin (2000) relate to dynamic capabilities as "*organizational and strategic routines by which firms achieve new resource configuration*". Barreto (2010) argues that "a dynamic capability is the firms potential to systematically solve problems".

Based on the above, it becomes apparent that McElroy's "capability to learn and adapt" is closely related to dynamic capability as set forth in literature. Noblet et al. (2011) describe dynamic capability as an "organizational skill that creates, builds up and reconfigures its resources so as to better address changes in its environment". 'Resources' in the context of sustainable innovation could be the knowledge that an organization acquires about its impact on the world. The correlating 'skill' could then be the process of organizational learning and adaption based on the acquired knowledge. This notion is comparable to the view of Zollo & Winter (2002) who regard dynamic capability as the result of organizational learning and furthermore underscore the role of learning mechanisms in dynamic capabilities.

4.2.3 The New Knowledge Management

NKM was coined by McElroy (2003) and is based on four cornerstones. While these cornerstones are not completely new, the novelty of NKM lies in the extension of these cornerstones, explicit focus on knowledge evaluation and the claim that adoption of the NKM proposition will boost sustainable innovation in organizations.

The first cornerstone is referred to as the Knowledge Life-Cycle (KLC). This concept represents the cyclical flow of knowledge in organizations (e.g. creation, distribution and application). This idea was previously discussed by scholars such as Wiig (1993) and Weggeman (1997). McElroy's adds the explicit evaluation of knowledge claims as a part of the life-cycle, stressing that knowledge should always be regarded as fallible and hence be evaluated regularly.

The second cornerstone of NKM is the idea of the Open Enterprise (OE) that states that knowledge-making is not the same as decision-making. The organization should be open so that every employee can participate in knowledge processes and learning and that all knowledge is accessible to everyone in the organization. The idea of OE is derived from e.g. Daft (2003) who argues about organizations as organic structures instead of bureaucratic systems. It also leans on the concept of Empowerment (Thomas & Velthouse, 1990).

The third corner stone of NKM is based on the idea of an Epistemic Hierarchy that promotes separation of knowledge processes and business processes. It calls for a distinct Knowledge Management (KM) function that is not integrated in the executive (decision making) function. The KM function should have its own resources. Earlier scholars that detected the formation of such distinct KM functions in organizations are Davenport & Prusak (1998), Smith & McKeen (2003) and Awad & Ghaziri (2004).
The fourth cornerstone of NKM is the theory of Complex Adaptive Systems (CAS), previously proposed by Holland (1995). CAS theory promotes the self-organizing tendencies of humans (in organizations) and underscores the potential value of that capability for organizations. Every human is regarded as a complex adaptive system that will intrinsically adapt its behavior based on the changing environment it is acting in. McElroy states that an organization may also be regarded as a complex adaptive system.
The NKM proposition was criticized by other scholars, for defects in its theory formulation (Loan, 2006) but mainly for its lack of guidelines for organizations to implement NKM in practice, while the primary work on NKM was aimed at practitioners (Connell, 2003; Nowe, 2003; Loan, 2006).
Perhaps therefore, McElroy (2006) formulated a policy model based on the four cornerstones: the Sustainability Code. The sustainability code consists of 11 policies: guidelines that an organization can adopt. The 11 policies from the Sustainability Code are based on three of the four NKM cornerstones. In order to cover all four cornerstones, we extended the model with the four policies from CAS theory as defined in McElroy (2003), resulting in a model of 15 policies (van Reijsen et al., 2007b). Table 4.1 below provides a brief overview of these policies.

Table 4.1. The policies of the NKM proposition, mapped onto their cornerstones

Policy	Description
Cornerstone: Knowledge Life Cycle (KLC)	
Fallibility	Knowledge is regarded never true with certainty and hence fallible
Fact/Value	Knowledge claims of both fact and value are evaluated
Fair Comparison	Openness to testing & criticizing knowledge
Internalization	Social and environmental impact of knowledge processes are evaluated
Cornerstone: Open Enterprise (OE)	

Transparency	All knowledge is available to all actors
Inclusiveness	All actors have access to all learning processes
Looking for Trouble	Actors evaluate the performance of knowledge in action
Growth of Knowledge	All actors may produce new knowledge policies if not contradicting
Policy Synchronization	Policy is formed from behavior, not the other way around
Enforcement	Actors that do not abide these policies leave the organization

Cornerstone: Knowledge Management (KM)	
Knowledge Management	A distinct knowledge management function exists with distinct budget

Cornerstone: Complex Adaptive Systems (CAS)	
Embryology	Employees should be allowed to have own personal learning agendas
Politics of Knowledge	Knowledge creation may not be limited to the executive function
Ethodiversity	Employees should be hired based on divergent worldviews
Connectedness	Resources for IT based and social connectivity must be adequate

4.2.4 Social Capital

Social capital is a component of intellectual capital that specifically focuses on the availability of social relationships and shared values and trust in organizational networks (Coleman, 1988; Adler & Kwon, 2000; Lin, 2001) and is hence argued to be a suitable indicator for informal activity in an organization. We adopt the availability of social capital as a means to operationalize the informal approach to the potential impact of knowledge on sustainable innovation.

The concept of social capital is well-defined by Lin (2001), who defines it as "*resources embedded in social structure that are accessed and/or mobilized in purposive actions*". Social capital follows a relational approach towards knowledge in organizations (Brown & Duguid, 1991; Lave & Wenger, 1991; Nahapiet & Ghoshal, 1998; Cohen & Prusak, 2001. In Kianto & Waajakoski (2010), the authors provide a clear overview of the relational approach that social capital has towards knowledge. They state that knowledge is understood as a "socially constructed and shared resource", that the main interest is "social relationships and interaction" and that the focus is on "the characteristics of the

social relationships connecting the actors and social capital embedded in them". The availability of social capital is regarded as a valuable resource that supports employees in performing activities in organizations. In literature several views and/or levels of social capital have been described. Four of these views will be discussed below as they help to operationalize the measurement of social capital. Social capital can be divided into three dimensions: structural, relational and cognitive (Nahapiet & Ghoshal, 1998). Structural refers to the existence of relations between actors (i.e. people in organizations). Relational focuses on the quality of these relations and is expressed in the form of norms, shared values and trust. Cognitive focuses on the extent to which relational capital is shared among actors in the organization and is hence a marker for a shared organizational mind. Hence, social capital describes the relations between people that they can use to utilize the knowledge of their colleagues. Through these social relations they share knowledge and contribute to knowledge creation in the organization.

Another view on social capital is presented by Adler & Kwon (2002) who distinguish 2 viewpoints. First is the ego-centric approach focusing on the benefits of social capital for the individual actor in a network (i.e. organization). Second is the social-centric approach (Putnam, 1993) focusing on social capital as a shared resource for the collective (i.e. the organization). In our research, we only focus on social capital from a socio-centric approach as we are interested in potential benefits for the entire organization and to allow to compare with formal KM approaches that also focus on an organizational level.

Finally, social capital can be regarded from an internal and an external scope. The internal or intra-organizational (Kianto & Waajakoski, 2010) scope focuses on the availability and advantages of social capital in the internal organization. The external or inter-organizational (ibid) scope focuses on the availability of social capital between a focal organization and its environment (e.g. customer, supplier) and its potential advantages for both parties.

4.3 Research questions about impact

Now that the link between organizational knowledge and dynamic capability has been clarified from a theoretical stance, we ask ourselves if this link can be empirically supported. Moreover, given the recognition for both a formal and an informal approach to knowledge in organizations, we wish to examine both perspectives with regard to dynamic capability. Here, we take an explorative approach with no predefined hypotheses on which approach is better suited to impact dynamic capability. Our effort is thus a theory-building effort instead of a

theory-testing effort. As mentioned in the introduction, earlier exploratory research tested the impact of a formal approach towards knowledge on dynamic capability in organizations (Van Reijsen et al., 2007a, 2007b). We then operationalized this formal approach by means of the NKM policies and found a positive relation with dynamic capabilities. In our current research, we aim to retest this link using both a larger sample and a more advanced research approach. For this purpose, we propose our first research question as follows:

Q1a: *Does NKM adoption positively impact the dynamic capability of organizations?*

Since the NKM policies are grouped in the 4 cornerstones of NKM adoption, we can furthermore research the link between these specific dimensions of NKM and dynamic capability to observe if certain dimension are better capable of boosting dynamic capability than others. We therefore formulate a side-question:

Q1b: *Which specific NKM cornerstones are better suited to impact the dynamic capability of organizations?*

Referring to our notion that knowledge should not only be regarded from a formal perspective, we are also interested in the potential impact of an informal perspective on dynamic capability. We operationalize this informal approach by means of social capital availability in organizations. Our second research question is then formulated as follows:

Q2a: *Does the availability of social capital positively impact the dynamic capability of organizations?*

Since social capital consists of separate dimensions we are also interested in the individual contribution of these dimensions to dynamic capability in organizations and formulate a second side-question as follows:

Q2b: *Which specific social capital dimensions are better suited to impact the dynamic capability of organizations?*

Finally, we are interested to learn whether NKM adoption, as a formal approach or social capital availability, as an informal approach, has more leverage on dynamic capability. Learning which approach can better leverage dynamic capability may provide us with new knowledge on how to effectively improve the

dynamic capability of organizations. We formulate our third research question as follows:

> *Q3: Which of both formal and informal KM perspectives has more leverage to impact the dynamic capability of organizations?*

4.4 Research Model for impact

Based on our research questions above, we introduce our research model. Our model is composed as a Structural Equation Model (SEM), where all constructs are formatively measured. The model consists of one central dependent variable (dynamic capability) and two determinant variables: NKM adoption and social capital availability. Each of the 4 cornerstones of NKM adoption are first order constructs that together constitute the formative second order construct NKM Adoption. An analogous reasoning holds for the 6 dimensions of social capital availability.

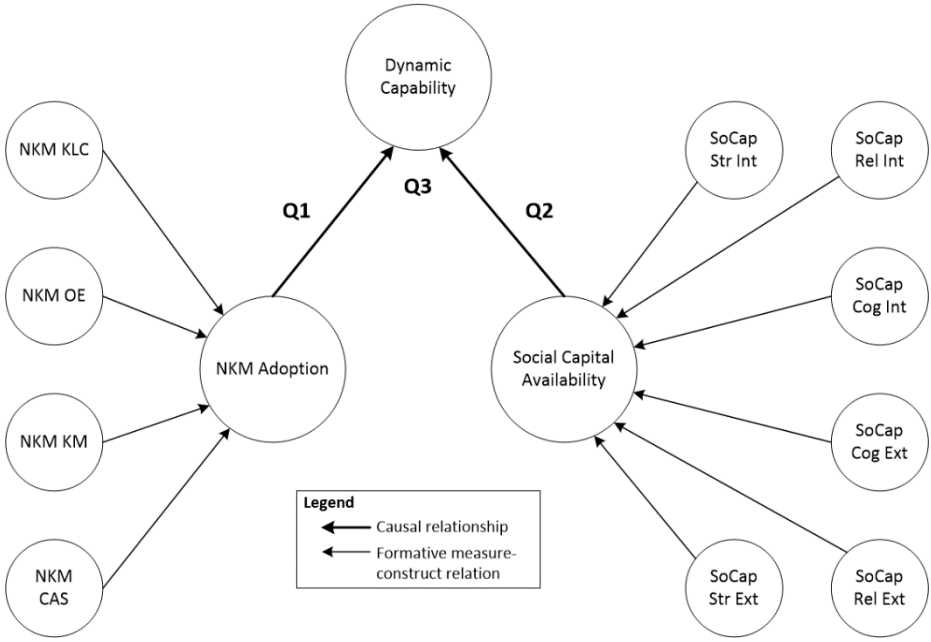


Figure 4.1. Research Model

4.4.1 A PLS-SEM Approach

We decided to apply a PLS-SEM (Partial Least Squares Structural Equation Modelling) approach, for multiple reasons. Foremost, PLS-SEM provides a more robust estimation of our structural model than other analysis techniques (e.g. Reinartz et al., 2009; Ringle et al. 2009). Secondly, there is not yet a scientific foundation for the effect of NKM adoption and/or the availability of social capital on dynamic capability and therefore, this research is moreover oriented on theory development than on theory testing. PLS-SEM is the better approach in this case compared to e.g. components-based SEM (CB-SEM) (Gefen et al., 2000). Moreover, PLS-SEM allows for the application of formative constructs. While the indicators that we associated with NKM adoption and social capital availability *constitute* instead of *represent* their respective constructs, our model is based on formative constructs. Also, the first order constructs applied in our model are different *aspects* instead of different *indices* of their respective second order constructs (Becker et al., 2012) and are hence formatively linked to their second order constructs. This design choice prevents us from wrongfully modelling our items as reflective which may lead to biased analysis results (Jarvis et al., 2003). PLS-SEM is also well-suited when a relatively small sample size is available (Marcoulides & Saunders, 2006; Sosik et al., 2009) such as in our case (N=55). Furthermore, PLS-SEM is well capable of handling ordinal measures (Hair et al., 2010; Haenlein & Kaplan, 2004; Chin, 2010) (which our measures are) and it can deal with models that contain both single-item and multiple-item constructs (Hair et al., 2010), which is the case in our model.

4.4.2 Measurement formulation

To allow observation of the proposed constructs in empirical research, we formulated a set of measures for each construct. First, 15 measures are introduced for the adoption of NKM policies. The measures are formatively assigned to their respective NKM cornerstone construct in line with table 1. Each measure is attributed 3 values that reflect a 0%, 50% or 100% adoption of the policy of focus. This value attribution is comparable to our previous NKM measurement effort (Van Reijsen et al., 2007a, 2007b) where it proved to be an adequate means to observe NKM adoption. Moreover this component was expert-reviewed by several KM experts, providing face validity.

Secondly, 18 measures are introduced to capture social capital availability. For each first order social capital construct in our model, 3 measures are formatively assigned. Each measure is valued by a 5-point Likert scale question, whose scale runs from 'totally disagree' to 'totally agree'. These questions have been successfully applied previously by Kianto & Waajakoski (2010) in their research

on the impact of social capital on organizational growth. Reapplying this approach positively impacts face validity for this component of our research model and is moreover supportive for the coverage of the concept space (Petter et al., 2007) of social capital.
Thirdly, we introduce a set of measures for dynamic capability. Admittedly, this construct is hard to measure. Barreto (2010) argues that dynamic capability is not yet a theory and although he proposes guidelines, he concludes that currently, an operationalization of the construct does not exist. This notion is supported by other researchers (c.f. Kraatz & Zajac (2001), Winter (2003) and Danneels (2008)). As proposed by Barreto (2010), we approach the measurement of dynamic capability by means of objective proxies and introduce 4 proxy measures that are formatively assigned to the dynamic capability construct. Each measure is valued by a 5-point Likert scale question that expresses an extent of dynamic capability, e.g. 'to what extent is your organization able to adapt to changing regulations' or 'client demands'. The Likert scale runs from 'far less' to 'far better'. These measures were expert-reviewed and their formulations were adjusted.

4.5 Data collection on impact

4.5.1 Approach

In order to analyze the proposed model, a data collection approach was set up. We defined our population as knowledge-intensive organizations in general. In our sampling approach, we limited our scope to knowledge-intensive organizations in The Netherlands and Belgium for practical reasons. We did not restrict our sample for organizational characteristics such as size or industry. However, we did measure these variables in order to get an idea about the organizational characteristics of our sample. The applied sampling method thus is convenient random sampling (Triola, 2004). In our sampling effort, we approached senior general-, knowledge- or HR- managers from 75 organizations, aware of knowledge processes in their organization. To collect data from our sample we used the open source web survey tool LimeSurvey (v1.90) that was made available from May to August 2011. Approached managers were invited by email and provided with a description of the survey and a link to participate.
The survey consists of 4 components. The first component is a generic component that gathers information about organizational characteristics such as size in FTE, structure (e.g. flat or hierarchical), value strategy (e.g. customer intimacy) and whether the organization has a KM function and/or KM IT

infrastructure (e.g. intranet, Wiki). The other 3 components contain the measures for NKM adoption, social capital availability and dynamic capability respectively, as set forth in the section on measurement formulation.

4.5.2 Sample

A total of 55 managers participated in our survey (n=55). 42% of the respondent organizations are SME's (< 250 FTE) and 58% large enterprises (250+ FTE). Moreover, 29% has a flat structure and 71% an average to hierarchical structure. 55% of our respondents holds customer intimacy as their value strategy, while 27% aims at product leadership and 18% at operational excellence. Although all organizations are knowledge-intensive organizations, only 35% has a dedicated KM department. Most KM departments measure up to 1-5 FTE. On the other hand, 80% of the respondents indicated that their organization has a KM IT-infrastructure.

4.6 Data analysis and results about impact

After collecting the data via our survey, we set up our SEM model and assigned our data as described. The PLS-SEM tool that we applied for our analysis is WarpPLS version 3.0 (Kock, 2012). We preferred this tool over other PLS-SEM tools as it applies Wold's original PLS regression algorithm (Wold, 1982) that renders lower levels of collinearity, no inflated coefficients and more stable weights. Relatedly, since WarpPLS does not let the inner model influence the outer model, interpretational confounding and point variable instability do not influence our research. Moreover, WarpPLS is well-suited for applying formative constructs. WarpPLS is also capable of identifying non-linear relationships, which is useful since it is not logical to assume linear relations (Kock, 2011b). To load our dataset in WarpPLS, we cleaned our data and left only the data required for the indicators of our model, i.e. the indicators for NKM adoption, social capital availability and dynamic capability. Additionally, we recoded contextual variables such as organizational size and hierarchy in an ordinal way so they can express an 'extent of largeness' and 'extent of hierarchy' respectively. We then imported all measures in WarpPLS and standardized all values to render the measures that were based on varying ordinal ranges dimensionless to allow value comparison among variables. We then defined our hypothesized model in WarpPLS as depicted in figure 1. All indicators are formatively linked to their first order constructs which are in turn formatively linked to their respective second order constructs. Contrary to Kock's (2011b) approach of modelling second order variables that resembles a two-stage approach (Ringle et al., 2009; Wetzels et

al., 2009), we applied the repeated indicator approach (Becker et al., 2012). A two-stage approach separately estimates the lower and higher-order model which might cause interpretational confounding (Wilson & Henseler, 2007) although WarpPLS will prevent this from happening as well. Moreover, Becker et al. (2012) empirically found the repeated indicator approach to yield the most stable model estimations.

4.6.1 Model evaluation

Since our model is fully formatively constructed, we are required to validate our model with formative validation techniques instead of standard tests such as convergent validity and reliability. The indicators that we applied to measure our constructs are not necessarily expected to be highly correlated since they all represent different aspects of their respective constructs (Hair et al., 2010; Kock, 2010a). Therefore, for the validation of our model, we follow the evaluation guidelines for formative PLS-SEM models as posed by Hair et al. (2011) that focus on the measurement (outer) model and the structural (inner) model. Instead of applying bootstrapping for significance assessment we applied jackknifing. This resampling technique has two advantages over bootstrapping: it has more reliable p values and hence renders a more stable model with sample sizes below 100 and reduces the effect of outliers in our data (Kock, 2011a). The model outcomes are displayed in figure 4.2 below.

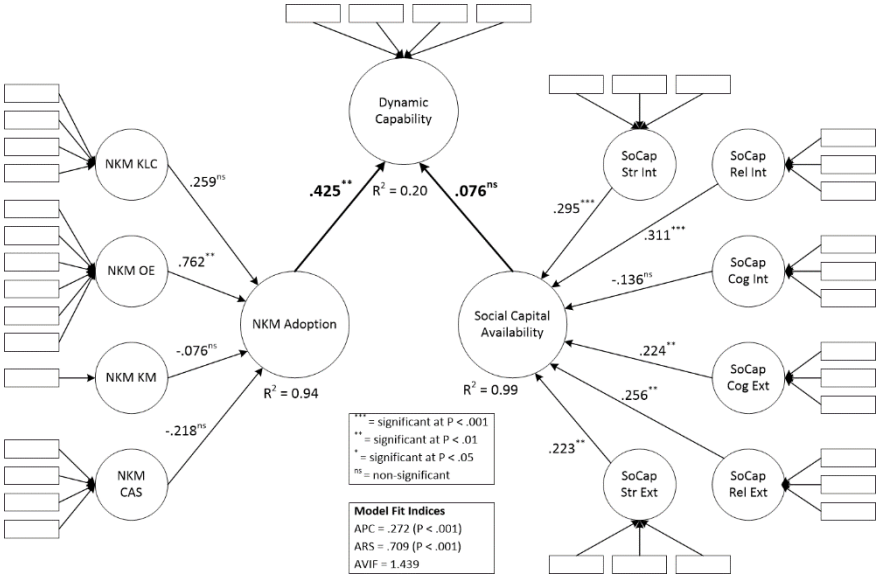


Figure 4.2. PLS-SEM model and outcomes

From a methodological perspective, a requirement for formative constructs is that they form their concept space, meaning that all theoretical concepts of the construct are taken into account by their measures (Petter et al., 2007). We have covered this requirement through prior expert and empirical validation of the measures for NKM adoption (Van Reijsen et al., 2007a) and social capital availability (Kianto & Waajakoski, 2010). The measures for dynamic capability were evaluated by peers as well.

On indicator level (outer model), we evaluated validity by examining the weights (relative contribution) and loadings (absolute contribution) of each indicator on their respective construct. Concerning the weights, Kock (2012) suggests that all p values should be < 0.05. Most of the measures pass this test. Some measures, however, do not. This mainly applies to the measures that form the CAS cornerstone of NKM and the Cognitive Internal social capital construct. This finding suggests that these dimensions are either stronger or weaker associated to their respective constructs than the other dimensions. From a theoretical ground, however, there is no argument to remove these dimensions from our model and therefore decided to leave our model intact to examine in more detail how these dimensions behave in their relation to their constructs. Concerning the loadings, we find comparable results as with the weights. Additionally, Hair et al. (2011) suggest to inspect each indicator's VIF (Variance Inflation Factor). While VIF factors indicate the extent to which an indicator's variance is explained by the other indicators of the same construct, high VIF values are signs of redundant indicators (Urbach & Ahlemann, 2010). Hair (2011) suggests that each VIF should be < 5. Kock (2012) suggests a stricter threshold of VIF < 2.5. In our model, all measures pass this stricter test and hence there is no indication of multicollinearity among our model's indicators.

On a construct level (inner model), the R^2 values for endogenous latent variables indicate the percentage of explained variance for that latent variable and therefore, higher R^2 values indicate a higher explanatory power. The R^2 values of the second order constructs are expectedly high because they are constructed through the repeated measures method (Becker et al., 2012) and hence represent the relationship between the construct and its measures. The R^2 value of the dynamic capability construct is .20 which Hair et al. (2011) consider to be weak. Although this points out that the predictive power of our model is low, our goal is rather to find relationships among the constructs. Notwithstanding, we applied a set of additional tests to further evaluate the validity of our construct model (c.f. Foorthuis et al., 2012). First, we inspected the full collinearity VIF for each latent variable that tests vertical and lateral collinearity. Higher values suggest conceptual redundancy. Kock and Lynn (2012) suggest a threshold of < 3.3. In our model, all full collinearity VIF's are higher. However, lateral

collinearity is expected, because we applied a higher order construct model and used the repeated measures technique to model the second order constructs. In order to check this assumption, we reconstructed our model in a theoretically identical composition but without a second order hierarchy (i.e. directly linking all first order constructs to the dynamic capability construct) and found that all full collinearity VIF's would then be reduced to at least < 1.3. A different test for vertical collinearity is the Block VIF. Kock (2012) suggests a maximum of 3.3. In our model, the highest Block VIF is 1.6. Secondly, an extent of discriminant validity can be evaluated based on a test suggested by Andreev et al. (2009) that requires all correlations between constructs to be < .71. Here, we only regarded correlations between the second order constructs and the dynamic capability construct while high correlations between the first and second order constructs are again expected. No correlation between the constructs of focus fails this test. Next, we evaluated full model validity by means of checking several model fit indices. First, we evaluated the APC (Average Path Coefficient), ARS (Average R^2) and AVIF (Average Variance Inflation Factor) of the model. Kock (2012) suggests that both the APC and ARS values should be significant at the .05 level. In our model, both indices are highly significant with p values of < .001. Moreover, the AVIF, which should be < 5 (Kock, ibid), is 1.4 in our model. Lastly, we evaluate Stone and Geiser's Q^2 values for predictive relevance. All Q^2 values should be > 0 (Chin, 2010), which is true in our model.

To investigate the possible influence of organizational conditions on our results, we checked our model for confounding effects by means of controlling for the influence of contextual variables. In WarpPLS, this can be evaluated by modelling a contextual variable as a direct link to an endogenous variable. We applied two contextual variables (organizational size and hierarchy) and found that all significant relations in the original model remain significant while controlling for both contextual variables. From this finding we derive that all significant relations retain their significance, regardless of organizational size or hierarchy.

As a final test, we visually inspected the curves of the relations between our exogenous variables (NKM adoption and social capital availability) and our endogenous variable (dynamic capability). Since we applied the Warp3 PLS regression algorithm, WarpPLS will try to identify warped relationships (Kock, 2011b). We found that both relations are warped. Moreover, we found two suggestions. First, the NKM curve shows signs of decreasing returns to scale, suggesting that the positive effect of NKM adoption on dynamic capability decreases as NKM adoption increases. Second, the social capital availability curve approaches an inverted u-curve which hints that a certain availability of social capital may be supportive for dynamic capability, but that too much social capital availability is in fact damaging dynamic capability. These findings will be

further discussed in the conclusion section of this article. Both curves are displayed in figures B.1 and B.2 in Appendix B.

4.6.2 Discussion on the PLS results

The primary insight that our model provides is the significant ($p < .01$) relation of NKM adoption with dynamic capability (Q1a). On the other hand, there appears to be no significant relation of social capital availability with dynamic capability (Q2a). This leaves us with the preliminary conclusion that the adoption of formal KM policies does and the availability of social capital does not impact dynamic capability. In order to better understand the impacts of our independent variables, we drill down into the dimensions that build up NKM and social capital.

First, we observed how well the first order NKM adoption constructs individually correlate with the dynamic capability construct. A correlation matrix on first order construct level and an overview of p values is provided in table B.1 and B.2 in Appendix B. It appears that both the Knowledge Life Cycle (KLC) ($P < .001$) and Open Enterprise (OE) ($P < .05$) cornerstone constructs are significantly positively correlated with dynamic capability. The other cornerstones are not. The CAS cornerstone is negatively correlated with dynamic capability. We argue that this findings occurs due to the negative (non-significant) weights for the CAS measures we found earlier. To test this assumption, we re-rendered our model in WarpPLS, applying the Robust Path Analysis algorithm that equalizes all weights (Kock, 2012) and then found that the CAS cornerstone is no longer negatively correlated. However, no positive significant correlation was found either.

To provide more clarity on these findings, we zoomed in even one step further and inspected the correlations among all individual measures of NKM adoption and dynamic capability. A correlation matrix on measures level and an overview of p values is provided in table B.3 in Appendix B. We found that indeed many KLC and OE policies have significant correlations with the dynamic capability construct. Standing out are the Fact/Value (KLC), Internalization (KLC), and Looking for Trouble (OE) policies (Q1b). Furthermore, we found that, most CAS correlations are non-significant, indeed suggesting no effect of the CAS cornerstone on dynamic capability. In any case, we should be modest about these CAS findings given the non-significant weights of the CAS measures in our model.

We then observed how the first order social capital availability constructs correlate with the dynamic capability construct. Here, we find similar results as at the second order construct level: no significant positive correlations are found. However, we did find a significant negative correlation: the Internal Cognitive

social capital construct, which is again blurred by the negative (non-significant) weights of the construct measures as found earlier. Re-rendering our model using the Robust Path Analysis algorithm again confirmed that the negative correlation no longer exists if the measure weights are equalized. This finding, however, motivated us to again zoom in one level deeper and inspect the correlations of all individual social capital availability and dynamic capability measures. At this level of scope, we found some significant correlations (all positive) for the Internal social capital availability measures but almost none for External social capital availability (Q2b). Some of the significant correlations are found in the Cognitive Internal social capital measures, so we have to be modest about these findings. The implications of our findings are discussed in the next section.

4.7 Conclusions and discussion on the impact

In light of the importance of sustainable development by organizations and sustainable innovation as the process of striving for sustainable development, a link to organizational knowledge is suggested (McElroy, 2008; Jorna et al., 2009). In this paper, we were interested to learn how sustainability can be regarded from a knowledge (management) perspective. We identified dynamic capability (Barreto, 2010) as a major component of sustainable innovation and set out to investigate how dynamic capability can be leveraged from two key perspectives on knowledge: formal and informal. In more detail, we observed adoption of formal KM policies by organizations and availability of social capital and tested if these approaches towards knowledge are supportive for the dynamic capability of these organizations and to what extent.

4.7.1 Key Findings and implications

What can we learn from our research? Based on our main model, we found that the adoption of formal KM policies has more impact on the dynamic capability of an organization than the availability of social capital has. In fact, it appears that the formal perspective on KM (i.e. NKM adoption) is the only perspective that in fact has an observable impact on dynamic capability.

This leaves us with the conclusion that if organizations were to improve their dynamic capability, their primary focus should be on implementing a formal KM approach instead of investing in their social capital (Q3). This approach should stimulate an open organization where knowledge may transparently flow (OE cornerstone) and where focus is on evaluation of that knowledge with regard to its accuracy and usability (KLC cornerstone). While the findings of Faber et al. (2005) indicate that in light of sustainable development organizations nowadays

rely more than ever on their capability to process knowledge and adapt to changes, it can be argued that adopting the ideas of NKM provides organizations with the means to adequately address these challenges. Interestingly, these findings are consistent with the findings of Noblet et al. (2011) who also conducted a study on dynamic capability (in their research more specifically on absorptive capacity). These authors found that an open organization is more likely to inspire a strong absorptive capacity, which is comparable to our findings. Moreover, Noblet et al. (ibid) found that strong managerial commitment is a premise for absorptive capacity. This is in line with our main finding that a formal approach towards knowledge can best stimulate dynamic capability.

From a relational perspective, however, our main model did not uncover that the availability of social capital supports organizations to impact their dynamic capability. Since a formal and informal approach towards knowledge are in fact two sides of the same coin, we would have expected to find at least some support for an effect of social capital availability. From a theoretical stance, it could be expected that social capital can be of help to improve dynamic capability, e.g. the existence of structural relations among employees could support more efficient and effective knowledge transfer throughout the organization. Moreover, the quality of relations (e.g. trust) could be beneficial to the timeliness and validity in which crucial knowledge is exchanged. On the other hand, an abundance of relations could also be distortive to dynamic capability: employees with a lot of relations might be overburdened with retaining these relations, which might lead to inertia in knowledge exchange. This is in line with the warped relation that we found earlier, although we have to be modest about the warped curves given the relatively low amount of cases that bend the curve. Moreover, but again in modesty, on a measures level, we did find several significant positive correlations for Internal social capital availability. This suggests that internal social capital is to some extent important for dynamic capability and more than external social capital. From a theoretical viewpoint, this again makes sense: dynamic capability foremost refers to a capability that involves the organization itself, i.e. its internal employees. Moreover it could be argued that organizations can only focus on one of both perspectives at once and since we found hints that internal social capital supports organizations for their dynamic capability, these organizations cannot be investing in external social capital at the same time. Clearly, our findings call for a more extensive investigation of the role of the informal perspective on knowledge concerning the dynamic capability of organizations. Suggestions are provided below.

As a practical implication, we argue that organizations can embrace the NKM policies in practice to strengthen their dynamic capability. Organizational interventions that implement these policies are available. Strengthened dynamic

capability makes organizations more aware of changing conditions and makes them more capable to adapt. Investing in social capital could play an additional role to strengthen dynamic capability. However, additional research needs to further clarify the role and importance of social capital. Lastly, NKM adoption could play a supportive part in corporate social responsibility initiatives. Such initiatives call for process guidelines. For example, the EU strategy on corporate social responsibility (COM(2011) 681) calls for a 'code of good practice for self- and co-regulation exercises, which should improve the effectiveness of the CSR process'. Furthermore, the EU calls for a 'strategic approach to corporate social responsibility where company transparency should be stimulated' (ibid). Based on our research findings we are able to promote adoption of the NKM policies as a means to implement that code of good practice and operationalize that strategic approach.

4.7.2 Limitations

Concerning our PLS-SEM model, it should be noted that in terms of interpreting our results, we need to apply modesty. While our model did pass an elaborate set of evaluative tests, at least we may claim that our constructs are more than the arbitrary summary composites (Bollen, 2011). On the other hand, constructs cannot be validated in a single study (Cenfetelli & Bassellier, 2009). Clearly, there is room for more research to be conducted before our constructs can be claimed to be mature.

Another limitation, could be the comprehensiveness of our central dependent variable 'dynamic capability'. As discussed, however, a true operationalization of this construct does not yet exist and would be multi-interpretable (Barreto, 2010). We therefore rely on our proxy measures.

Finally, while McElroy (2006) suggests that sustainable development requires both knowledge on the impact of the organization on the world and the capability to adapt in response, this study only examined the latter aspect. Although not decisive in our research approach, we add that measuring sustainability performance, e.g. by means of incorporating a sustainability reporting framework in our survey would have been too extensive to conduct in our sample of 55 organizations. It has therefore been a choice of scope to focus on dynamic capability separately.

4.7.3 Future Research

We recommend future research to further examine the links between formal and informal knowledge processes and dynamic capability. This extension could be achieved in multiple ways. One is to improve the measurement of dynamic

capability. A framework that measures dynamic capability or absorptive capacity specifically could help here. Noblet et al. (2011) propose such a framework, although it would still need to be operationalized before it can be applied in empirical research. Another extension would be to more deeply inspect the informal perspective of knowledge with regard to dynamic capability. Our research findings hinted that social capital availability is non-linearly related to dynamic capability. However, our study does not uncover the inner workings of that relation. It could therefore be relevant to study the effect of informal knowledge characteristics on dynamic capability from a different angle, e.g. from a relational angle, by means of observing social structures and their effect on dynamic capability.

Part IV

Knowledge Networks: Techniques

Chapter 5

Knowledge Network Data Capturing Techniques

In today's knowledge driven economy, knowledge is considered to be the key factor in defining the success of an organization. We have learned that knowledge is residing in the informal network of the organization. Hence, to improve performance, it is the informal knowledge network that should be examined and developed. For this purpose, social network analysis is increasingly applied in business contexts. This is, however, a new domain, which is still in development. This paper aims to aid in this development by researching how representative knowledge networks can be revealed in organizations. While surveying is a common first option to capture an organizational network, this technique may not always be suitable. Communication sources (e.g. email) may provide an alternative, however, we do not know to what extent these sources can represent the actual knowledge network. This paper examines a Dutch IT services organization. Here, a web-survey among the employees baselines the knowledge network, which is compared to 3 communication networks from the same organization, captured by means of email, telephone and SMS (Short Message Service) communication (also known as text messaging or texting). A comparison is made by means of correlating the network matrices and by comparing essential network properties. Findings show that only the email network is significantly representative for the baselined knowledge network. This exercise is exploratory in nature as only one organization is examined, but comprehensive with regard to the richness of data that is available for examination. From our findings we gain insight in the extent to which networks, captured from email, telephone and SMS archives can represent an organizational knowledge network.[1].

[1] This work has been published as: Reijsen, J. van and Helms, R. (2009). Revealing Knowledge Networks from Computer Mediated Communication in Organizations. In Newell, S., Whitley, E.A., Pouloudi, N., Wareham, J. and Mathiassen, L. (Eds.), *Proceedings of the 17th European Conference on Information Systems*, Verona, Italy, 2009.

5.1 Introduction to Knowledge Networks

Knowledge management is widespread in organizations and involves the management of knowledge processes concerning generating, sharing and using knowledge (Davenport & Prusak, 1998). Typically, there are two approaches toward knowledge management: codification and personalization (Hansen, Nohria & Tierney, 1999). The first approach assumes that knowledge within the organization can be made explicit and stored within information systems such as knowledge repositories. Hence, knowledge should be retained so that it is available for re-use. The second approach considers organizations as transactive knowledge systems where knowledge is exchanged between individuals (Wegner, 1987). In this approach, knowledge management focuses on stimulating the interaction between individuals so that knowledge diffusion takes place throughout the organization.

The personalization approach has gained more attention of researchers in recent years. Part of this research focuses on the pattern of knowledge interactions that we refer to as knowledge networks (Hansen, 2002). A visual representation of such a knowledge network consists of nodes that represent the employees of an organization while the links between these nodes represent the knowledge exchanges between these employees. This contextual specification is the main difference between a social network and a knowledge network: a knowledge network is a social network regarded from a knowledge perspective. A useful method for studying these networks is Social Network Analysis (SNA) as it supports both qualitative and quantitative network research (Wasserman & Faust, 1994; Cross & Parker, 2004). Network data that is required for this research is typically collected using surveys or in some instances using interviews. In a survey, a respondent is asked about his/her knowledge exchange relations with his/her colleagues within the organization. Aspects of the relation that can be of interest include the type of knowledge that is exchanged, how it is exchanged, and how frequently it is exchanged. A disadvantage of surveys is that, especially for large surveys, it takes considerable time from the respondent to fill out the survey and that high response rates are required to do qualitative analysis in case studies (Helms, 2007; Teigland, 2002). Consequently, there is hardly any longitudinal analysis of knowledge networks as it requires that a survey is sent out several times during a certain period.

To overcome these issues, some researchers analyze email traffic within organizations as a source for collecting network data (e.g. Tyler, et al., 2005). The advantage here is that because respondents do not need to fill out a survey, the response rate is 100% and longitudinal analysis becomes possible by examining consecutive time frames. A limitation, however, is that the assumption

with analyzing email traffic is that email communication is representative for communication that concerns knowledge exchange. Principally, this idea is not wrong as knowledge is an act of personal interaction by means of communication. But this communication does not only take place through email messages. Face-to-face communication is also an important means for getting knowledge across (Lock Lee & Neff, 2004). Furthermore, email messages are not only used for knowledge exchange but for instance also for coordinating tasks and personal messages (Whittaker & Sidner, 1996). Next to email traffic, other communication sources may be applied to overcome the issues of capturing an informal network by means of surveying. One alternative is by means of tracking telephone conversations within an organization. Also, tracking text messages (texting), further referred to as SMS messages (Short Message Service), may be a valuable source for capturing the informal network of the organization.
This paper intends to examine the extent to which networks that are created from sources such as email, telephone and SMS communication are representative for the knowledge network of an organization. We define our research question as follows:

RQ: *To what extent are networks, captured from computer mediated communication sources representative for the knowledge network of an organization?*

The need for this research initiative stems from the fact that the analysis of knowledge networks is becoming a more popular instrument in both science and management. Data capturing by means of surveying knows several limitations that data capturing from computer mediated communication sources does not have. The latter form of data capturing always yields a 100% participation, covering the full network, and it supports longitudinal analysis opportunities. If this research can indicate if and to what extent computer mediated communication sources are suitable to represent knowledge networks, it enables new possibilities for analyzing networks for both science and business.
The remainder of this paper is structured as follows. In section 5.2 this research is embedded in its theoretical background. Section 5.3 elaborates on the research method and approach. A case study were networks are captured and compared is introduced and a comparison approach of the networks is elaborated upon. In section 5.4 the results of the case study are provided, based on the proposed measuring and comparison approach. In section 5.5 our findings are discussed and conclusions and limitations are provided.

5.2 Theoretical background on Knowledge Networks

A knowledge network concerns the knowledge management activities (e.g. knowledge creation or sharing) that take place among people in an organization. When focusing on a particular knowledge management activity, several types of knowledge networks can be distinguished. Two types of knowledge networks that are often distinguished in literature include learning networks (cf. Skerlavaj, Dimovski, Mrvar & Pahor, 2008) and advice networks (cf. Borgatti & Cross, 2003). Both types of knowledge network are included in this research and described in more detail below. Furthermore, the role of communication in knowledge exchange is briefly explored, which finally leads to the idea to use communication data stored by technology supported media as a source for collecting data on knowledge networks.

The traditional, cognitive view on learning assumes that learning is a mental process within the heads of individuals (Hustad, 2007). In this view, learning is separated from doing in practice and therefore neglects what can be learnt through experience and collaboration. More recent views consider learning as a social process of mutual engagement and relate learning explicitly to practice. Two major accounts in this field are the work by Lave & Wenger (1991) and Brown & Duguid (1991). Based on their studies, they introduced the concept of Situated Learning and Learning in Working respectively. The concept of situated learning is based on master-apprenticeship relationships where apprentices learn and master a practice through legitimate peripheral participation. Peripheral participation means that the apprentices start participating by performing relatively easy tasks and with low risk to the practice, i.e. in the periphery of the practice. During the execution of his tasks, the apprentice engages with and is coached by more experienced practitioners in the practice. If an apprentice is successful, i.e. he is learning, he gets more responsibilities until he finally becomes a master himself.

In this research, we refer to the learning relations between employees in an organization as knowledge networks (Skerlavaj et al., 2008; Palazzolo et al., 2006). Knowledge that is exchanged in learning relations typically involves tacit knowledge and consists of skills, experience and attitudes. This makes knowledge exchange difficult and therefore not every type of knowledge exchange is as effective as another. More active learning approaches, e.g. guided problem solving or guided observation, are preferred as they result in richer knowledge transfers from the master to the apprentice (Leonard & Swap, 2005; Davenport & Prusak, 1998). Richer knowledge transfers results in a higher level of knowledge exchange and therefore contribute to a deeper understanding of the practice. The goal of learning networks is to increase and preserve the

knowledge and competence level of employees in the organization, which should ultimately result in a better performance of the organization (Skerlavaj et al., 2008).

Advice networks refer to the idea that employees are dependent on the knowledge of others to execute their job (Cross & Parker, 2004). In that case, it is important to know who knows what and to have access to these people so that they can be asked for advice when needed (Borgatti & Cross, 2003). Cross, Borgatti & Parker (2001) defined five different types of advice that can be sought: Solutions, Meta-knowledge, Problem reformulation, Validation, and Legitimation. These types indicate the intention for seeking advice from a colleague. Providing advice takes place by exchanging knowledge, however, this knowledge exchange is considered to be different from knowledge exchange in a learning network. In the case of an advice network, the goal is to transfer just enough knowledge so that the advice seeker can solve his problem. Hence, more passive learning approaches for knowledge exchange can be used such as directives, rules of thumb or pointers to information sources (Leonard & Swap, 2005). Besides knowing who knows who and having access, it is also important that you can tap into this knowledge quickly (Cross & Parker, 2004). The speed of knowledge exchange is referred to as velocity (Davenport & Prusak, 1998). It is defined as the time between contacting a colleague and finally receiving the requested knowledge from this colleague, either directly from him or via him from another colleague. The higher the velocity of the knowledge exchanges in the advice network, the better it is for the job performance (Hansen, 2002).

Communication is a vital mechanism when it comes to exchanging knowledge in learning as well as advice networks (Palazzolo et al., 2006). It is through communication, consisting of for example discussions and asking questions, that an apprentice can learn from a master. Furthermore, communication is also the basis for asking advice from colleagues. Several media are available for communication and hence for knowledge exchange in learning and advice networks. Basically, two types of media can be distinguished: Face-to-face contact and technology supported media. According to media richness theory (Daft & Lengel, 1986), the selection of the right medium depends on the richness of the knowledge that needs to be exchanged. Consequently, it might be wise to use different media for learning and asking for advice as the richness of the knowledge transfer in both cases is different. Research shows that people have a strong preference for face-to-face contact when it comes to exchanging knowledge (Cross et al., 2001; Smith & McKeen, 2003; Lock Lee & Neff, 2004). All studies reported that computer supported media such as email, telephone or intranet have a lower preference. It is not just that face-to-face contact is the best medium per se but also that other factors are involved why

people prefer face-to-face contact. These factors include trust and social cues for example (Wenger, McDermott & Snyder, 2002; Van den Hooff, De Ridder & Aukema, 2004). But it is not just a matter of selecting the best medium, but using several media at the same time as they reinforce and support each other (Davenport & Prusak, 1998). Hence, it is likely that people will use several computer supported media to support face-to-face contact. Based on this assumption, it might be worthwhile to explore to what extent data about knowledge network relations can be retrieved from the computer supported media that store data about communication.
Email is a computer supported medium that is more frequently used to capture the social network of an organization (e.g. Tyler, Wilkinson & Huberman, 2005) and a variety of tools exist that support capturing a social network from email data (e.g.: Gloor (2004), Edwards (2005), Mika (2005) and Viegas, Golder & Donath (2006)). Email is argued to be a plausible source for capturing a social network. Farnham, Portnoy & Turski (2004) for example reveal that the people we mail most are also the people we tend to work with most. This does, however, not argue for the fact whether email data may also be applied to capture a knowledge network. Hence, it is relevant to investigate to what extent email data, along with other computer mediated communication sources, such as telephone communication and SMS messages, are plausible as sources to capture the knowledge network of an organization.

5.3 Research method for techniques comparison

5.3.1 Approach & Sample

In order to examine the research questions, a comparison was made between an advice and a learning network on the one hand and 3 communication networks on the other hand, derived from email traffic, mobile phone calls and SMS messages. The choice for these networks stems from the availability of data in our sample. A case study was conducted in a Dutch consultancy firm in the IT services sector. The firm consists of 68 employees, of which 41 were included in our sample due to their participation in the survey. Of these 41 employees, 10% is female. Moreover, the sample is divided over 6 functional areas (e.g. management, consultancy) and 3 levels of seniority (junior, medior, senior). The case study was conducted in June 2008, a non-holiday period, boosting the representativeness of the networks while no colleagues were unavailable. The scope of the data collection was 1 month. Most employees in our sample are geographically separated in their daily work. Therefore, these employees heavily

rely on computer mediated communication media such as email, telephone and SMS to communicate with each other.

5.3.2 Data collection

The data for the advice and the learning network was collected by means of an online web-survey that was specifically created for this research. In the survey, employees were asked to indicate to what extent they give advice to each other and to what extent they learn from others. Both questions could score on a 5-point scale, ranging from “sporadically” to “intensively”. From the survey results, two adjacency matrices were created: an advice network and a learning network. The scores that each 1 respondent provided for 1..n colleagues were placed in the cells of an adjacency matrix where each respondent is represented by a row and each colleague by a column. The cells were the row and column match the same person were not taken into account. While no advice or learning (score: 0) was also denoted in the adjacency matrix, a matrix is always squared. Eventually, before the calculations were performed, the 2 matrices were recoded. The 5 points in the scale were reduced to 4 points, cancelling out the 1 on the scale, leaving a scale of 2-5. This was done after an examination of the scores in the web-survey. About 50% of the respondents indicated a connection to all other respondents of at least 1 on the scale, meaning that these respondents indicated that they at least sporadically contacted all other respondents. The other 50% of the respondents did not indicate this connection of at least 1 on the scale to all other respondents. This distortion was solved by removing the 1 on the scale. The communication networks (email, telephone and SMS) were not recoded.
For the respondents that participated in the survey, we also collected data about their email, telephone and SMS communication. For this purpose, the Exchange server was accessed to extract one month of email communication data and mobile phone bills were accessed to extract telephone and SMS communication data. Both the data from the Exchange server and the mobile phone bills were applied in a data mining application that was specifically designed and developed for this research, called ESNE: Email Social Network Extraction. The application uses the header data of email messages (the “from” and “to” headers). The content of the messages (body data) was discarded due to privacy regulations in our organization of study. Also, the application supports filtering of the email messages. Filtering was applied in various ways. First of all, the data was filtered for a specific time frame of 1 month. Moreover, an upper bound was defined for mass emails. Messages that were sent to over 20 recipients were filtered out from our research. It is argued that these emails do not represent personal communication as is the case in an advice and a learning network. No lower

bound was defined. Different from other tools, our application also filtered out automatically generated messages (e.g. an out-of-office reply) and all senders and recipients external to the company, leaving only the communication between employees, as again is the case in an advice and a learning network. Similar to other tools (e.g. Holzer, Malin & Sweeney (2005) and Bird et al. (2006)), the application also supports finding aliases. The application scanned all employees on their first and last name and provided possible aliases for each employee (i.e. different mail addresses). All possible aliases were manually linked to an employee or discarded by a manager from the organization. The application itself does not support the visualization of a social network from the data but it is capable of creating adjacency matrices from the email data in the format of the social network analysis software used in this research (.ntf file to import in Cyram Netminer 3.30a). The .ntf file contains both the adjacency matrix and an attribute table containing actor attributes that were derived from employee data managed in the application. This way, an adjacency matrix was created from the filtered email data (including aliases) from June 2008. The weight in the adjacency matrix is expressed by the amount of email messages exchanged between two actors.
Likewise, two adjacency matrices were created from the telephone and SMS data. The application filtered the telephone data to exclude all but mobile phone calls from and to the employees of the focal organization. Also, calls that lasted less than 10 seconds were filtered out. Concerning the SMS data, only the messages that were sent from and to employees were included. The weight in both matrices is again expressed by the amount of calls or messages exchanged between two actors. All matrices i.e. the advice and learning matrices from the web-survey and the email, telephone and SMS matrices from the analysis tool, were manually combined to one file containing the 5 matrices, identical in size and actors, and one attribute table to be used in our social network analysis software.

5.3.3 Measures

In order to investigate the differences between the networks, a means to compare the networks is required. In the comparison process, the networks that were captured by means of the web-survey were treated as a baseline. It is argued that these networks represent the actual advice and learning network of the organization, as these are the only networks where the employees indicated their relations themselves. In comparison: the email, telephone and SMS networks are a result of communication, moreover than an indication of relations by the employees themselves.

For the comparison between the networks, a two-way comparison format is proposed. First, the networks are compared by means of correlating the matrices. Correlation coefficients can indicate the extent to which the matrices of the networks are similar to each other. The correlation coefficients can be calculated over the non-weighed (binary) data and the weighed data. The first calculation indicates similarity when only observing whether actors are tied or not. The second calculation indicates the similarity when also taking into account the weight of links between actors. The correlation coefficients for the non-weighed matrices are calculated using the Jaccard coefficient. This coefficient is based on only the existing relations in a matrix and neglects the non-existing relations (i.e. it matches the 1 and neglects the 0). For the weighed matrices, the Pearon's correlation coefficient is applied. For all correlation measures, a QAP permutation test (Borgatti, Everett & Freeman, 1992) is applied with 2.500 iterations in order to support the significance of the correlation scores.
In the second way of comparing the networks from our comparison format, the networks are compared by means of calculating and comparing network properties that tell something about the structure of the networks. By comparing the networks by means of their properties, further insight can be gained in the equivalence of the networks. For comparing the network properties, we use a number of well-known network measures (derived from Hanneman & Riddle (2005)) that cover different aspects of network structure. An overview of the network properties that are examined is provided in table 1. For a more elaborate description of the network properties, the reader is referred to Hanneman & Riddle (2005)).

Table 5.1. Network properties used to compare the networks

	Description
Basic Demographics	
Number of Links	Total amount of links that exist between the actors in the network (e.g. 50)
Average Degree	Average amount of links per actor in the network (e.g. 5)
Connection	
Mean Distance	Network average of geographic path distance between 2 actors in the network (e.g. 2,2)
Diameter	Network maximum of geographic path distance between 2 actors in the network (e.g. 5)
Density	Ratio of existing links relative to the amount of possible links (e.g. 35%)

Connectedness	Extent to which the network is a single component (e.g. 35%)
Embedding	
Reciprocity (Dyad method)	Extent to which relations are dyadic (e.g. 35%)
Transitivity	Extent to which relations are triangular (e.g. 35%)
Centrality	
In-Degree Centralization	Degree of variance in in-degree centrality opposed to a perfect star network (e.g. 35%)
Out-Degree Centralization	Degree of variance in out-degree centrality opposed to a perfect star network (e.g. 35%)
Clustering	
Clustering Coefficient	Extent to which connections overlap per actor (my link is also your link) (e.g. 35%)

5.4 Results of techniques comparison

5.4.1 Matrix correlations

In tables 5.2 and 5.3 below, an overview is provided of the correlation coefficients between all five networks. For the QAP permutation test, in all cases the p >= observed values were .000, indicating that all results are significant. For the Pearson correlations of the weighed matrices, the significance is expressed by either * or **.

As can be derived from tables 5.2 and 5.3, the correlation coefficient between the advice and learning network indicates that both networks have no specifically high overlap. From this fact we may conclude that it is plausible to interpret the correlations of the email, telephone and SMS networks to the advice network separate from the correlations of those communication networks to the learning network. A clear decreasing trend is visible for the similarity between the survey networks (advice and learning) and the communication networks, decreasing from mail, to telephone, to SMS. This trend applies for both the non-weighed and weighed data and for both the advice and learning network. Another result from the calculations is the fact that the weighed communication network matrices show higher scores than the non-weighed communication network matrices, meaning that e.g. the email network is more similar to the advice and learning network if the weight of the links is taken into account. The email, telephone and SMS networks tend to be more similar to the advice network than to the learning network. However, these differences are only minor.

Table 5.2: Jaccard coefficient calculations between the non-weighed networks

	Advice	Learning	Mail	Phone	SMS	Extended
Advice						
Learning	.376					
Mail	.409	.397				
Phone	.212	.212	.312			
SMS	.074	.079	.085	.202		
Extended	.389	.386	.502	.184	.054	

Table 5.3: Pearson correlation coefficient calculations between the weighed networks

	Advice	Learning	Mail	Phone	SMS	Extended
Advice						
Learning	.458**					
Mail	.419*	.383*				
Phone	.287	.230	.487**			
SMS	.132	.098	.199	.413*		
Extended	.499**	.456**	.830**	.438*	.214	

5.4.2 Extended mail network

From our findings from the matrix correlations, we learned that of all communication networks, the email network is the most similar to the advice and learning network. Therefore we decided to extend the research concerning the similarity between the advice and learning network on the one hand and the email network on the other hand. It is argued that the timeframe of one month that is applied in this research may yield that the email network is less similar to the advice and learning networks than it could be if the timeframe is extended. Therefore, the timeframe of the email network was extended to 6 months, from January to June 2008. From this data, a new network, the extended email network, was constructed using the data mining application (ESNE). The extended email network was then correlated against the advice and learning network. Again, the p >= observed values were .000 in all cases, indicating that all results are significant. The results from these calculations are incorporated in tables 5.2 and 5.3 above.

The results show a different outcome for the non-weighed than for the weighed data. The non-weighed data shows that the extended email network is less similar to the original email network that consists of only one month of data. However, the difference between the scores from the non-weighed and the weighed data are minimal. On the other hand, the weighed data does indeed show that the extended email network is more similar to both the advice and learning networks than the original email data of one month.

5.4.3 Network properties

In table 5.4 an overview is provided of the scores from 11 network properties that are commonly used in social network analysis. The scores are calculated for all basic weighed networks (i.e. the extended email network is excluded from our scope here).

Table 5.4. Network properties and scores

	Advice	Learning	Mail	Phone	SMS
Basic Demographics					
Number of Links	464	465	493	193	57
Average Degree	11	11	12	5	1
Connection					
Mean Distance	1,8	1,8	1,8	2,1	2,4
Diameter	4	4	4	5	5
Density	28%	28%	30%	12%	4%
Connectedness	81%	90%	100%	37%	6%
Embedding					
Reciprocity (Dyad method)	36%	36%	76%	30%	43%
Transitivity	54%	54%	53%	35%	26%
Centrality					
In-Degree Centralization	38%	71%	44%	39%	14%
Out-Degree Centralization	71%	48%	46%	37%	12%
Clustering					
Clustering Coefficient	72%	71%	69%	59%	21%

The network properties displayed in table 4 show different scores for the different networks. For most network properties, the same trend can be visualized as with the matrix correlations. Of all communication networks, it is again the email network that most resembles the advice and learning networks. The telephone network is less similar to the advice and learning networks and the SMS network even less. This trend does, however, not apply for the reciprocity network property. An explanation for the deviating reciprocity value in the email network may be that of all forms of communication studied in this research, email is typically a medium of bilateral communication, i.e. an email is typically replied to with another email. This way of communicating is not found in media such as telephony or in an advice or learning network, where one instance of communication already involves both sender and receiver.
The matrix correlations showed that the email network, which is the communication network that most resembles the surveyed networks, is more similar to the advice network than to the learning network. In the case of the network properties, however, the email network is more similar to the learning network than to the advice network. Again, these differences are only minor. This does, however, not apply for the centralization properties, where the in-degree centralization index of the email network is far more similar to the advice network and the out-degree centralization index of the email network is far more similar to the learning network.

5.5 Conclusions and discussion on the comparison

5.5.1 Discussion & conclusions

This paper intended to examine to what extent computer mediated communication in organizations may be representative sources for capturing and analyzing organizational knowledge networks. As the analysis of organizational networks is becoming an increasingly more important management instrument, there is a need to continuously improve the analysis method. While capturing network data by means of surveying knows several limitations, the analysis of computer mediated communication sources may provide a promising alternative. In the Dutch IT services organization were we conducted our case study, 6 networks were captured: the advice and learning network by means of surveying and 4 communication networks from email traffic (1 month and 6 months in length), telephone conversations and SMS (text) messages. Consequently, a comparison between the networks was conducted by means of two comparison approaches: correlating the network matrices and comparing basic network

properties, applied in social network analysis. Results from the matrix correlations show that only the email network (both the original and the extended network) is significantly representative for both the advice and learning network. The telephone and SMS network are only slightly representative to the advice and learning network. The results from the network property calculations support the findings from the matrix correlations to a large extent. A secondary finding is the fact that the extended email network has a mixed effect on the quality of representativeness of the original email network. While the weighed extended email network is more representative to the learning and advice network as its weights are more representative, the non-weighed extended email network is less representative for the advice and learning network. This is probably caused by a distortion due to introducing new relations in the extended email network that were not present in the original email network and also not in the advice and learning network. This distortion may be removed by defining a minimum amount of messages sent between two actors before including the relation in the network (recoding the data). Although this examination was only conducted in one organization, the richness of the data proved worth to investigate how the computer mediated communication networks resemble the advice and learning network that provided a baseline for the knowledge networks in the organization of our case study. We may conclude from our research that a network based on email traffic proves to be a valid representation for a knowledge network when conducting knowledge network analysis if surveying the focal organization is not an option.

5.5.2 Limitations

Probably the most important limitation on our research is the fact that this research was conducted in only one organization. Therefore, we cannot conclude on the repeatability of our findings in other organizations. It is, however, imaginable that it is quite a challenge to find multiple organizations that are willing to participate in a survey and also provide access to their Exchange server (email) and to provide mobile phone bills (telephone and SMS). This is the reason that this research was addressed as an exploratory case study. Another limitation is that the scales used in the data capturing process for the 6 matrices were not normalized. The advice and learning networks consist of a 5-point scale, whereas the email, telephone and SMS networks were based on the amount of messages or calls. However, the analysis of the matrix correlations lowers the effect of this limitation as the coefficients calculated over both the weighed and non-weighed networks are similar to a large extent. A final limitation is the fact that the telephone and SMS networks could not be captured for 100% of the data. This

is due to the fact that the telephone bills were partially concealed. This was done by the provider of the telephone network and could not be altered. In the telephone network 20% of the data was removed and in the SMS network 9% of the data was removed due to concealed data (anonymous calls and SMS messages). Because the blocked entries on the telephone bills are spread over all of the actors, it is false to conclude that the measured indicators deviate by 20% and 9%. The percentages only decrease the amount of calls and messages, they do not remove 20% and 9% of the links. From the existence of concealed entries it is, however, evident and fully in line with the findings of this research that telephone and SMS networks should not be favored as a surrogate for the advice and learning network of an organization.

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Chapter 6

Knowledge Network Email Mining Techniques

There is nothing new about the notion that in today's knowledge driven economy, knowledge is the key strategic asset for competitive advantage in an organization. Also, we have learned that knowledge is residing in the organization's informal network. Hence, to leverage business performance from a knowledge management perspective, focus should be on the informal network. A means to analyze and develop the informal network is by applying Social Network Analysis (SNA). By capturing network data in an organization, bottlenecks in knowledge processes can be identified and managed. But where network data can easily be captured by means of a survey in small organizations, in larger organizations this process is too complex and time-intensive. Mining email data is more and more regarded as a suitable alternative as it automates the data capturing process and enables longitudinal research possibilities. An increasing amount of tools for mining email data into social networks is available, but the question remains to what extent these tools are also capable of conducting Knowledge Network Analysis: the analysis of networks from a knowledge perspective. It is argued that in order to perform Knowledge Network Analysis, a tool is required that is capable of analyzing both the header data and the body data of email messages. In this paper two email mining tools are elaborated. One focuses on the analysis of email header data and the other focuses on the analysis of email body data. Both tools are embedded in their theoretical background and compared to other email mining tools that address email header data or email body data. The aim of this paper is two-fold. The paper primarily aims at providing a detailed discussion on both tools. Continuing, from the in-depth review, the integration of both tools is proposed, concluding towards a single new tool that is capable of analyzing both email header and body data. It is argued how this new tool nurtures the application of Knowledge Network Analysis.[1]*.*

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6.1 Introduction to networks and email mining

Informal networks are based on social relations between people that cross traditional hierarchical relations in organizations (Krackhardt & Hanson, 1997). These informal networks connect people horizontally rather than vertically and are used for many different purposes, such as finding expertise, problem solving, seeking advice or collaboration. It is often through these informal networks that problems are solved that are encountered when strictly following the formal work descriptions of an organization (Brown & Duguid, 1991). Or as Cross & Parker (2004) state, the informal networks explain "how work really gets done in organizations". Informal networks also play an important role from a knowledge management perspective. In this context, they are also referred to as knowledge networks (Wenger, McDermott, & Snyder, 2002; Back et al., 2005; Helms & Buysrogge, 2006) Within knowledge networks, more specific networks could be identified if one focuses on a particular activity such as learning (learning networks) or seeking advice (advice networks) (Borgatti & Cross, 2003; Skerlavaj, Dimovski, Mrvar, & Pahor, 2008). One particular sub-discipline of knowledge management focuses on studying knowledge networks from a structural point of view, using Social Network Analysis (SNA) techniques. By studying the patterns of these networks, researchers try to identify malfunctions of knowledge networks or common patterns in successful networks (Back et al., 2005; Helms, 2007; Liebowitz, 2005; Mueller-Prothmann & Finke, 2004; Marouf, 2007; Cheuck, 2006). Applying network analysis implies that network data needs to be collected. Traditionally, this is done through surveys or questionnaires (Hanneman, 2005). A disadvantage of surveys is that, especially for large surveys, it takes considerable time from the respondent to fill out the survey and also that high response rates are required to do qualitative analysis in case studies (Helms, 2007; Teigland, 2002). Consequently, there is hardly any longitudinal analysis of knowledge networks as it requires that a survey is sent out several times during a certain period. But as knowledge sharing or knowledge creation is based on communication and social interaction, it might be worthwhile to consider the use of email data as sources for collecting network data. In previous research, we already demonstrated for one case in a knowledge-intensive organization that there is a significant correlation between the email network and the knowledge network of that organization (van Reijsen & Helms, 2008). As this seems a promising field that can bring the analysis of knowledge networks a step further, we developed a tool that is capable of analyzing and refining email data in order to construct knowledge networks. The tool focuses on email header data (i.e. to, from, subject and time fields). The pitfall of this approach is that, even while our earlier study provided strong argumentation that

our approach uncovers actual knowledge networks from email data, there is no 100% certainty that the uncovered network is in fact a knowledge network comprising of knowledge transfer. Moreover, our approach does not provide any understanding on what knowledge topics are actually distributed over the network. This deficiency calls for a complementary approach in which the email body data (i.e. the body of the message) is also regarded. A tool that combines both email header and body data can construct a network map from the email header data and plot knowledge topics on the network map derived from the email body data.
The remainder of this paper is structured as follows. In section 6.2, our initial email header data analysis tool is discussed in detail. Moreover, it is compared with similar tools on a variety of characteristics. In section 6.3, a complementary tool is introduced that focuses on the analysis of email body data. Section 6.4 proposes the integration of both tools into a single new tool and discusses how this new tool may be appropriate for conducting Knowledge Network Analysis. Finally, section 6.5 concludes our paper and scopes on future research opportunities.

6.2 ESNE: Email Social Network Analysis

6.2.1 ESNE: mining email header data

Email Social Network Extraction (ESNE) is a tool that is specialized in mining header data from email messages. ESNE uses raw Microsoft Exchange data as input to identify nodes and edges to construct a social network (sociogram) based on email messages exchanged in a controlled environment (e.g. an organization). ESNE uses the sender and receiver information from email headers to identify which nodes are present and which edges exist between the identified nodes. In identifying senders and receivers as edges, ESNE is capable of identifying alternative email addresses that represent the same edge, e.g. an employee in an organization, by automatically scanning names in email addresses or by manually comparing email addresses. Moreover, ESNE contains strong filtering options that are relevant to create specific network slices for specific research ends. ESNE can filter email for a specific domain, e.g. leaving only email messages sent and received between employees of a focal organization or department. Also, it filters out mass mail messages (e.g. an email sent to over 30 employees) as it is argued that this form of emailing does not represent individual knowledge exchange. Automatically created messages can also be

filtered out (e.g. an out of office reply). The combination of these characteristics enables ESNE to create specific social network slices from raw email data.

6.2.2 Deriving networks from header data

This section elaborates on the use of header data in email messages to construct social networks. The header of an email message contains valuable information that can be used to construct a social network of people, sending email in a specific domain (e.g. an organization) and timeframe (e.g. a month). The header data of email consists of 3 parts that are relevant for constructing a social network: sender/receiver information, the subject and the timestamp. The sender and receiver information can be used to track who is sending email to whom. Hence, the sender and receiver information is by itself already adequate information to construct a social network from, consisting of nodes (senders and receivers) and edges (the link between nodes that exists as a result of an email message sent between both nodes). The subject of an email message can be additionally applied in the construction of a social network. It adds contextual information to the edges of the social network by e.g. identifying whether an edge is reciprocated (symmetric) due to a reply on a message or due to several distinct messages sent from and to both nodes. The timestamp of an email message can be applied for filtering purposes, enabling the construction of a social network from email from e.g. one month. Also, a filter can be in place that counts edges only if a message has been replied to within a specific timeframe.

6.2.3 Tools for mining header data

In order to position the ESNE tool in its domain among other tools, a literature study has been conducted to identify existing tools that mine email header data to construct a social network. Moreover, for each identified tool, we analyzed to what extent the tool uses the 3 parts of header data, thus providing characteristics for each tool. In our study, 5 tools have been identified: Themail (Viegas, Golder & Donath, 2006), Condor (Gloor, 2004), Metasight (Edwards, 2005), Flint (Mika, 2005) and Commetrix (Trier, 2006). During the literature study, we found two more relevant characteristics that describe the functionality of the tool: handling email aliases and handling filters. Handling email aliases concerns the identification and translation of alternative email addresses that belong to one sender (one node). If a tool can handle aliases, it can find email addresses and corresponding messages, based on e.g. the name of a sender or receiver and combine those messages with the messages that originate from the initial email address. Handling filters concerns filtering out senders and receivers when constructing a social network. By applying filters, specific social networks

can be constructed, e.g. a network only depicting strong ties by filtering out edges that are based on only a few messages exchanged between sender and receiver. In table 6.1 below, an overview is provided of the tools of our study, indicating what specific header data is used by each tool. Additionally, ESNE is included to compare the results to.

Table 6.1. Overview of tools for creating social networks from email header data

Tool	Sender/Receiver	Subject	Timestamp	Aliases	Filters
Themail	yes	no	yes	yes	no
Condor	yes	no	yes	yes	no
Metasight	yes	yes	yes	no	no
Flink	yes	yes	yes	no	no
Commetrix	yes	no	yes	no	yes
ESNE	yes	no	yes	yes	yes

6.2.4 Discussion

As can be derived from table 6.1, all tools apply the sender/receiver part of the header data in constructing a social network. This option is, however, expected as the sender/receiver information is a prerequisite for constructing an overview of nodes and edges. Not all tools apply the subject and timestamp parts in order to construct a more sophisticated network. What is more striking is the fact that only few tools support the aliases functionality and that most tools do not provide filtering options. Especially the filtering option is regarded as an essential characteristic of any email mining tool as it enables researchers to refine the raw email data for specific research questions. In fact, in many research initiatives where email was mined to construct a social network, researchers applied filters to refine their email data manually (Adamic & Adar, 2005; Arenas et al., 2004; Culotta, Bekkerman & Mccallum, 2004; Bird et al., 2006; Balog & De Rijke, 2006). While ESNE is a tool that cannot visualize a social network from email data, it specifically focuses on refining email data for specific research ends by providing many filtering options. ESNE is the only tool that supports both email aliases and filters. Figure 6.1 displays a screenshot of the ESNE interface.

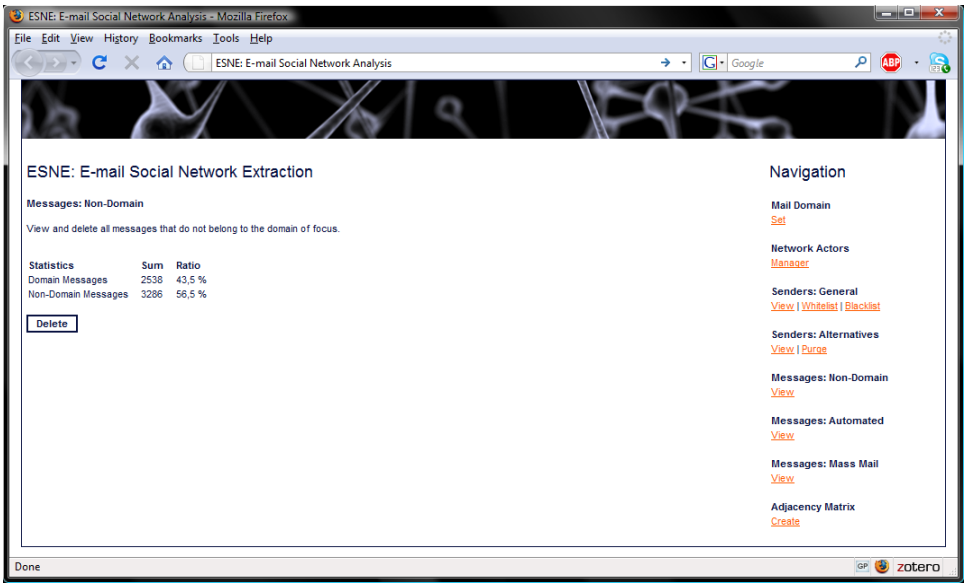

Figure 6.1. Application of ESNE: Email Social Network Extraction

6.2.5 Application of ESNE in practice

In 2008, ESNE was successfully applied in a Dutch IT services organization. The organization of focus was going through a large organizational change, where the current management team was followed up by a new management team. The board of directors required a means to keep track of the change process in terms of how knowledge flows from and to the management team in the old and the new scenario. ESNE was applied to construct three social networks from email data of the full organization: one slice before the transition, one slice during the transition and one slice after the transition. Each slice concerned a timeframe of one month. Before the analysis of the data, ESNE filters were applied to refine the data: only domain messages were considered, only edges of more than 20 messages per month were considered, mass mail messages were ignored and automatically generated messages (e.g. out of office reply) were ignored. The refined data resulted in three network slices that exactly depicted how the new management team emerged as a key knowledge player in the center of the organizational network. ESNE helped the board of directors in understanding and managing the transition of the management team. Figure 6.2 displays the end-state slice, displaying the new management team in the largest dotted border.

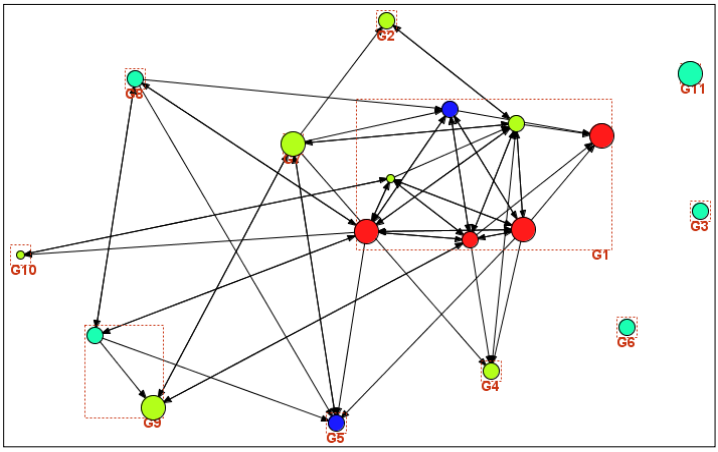

Figure 6.2. End-state slice from the Dutch IT-services organization analysis

6.3 EKE: Mining email body data

Opposed to ESNE, Email Knowledge Extraction (EKE) is a tool that is specialized in mining body data from email messages. EKE consists of a front-end and a back-end. The front-end represents a plug-in that can be installed in Outlook. If senders within a specific domain (e.g. an organization) send email messages to their receivers, EKE tracks specific words used in the body of an email message and asks the sender to what extent he/she is knowledgeable about that word. This information is stored in EKE's back-end, hence creating a database containing an overview of senders (e.g. employees) and their knowledge on specific topics. The back-end is searchable for e.g. other employees in order to track knowledge ownership and e.g. to identify whom to approach when an employee searches for knowledge on a specific topic.

6.3.1 Deriving knowledge from body data

Email has several characteristics which makes it suitable for inclusion in a semi-automated/automated application to finding knowledge. It supports key knowledge processes such as knowledge creation and sharing. Moreover, it creates an electronic record of these knowledge processes, making it possible to track and link daily workflows to the people involved (Lichtenstein, 2004). However, extracting key phrases that describe the individual's expertise from an email body poses an immense challenge. Emails are freestyle text, not always syntactically well-formed, domain independent, of variable length, and on multiple topics (Tzoukermann et al. 2001).

6.3.2 Tools for mining content data

There have been numerous attempts to create tools which utilize email as their source of information including Tacit's ActiveNet (Tacit Software, 2007), AskMe Enterprise (AskMe) and Corporate Smarts' Intelligent Directory (Corporate Smarts). Expert locator systems have been implemented in a variety of organizational domains (Maybury, 2002). Successful deployment of such systems is dependent on many factors including: user involvement, the establishment of clear objective(s)/purpose(s), measured usage and benefit, ease of use, incremental deployment, appropriate privacy, incentives for use, and effective training (Maybury, 2002).

Figure 6.3 shows how such systems can be used to analyze emails to identify individuals or groups that have specific expertise. When an email is sent (step 1 in Figure 6.3), key phrases are extracted (step 2 in Figure 6.3). The extracted key phrases are then sent back to the user (step 3 in Figure 6.3) and placed into an expertise profile that the user can edit (step 4 in Figure 6.3). The expertise profile contains information about 'who knows what' within the organization. This information is then distilled into a searchable database (step 5 in Figure 6.3) which users can query to find relevant people.

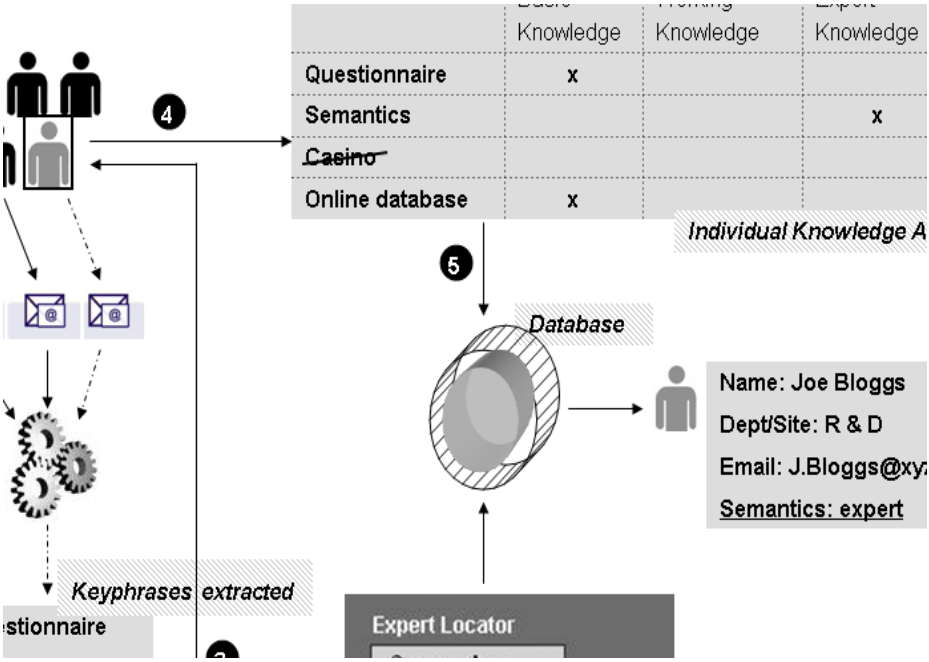

Figure 6.3. Schematic representation of email content analysis

6.3.3 Discussion

Not all systems perform steps 3 and 4 and in this particular case. These steps are specific to the system some of the authors have developed that is called Email Knowledge Extraction (EKE). Users are provided with an interface to rank their knowledge in the extracted key phrases. With regards to similar extraction systems and how they work, most of the system information is only available in the form of white papers serving as a marketing tool to promote an organizations product and point of view which potentially could be biased.

An important argument why EKE outperforms other tools that extract email body data is that EKE works in a prescriptive way. Compared to keyword searching, EKE does not only provide a means to search information in a database (step 5 in Figure 6.3), which may be labelled as descriptive, but in fact captures all possible knowledge areas. With EKE, a list is generated from knowledge topics that are derived from email messages. This is different from a keyword searching mechanism that is only capable of searching through the entire email database for specific keywords. Moreover, EKE adds important metadata to identified knowledge topics as it captures which person is knowledgeable of the topic and what the expertise level of this person is regarding the knowledge topic. In the field of knowledge management, these are relevant variables.

A final characteristic of EKE is that it secures privacy in a most comprehensive way. Senders of email messages are themselves asked what topics they are knowledgeable of and may choose to discard topics that are not relevant or private of nature. Hence, only the topics that the sender indicates are stored as searchable knowledge topics. Figure 6.4 displays a screenshot of EKE.

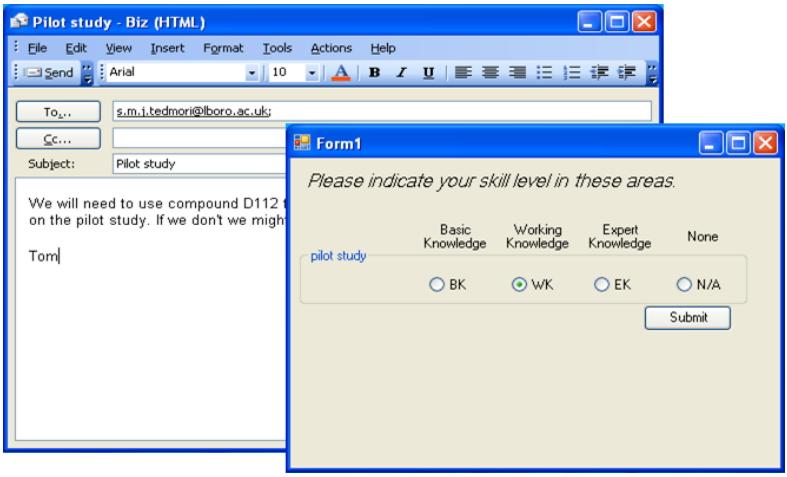

Figure 6.4. Application of EKE: Email Knowledge Extraction

6.3.4 Application of EKE in practice

A study was conducted at the Department of Information Science at Loughborough University with the aim of obtaining feedback from potential end users on functionality, robustness, clarity, and ease of use in a working environment.

After a six-week period of using EKE had past, the participants were asked to fill in a post-study questionnaire tackling areas related to EKE's performance, usability, and handling of socio-ethical challenges. As part of this questionnaire, participants were provided with a list of their key proficiencies, identified from their email communications by EKE. Participants were asked to judge how well the key proficiencies identified reflect their areas of knowledge. Results from this study provided valuable feedback on the end-users' perceptions of the EKE tool and to the enablers and the barriers to its adoption.

From the comments made, the concept of EKE was regarded as a good, useful, and interesting idea. It was suggested that the information captured by EKE could be used for personal ratings for the purpose of personal development. The key phrases extracted would highlight were an individual had expertise and where an individual might benefit from training as EKE could highlight a gap in their skill set. It was felt that EKE's ability to integrate with existing technologies (i.e. Outlook) would encourage its adoption and use.

When given the choice, 90% of participants said that they preferred to extract key phrases from email using EKE rather than manually. The majority of participants who favored EKE attributed this primarily to the speed of the system and its ease of use. Another reason mentioned was the tool's good coverage of main email subject categories.

6.4 Proposing an integrated ESNE and EKE

The purpose of the tools is two-fold: mining email header data to construct a social network of email traffic and finding (emerging) knowledge areas within that social network. Our proposed integrative tool originates from the two existing tools, but it is the integration and combined implementation of both tools that enables knowledge areas to be uncovered in the representation of a social network. It must be noticed that both tools are not yet integrated into a single new application. It is the combined use of both tools that forms the basis of our proposal. The actual integration of both tools, however, is currently being researched.

While ESNE is capable of creating a social network from email data, it cannot identify to what extent the exchanged messages comprise of knowledge transfer. Consequently, while EKE is capable of identifying knowledge areas among a group of senders and receivers, it cannot depict these knowledge areas within a social network. The integration of both tools results in a single new tool that is capable of analyzing and representing who-knows-who and who-knows-what. Because our tool can identify knowledge transfer within a constructed social network, the tool is capable of constructing knowledge networks.

6.4.1 Application of ESNE and EKE combined

By combining the ability of ESNE to construct a social network from header data and the ability of EKE to identify knowledge topics, our tool is capable of mapping knowledge areas on the social network of e.g. an organization. This is an interesting feature as the tool can be used to identify informal communities within an organization that were not recognized before. Furthermore, it is possible to do a longitudinal analysis where it is possible to study how the communities emerge and what dynamics exist between the communities. Instead of on an organizational level, it is also possible to study individual communities. The tool provides data on the expertise level of each individual in the community and on the frequency of communication with other community members. Additionally, a longitudinal analysis can be conducted to study how a community evolves and how the role of the different members changes over time. In order to integrate both ESNE and EKE, a common back-end is required to map the senders of email messages (from ESNE) on the owners of specific knowledge topics (as stored in EKE).

6.5 Conclusions and future work

6.5.1 Conclusion

In this paper, a tool is proposed that is capable of creating knowledge networks from mining email messages in a controlled environment. The proposed tool is an integration of two existing tools. One tool focuses on creating social networks from the header data of email messages. Nodes and edges are created from the sender and receiver information of email messages. The other tool focuses on revealing knowledge areas, based on linguistic analysis of body data of email messages. The integration of both tools enables constructing knowledge networks from email data as the tool makes transparent how knowledge resides among the nodes in a social network. The unique feature of our tool of

constructing knowledge networks enables both researchers and practitioners to apply knowledge network analysis while using email traffic in e.g. an organization as a data collection source.
Knowledge network analysis is becoming increasingly popular among both scholars and practitioners in analyzing and managing organizational knowledge from a network perspective. Current means to conduct knowledge network analysis are mainly restricted to surveying. As surveying knows several limitations (i.e. difficult to perform in large organizations, difficult to perform longitudinal analysis), finding alternative means to collect data is a relevant research topic. This paper intends to provide new means in conducting knowledge network analysis, by providing a tool that can mine email traffic to uncover both the network and knowledge transfer of a controlled environment.

6.5.2 Limitations

The actual integration of both individual tools that provide the basis of our newly proposed tool is not yet a fact. This paper is moreover a proposal and argues for the strengths and areas of application of the combination of both tools. Therefore, this paper cannot conclude on the usability of the tool and on the applicability of the tool for conducting knowledge network analysis.

6.5.3 Future work

The next step in our research initiative is to integrate ESNE and EKE into a single application. Also, the newly developed application has to be applied in a case study environment to test the application itself and to test whether the application is capable of conducting knowledge network analysis. Both steps are required before we can conclude on the added value of our proposed tool in the field of knowledge network analysis. Future work will elaborate on the integration process and application of our proposed tool. Another issue that requires attention is the privacy of the employees of an organization. Although, we have experience in applying both tools separately, the combination of the tools might be regarded as intrusive from a privacy perspective. Without paying close attention to the privacy issue, organizations might not be willing to apply the tool or to participate in research that applies the tool.

6.5.4 Acknowledgements

The authors would sincerely like to thank Andarr Organizational Services for providing the resources to develop ESNE. Also, the authors would like to thank Loughborough University for developing or supporting the development of EKE.

Part V

Knowledge Networks and Dynamic Capability

Chapter 7

Impact of Knowledge Networks on Group Performance

It is a generally accepted idea today that informal knowledge networks play a crucial role in organizations. Being aware of the importance of these knowledge networks, it is of interest to any organization to understand how the performance of these networks is influenced by their design. Based on theory from the field of social network analysis we defined 7 hypotheses concerning how the structure of knowledge networks contributes to the performance of these networks. For testing our hypotheses we collected network data from 18 knowledge networks within the product line of an international product software company developing ERP software. Data was collected by asking employees about their learning relations and the frequency of knowledge transfer (independent variable). Furthermore, we asked all respondents about the extent to which they feel that the knowledge they receive influences their perceived job performance, which we converted into a group performance measure to measure the performance on network level (dependent variable). To test our hypotheses we applied correlation analysis, which showed that only part of our hypotheses is supported by the data. We found support for a statistically significant relation with group performance for efficiency and transitivity, and marginal support for density and connectedness. From this we derived preliminary guidelines for managers to help them get results from their knowledge networks.[1]*.*

[1] This work has been published as Helms, R. and Reijsen, J. van. (2008). Impact of Knowledge Network Structure on Group Performance of Knowledge Workers in a Product Software Company. In Harorimana, D. (Ed.), *Proceedings of the 9th European Conference on Knowledge Management*, 4-5 September 2008, Southampton Solent University, Southhampton, UK. 289-296.

7.1 Introduction to Knowledge Networks

Knowledge has become an important corporate resource next to financial capital, labor, buildings, and equipment (Grant 1996; Von Krogh & Grand 2002). It is recognized that the development and sharing of knowledge takes place in informal networks and that these networks are an important factor in influencing the performance of the organization (Eppl, Argote & Murphy 1996; Cross & Parker 2004). In the field of knowledge management these informal networks are referred to as communities of practice or knowledge networks (Wenger et al. 2002; Back et al., 2005; Helms & Buysrogge, 2006). To increase our understanding of how knowledge networks contribute to performance we apply social network analysis techniques. These techniques emerged in the Sociology domain and are used to study patterns of social interaction between members of a particular group of people. From this domain it is also known that the pattern of social interaction, i.e. the network structure, is related to performance in many ways (Flap, Bulker & Völker 1998). This research applies social network analysis to the domain of knowledge networks to study patterns of knowledge exchange between members of a knowledge network. Insight in the relation between the structure of knowledge networks and its performance is needed because from this relation practical guidelines can be derived for managers for diagnosing networks that do not yield the intended results.

However, research on knowledge network structure and performance is still very limited and scattered over different domains, e.g. sociology, management science, and knowledge management. The contributions that have been found in literature include Sparrowe, Liden, Wayne & Kraimer (2001), Tsai (2001), Teigland (2002), Cross & Cummings (2004), Ashworth & Carley (2006), and Song, Nerur & Teng (2007). However, these studies have several limitations. First of all, the studies mainly focus on advice-seeking relations. We believe, however, that knowledge sharing in knowledge networks comprises more than just advice-seeking. Secondly, most of these studies focus on the effect of network structure on individual performance. But optimizing individual performance can be at the expense of other members in the knowledge network. Therefore, we suggest studying performance at a network level, i.e. group performance, rather than at an individual level. Finally, most of the studies focused on one or a very limited number of network measures. Among them, centrality measures were found to be most popular.

Considering these limitations in current research, our research contributes to the body of knowledge on knowledge networks in three ways. First of all, we focus on learning relations which is a broader concept than just advice seeking (Škerlavaj, Dimovski, & DeSouza 2008). Consequently, we prefer to refer to

learning networks rather than knowledge networks. Our second contribution is that we study a number of different network measures instead of just one or two network measures. Hence, we intend to get a deeper insight in how network structure relates to group performance. Finally, we suggest preliminary guidelines for (knowledge) managers for designing and/or diagnosing learning networks in their organizations.

7.2 Theory and hypotheses for impact

7.2.1 Learning networks and group performance

Much of a person's knowledge is tacit knowledge, consisting of experiences and skills that are typically stored in an individuals' heads and hands (Polyani 1983). Leonard and Swap (2005) also refer to this type of knowledge as 'deep smarts'. Deep smarts enable an individual to quickly analyze a situation and come up with a smart solution. An example is a computer engineer that is able to quickly identify a hardware problem without having to go systematically through all the possible failure options. When the job performance of an employee with deep smarts is compared to an employee without deep smarts, the first will come up with a better solution, within a shorter time (Leonard and Swap 2005). Consequently, it is important that less experienced colleagues, without the deep smarts, learn from their more experienced colleagues. Because of the tacit nature of knowledge, learning is achieved through social interaction. The pattern of social interactions between people, with the aim of knowledge transfer in the context of learning, is referred to as a learning network. In order to be effective it is assumed that learning takes place on a structural basis rather than on an ad-hoc basis because tacit knowledge is difficult to transfer, i.e. is 'sticky' (Szulanski 1996), and takes time to be transferred and fully understood by the receiver.

The goal of leaning networks is to stimulate that employees learn from each other, which will result in an increase of the knowledge of the employees. Because of their increased knowledge, the job performance of these employees will improve (Leonard & Swap, 2005). At a network level, the learning process is considered to be effective if all the members of the network can benefit from it. Consequently, in an effective network the job performance of all members will increase. At network level we can therefore define group performance as the aggregated increase in job performance of all members in the network.

7.2.2 Hypotheses on network structure and group performance

From the field of social network analysis it is known that performance is related to network structure. Therefore, in this section we will present a number of hypotheses concerning the relation between structure of learning networks and group performance.

Connectedness

Learning can only take place in a learning network when individuals are connected to each other. If inexperienced individuals are disconnected, i.e. isolated, they cannot learn which hinders the performance of the organization. On the other hand, if experienced individuals are not connected they cannot transfer their knowledge to others meaning that valuable knowledge is not available to and used by others. Connectedness is not related to individuals only, but also to groups. If groups are disconnected, they cannot learn from each other's experience.

H1: *Connectedness of a learning network is considered to be positively correlated to group performance.*

Density

A relation in the learning network indicates that learning takes place, assuming that the transfer occurs frequently. The amount of learning in the group increases if individuals transfer their knowledge to a larger a proportion of the group. Consequently, if the proportion of ties in the network increases this is an indicator that learning in the network increases. However, it is also recognized that there is a limitation in the number of learning relations that an individual can maintain (Helms 2007). Maintaining a relation costs time, which is limited because employees also have other duties to fulfil. Therefore, too many relations will negatively affect the job performance of an individual and hence group performance.

H2a: *Density of a learning network is considered to be negatively correlated to group performance.*

Efficiency

Besides that the number of learning ties is bounded by the time that an individual has available, there is another downside of having too many relations. If the number of relations in a network increases, also the chance of redundant ties increases (Krackhardt 1994). In the context of learning networks, redundancy means that you receive the same knowledge, but through different people.

Although each person adds his own knowledge and experiences to the knowledge that he receives from others, too much redundancy is not preferable because time is limited. Hence, it is expected that efficient network structure will contribute to better group performance.

H2b: *Efficiency is considered to be positively correlated to group performance*

Reciprocity

In social exchange theories it is assumed that people only invest in a relation if they get something in return (Blau 1964). Consequently, if one person invests in a friendship relation, he expects that his friend does the same, which results in a mutual relation. Reciprocity is also encountered in advice networks, i.e. you will help a person that request your knowledge if you expect that he can help you in the near future (Davenport & Prusak 1998). This is different for learning relations that are typically asymmetrical, because an expert will not expect that he will get much knowledge in return from a trainee (Škerlavaj et al., 2008). What the expert gets in return for his knowledge is recognition and repute (Davenport et al., 1998). Learning relations from a trainee to an expert are considered as unwanted, because the time spent on that relation could be better spent in an alternative way. Therefore, it is expected that symmetrical relations will not contribute to group performance.

H3: *Reciprocity is considered to be negatively correlated to group performance*

Transitivity

A well-known concept within social network theory is transitivity, which involves the notion that "a friend of a friend is a friend". In other words, if there is a relation between individual A and B and between B and C than A and C will probably also be friends. Some theorists consider these balanced triads as a natural state for triadic relations (Hanneman & Riddle 2005). Škerlavaj et al. (2008) already analyzed if there is a tendency in learning networks towards transitivity. Their research did not find support for this hypothesis. This might be explained by the fact that transitivity also creates a form of redundancy and tunnel vision within the group. From a learning perspective it is more useful to have varied contacts resulting in different perspectives and different types of knowledge. Hence, transitivity is considered to have a negative effect on group performance.

H4: Transitivity is considered to be negatively correlated to group performance

Network centrality
Asymmetrical ties also have an influence on the central position of employees in the network. Experienced individuals will mainly have outgoing learning relations, while inexperienced individuals will mainly have incoming relations. Hence, experienced employees will take a central position in the network when it comes to the number of outgoing relations (i.e. out-degree centrality). Likewise, the inexperienced people will take a more central position when it comes to the number of incoming relations (i.e. in-degree centrality). Consequently, in both cases there will be a clear variance in centrality. As we expect asymmetrical ties we associate variance in centrality with a positive contribution to group performance.

H5a: In-degree centralization is considered to be positively correlated to group performance

H5b: Out-degree centralization is considered to be positively correlated to group performance

7.3 Research method for KNA

7.3.1 Sample and procedure

The research was conducted in spring 2007 at Unit4Agresso, a product software developer that develops integrated business applications for different industries. Unit4Agresso operates in 10 European countries, the United States, and Canada, its headquarters are located in The Netherlands. At the end of 2006 Unit4Agresso had around 2,700 employees. The research was conducted at one of the product lines of Unit4Agresso, which develops software for the wholesale sector and employed 99 people at that time. We selected a single product line because it can be considered as a small product software company itself that is responsible for all activities concerning the development, sales, and implementation of a software product. Much of the learning is therefore considered to take place in this product line around their practices and software product. Furthermore, within the product line they actively promote knowledge transfer in learning networks, which they refer to as knowledge circles. In total, there are 18 learning networks (n=18) within the product line and each focuses on a particular topic such as EDI, Sales or Third Party Apps.

Data was collected using an electronic survey because (1) employees within the product line use their computer their daily and (2) collecting data using an electronic survey eases data processing compared to a paper process. The questionnaire was created using LimeSurvey, which is an open source software electronic survey tool. A first version of the electronic survey was tested with 2 employees. Based on their feedback some explanations were added to the questionnaire and some questions were rephrased. Next, the KM project manager sent out an email message to all employees of the product line explaining the goal of the research. This message also contained a hyperlink to the URL of the survey. After two and four weeks reminders were sent and finally some employees have been approached personally by the KM project manager to fill out the survey. In total, 79 employees completed the survey which equals is 80% of the target population of 99 employees. Comparing with other studies, this response rate can be considered as acceptable (Wasserman and Faust, 1994; Sparrowe et al., 2001; Teigland, 2002). Respondents are spread over 6 departments: 20 in Customization (e.g. information analyst, software developer), 3 in Sales (e.g. sales consultant, marketing manager, product manager), 24 in Consultancy (e.g. project leader, consultant), 11 in Technical Consultancy (e.g. technical consultant), 15 in R&D (e.g. software developer, team leader, quality assurance) and 6 in Helpdesk (e.g. support employee). Furthermore, 67% of the employees is younger than 40 years and 90% younger than 50. Finally, the employees are free to participate in one or more of the 18 learning networks. The total number of members varies from 12 to 54 (avg. 26,5; s.d. 13,6). The minimum number of memberships of an employee is 1 and the maximum is 12 (avg. 5,7; s.d. 3,3).

7.3.2 Measures

Knowledge transfer

The survey consisted of 3 questions to collect data on the learning relations and affiliations with the learning networks. The first question asked the respondents to indicate in which particular learning networks they participate by selecting one or more learning networks (e.g. EDI, Sales, Third Party Apps) from the list. Secondly, data concerning the learning relations was collected by asking the respondents “With which colleagues do you have a learning relation, i.e. transfer knowledge to you in a structural manner (i.e. not ad-hoc)”. Respondents answered the question by picking names from a list consisting of 99 names (i.e. all employees of the product line). The names were sorted by department and listed in alphabetical order to make answering the question as easy as possible. We chose to sort the names by department based on feedback of the employees

and from the positive experience with this method as reported by Teigland (2002).
Thirdly, the respondents had to indicate who transfers knowledge to them and the frequency of the transfer (1= daily; 2= several times a week; 3= several times a month; 4= several times a quarter; 5= several times half-yearly; 6= less than several times half-yearly). This question was used to filter out relations that occurred infrequently (i.e. 5 and 6) because these relations are not considered to take place structurally. Finally, demographic data about the population, such as age, function, department, and office, were provided by the human resources department.

Group performance
In a second part of the survey, we measured group performance by calculating the average perceived job performance of all persons in the learning network. The job performance score is based on a newly developed scale, which is inspired by Teigland (2002) and Sparrowe et al. (2001). The job performance scale consists of the following 6 items:

- "Using the knowledge received from my colleagues, I can execute my work/projects quicker"
- "The knowledge that I receive from my colleagues prevents me from making mistakes"
- "Using the knowledge received from my colleagues, it's easier for me to execute my work/projects"
- "The knowledge that I received from my colleagues does not make me more successful in my work/projects"
- "Due to the knowledge received from my colleagues, I feel more capable to execute my work/projects"
- "Due to the knowledge received from my colleagues, I have more fun in my work/projects"

The items are measured on a 5-point Likert scale ranging from "strongly agree" to "strongly disagree". To test if the 6-items can be aggregated into one group performance variable, we conducted a confirmatory factor analysis and calculated Cronbach's alpha. Factor analysis over this variable showed one very strong factor and reliability analysis showed an alpha value of 0,954. This value is very satisfactory because 0,7 is commonly applied as a threshold value for Cronbach's alpha (Hair, Black, Babin & Anderson, 2005).

Network measures
Data about the learning network was entered in Netminer II 2.60a, a social network analysis tool, for calculating the network measures as introduced in the hypotheses section. All network measures have been calculated using the Netminer software. The connectedness measure is based on Krackhardt (1994) who defines that a directed graph is connected if each person can reach each other person in the underlying graph (i.e. the symmetrized directed graph). Density is a very basic measure and is computed as the total number of relations present in the directed graph divided by the maximum number of relations (Wasserman & Faust, 1994). The efficiency measure is also based on Krackhardt (1994) who defines efficiency as the minimum number of relations to keep the underlying graph connected, i.e. n-1. Each relation above n-1 is considered as redundant and therefore inefficient. Reciprocity is calculated using the arc method. Hence, reciprocity is computed as the number of links that is involved in reciprocal relations relative to the total number of existing links (Hanneman & Riddle, 2005). Transitivity for directed graphs is computed as the number of transitive triads relative to the number of potentially transitive triads (Hanneman & Riddle, 2005). Finally, the network centralization index measure is based on Freeman (1979). We calculated both the in-degree and out-degree network centralization index, which is a measure for the variance of degree centralization in a network.

7.4 Results from KNA impact on performance

A correlation analysis has been performed to examine the relationship between network structure and group performance using SPSS. The descriptive statistics and the correlations resulting from this analysis are shown in table 7.1.

*Table 7.1. Descriptive statistics and correlations for network structure and group performance variables (***=p<.01; **=p<.05; *=p<.10)*

Variable	Mean	S.D.	1.	2.	3.	4.	5.	6.	7.
1. Density	0,15	0,04							
2. Reciprocity	0,33	0,10	0,30						
3. Transitivity	0,54	0,10	**0,65*** **	0,05					
4. Connectedness	0,24	0,14	-0,35	0,00	**-0,66*** **				
5. Efficiency	0,85	0,05	**-0,83*** **	-0,12	**-0,71*** **	0,35			
6. In-Degree Centralization	0,43	0,09	**0,53** **	0,26	**0,47** **	-0,34	**-0,62*** **		
7. Out-Degree Centralization	0,27	0,07	0,43	0,09	0,30	0,09	-0,39	-0,27	
8. Group performance	3,62	0,18	**-0,41* **	0,31	**-0,73*** **	**0,42* **	**0,60*** **	**-0,50** **	-0,01

The results show that connectedness is positively correlated to group performance (hypothesis 1). However, the statistical significance for this correlation is marginal, i.e. p= .08. Furthermore, we found a negative correlation between density and group performance (hypothesis 2a). Once again, the statistical significance is marginal, i.e. p=.10. A much better result is found for efficiency (hypothesis 2b), which is positively correlated to group performance with a statistical significance of p= .01. We did not found support for a negative correlation between reciprocity and group performance (hypothesis3). Furthermore, the direction of this relationship is pointing in the opposite direction, i.e. a positive correlation was found. Then, transitivity shows a strong positive correlation with group performance again (hypothesis 4). This correlation also has a statistical significance of p= .01. We also did not find support for our two hypotheses concerning network centralization. Although the relation between in-degree centralization and group performance is statistically significant (p= .05), the correlation is pointing in the opposite direction. The correlation between out-degree centralization and performance is very low and not significant.
Finally, it can be noted that there are strong correlations between some of the network measures. This can be explained due to the fact that these measures are logically related. For example, transitivity is positively related with network density. This makes sense because if the number of ties increase then there is also a larger chance to find transitive triads.

7.5 Conclusions and discussion on the impact

7.5.1 Network structure and group performance

The results suggest that it is important that all employees in a learning network are *connected* to each other. Disconnectedness in a learning network of individuals, or even complete disconnected groups, should be avoided as it hinders the diffusion of knowledge and experiences in the learning network. Furthermore, one could easily think that the more learning relations the better, i.e. the more you learn the better you will perform in your job. However, the negative correlation found between *density* and group performance suggests that a higher density is not necessarily better (it is noted that the found statistical significance is marginal). Additionally, the results found for *efficiency* and *transitivity* also suggest that employees should be selective in choosing their learning relations and that more is not always better. The positive correlation with *efficiency* suggests that employees should avoid redundancy in their contacts. This is furthermore supported by the negative correlation found for *transitivity*. The correlation with transitivity suggests that instead of having learning relations

with contacts of your contacts, it is better to have more variety in your contacts. The network *centralization* and *reciprocity* measures are related to assumptions on the direction of the knowledge transfer, i.e. from more experienced employees to less experienced employees. However, these assumptions are not supported by our findings. For both degree centralization and reciprocity we found an opposed instead of the hypothesized correlation (it is noted that only the correlation between in-degree centralization and performance was statistically significant). A possible explanation is that knowledge is not exclusively transferred from experienced to inexperienced employees but that there is also knowledge transfer between employees of similar levels of expertise. These relations might be typically reciprocal as suggested by social exchange theory. However, this assumption should be further studied and is an area for further research.

7.5.2 Limitations

A first and important limitation of our research is that it is conducted within one organization, which limits the possibility to generalize our findings. The fact that our sample comprises only 18 knowledge areas among 1 production line further adds to this limitation. On the other hand, measuring in one organization has an advantage as it rules out organizational or task dimensions, which can be considered constant across the 18 knowledge areas (Krackhardt & Hanson, 1993). Another limitation to our measurements might be that we did not specifically measure performance of the group as a whole but as the average of individual performance. Hence, it could be argued that we measured a variant of individual performance rather than group performance. Nevertheless, we consider this as the best possible option as members in the learning network can be from different backgrounds and department and do not necessarily collaborate on a common task or project like the members of a project team or department. Hence, there is not a clear group effort that can be distinguished from the individual effort. Another limitation might be the fact that in our survey, performance was measured on a basis of self-assessment. Employees might be too optimistic on their performance and therefore bias the outcome. Other options include peer assessment, supervisor assessment (Sparrowe et al., 2001; Cross & Cummings, 2004), or mining corporate records (Tsai, 2001). However, Teigland (2002) concludes that there is no best way to measure performance because each method is subject to a variety of biases. Nevertheless, we assume that a combination of different measurement techniques may provide more reliable results and needs more attention in further research.

7.5.3 Conclusions

In general, the results as presented in this paper contribute to organizational studies in sociology that study the relation between structure of intra-organizational networks and organizational outcomes. More specifically, this research contributes to the domain of knowledge management and knowledge networks where the application of social network analysis is relatively new. Furthermore, the results presented in this paper contribute to a further understanding of how the structure of learning networks contributes to group performance. This research distinguishes itself from related research as we analyze several network measures at the same time, instead of just one or two as is often seen in other studies. Additionally, we focused on learning relations instead of the narrower concept of advice-seeking, to replicate earlier findings in a broader context.

Although this study has limited generalization, two preliminary guidelines for managers could be formulated. The first is that isolates and/or isolated subgroups should be avoided in learning networks. Isolation means that the isolates cannot learn from others but also others cannot learn from the isolates. Second, members should not strive for as many learning relations as possible but should be selective in their relations and avoid redundancy as it results in wasted time and does not contribute to performance. Redundancy is typically found in cohesive sub-groups and should therefore be avoided. Finally, this research also revealed areas for future research such as reciprocity in learning networks as well as a number of improvements in the research method as discussed in the limitations section. This research should further support the development of practical guidelines for managers.

7.5.4 Acknowledgements

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Chapter 8

Impact of Knowledge Networks on Absorptive Capacity

Knowledge is considered the primary asset in organizations. Managing knowledge is associated with various organizational benefits such as innovation and sustainable competitive advantage. However, organizations should not only rely on their internal knowledge, but develop a capacity to deal with an increasing dependency on their dynamic environment. Absorptive capacity is the capability to detect, integrate, transform and utilize external knowledge and enables organizations to adapt, innovate and survive. This paper examines how organizations can advance their absorptive capacity by tapping into the social fabric that is central to today's thinking about knowledge: organizational knowledge networks. In an empirical study among Dutch knowledge-intensive organizations, we studied how structural properties of knowledge networks enhance or limit absorptive capacity. Through a PLS-SEM analysis of 42 cases of intra-organizational networks, we elaborate on several characteristics that advance distinct dimensions of absorptive capacity. The paper elaborates these findings and provides suggestions for practical follow-up.[1]

8.1 Introduction to networks and absorptive capacity

One of the primary challenges for organizations is to survive in a competitive and changing environment. Key to firm survival is not just competitive advantage, but the ability to continuously create and maintain new competitive advantages (Eisenhardt & Martin, 2000; Cepeda & Vera, 2007). Organizations that are able to continuously and timely adjust their resources, processes and routines are better able to cope with changing market environments (Barreto, 2010). This ability is referred to as dynamic capability (Teece et al., 1997). For this, organizations are highly dependent on knowledge. Knowledge is considered the primary asset in organizations (Alavi & Leidner, 2001) and therefore an important resource in itself. Moreover, knowledge and learning processes allow organizations to adequately adjust their resources and routines (Zollo & Winter,

[1] This work was recently submitted for Journal publication as "The Impact of Network Structure on Absorptive Capacity in Organizational Knowledge Networks".

2002; Cepeda & Vera, 2007). Therefore, Knowledge Management (KM), which can be seen as managed learning (Vera & Crossan, 2003), fulfills a prominent role in advancing dynamic capability and competitiveness.

Yet, KM on itself is deemed inadequate for sustained competitive advantage because of its focus on internal (i.e. already available) knowledge, lacking an external orientation (Easterby-Smith & Prieto, 2008). Organizations require external knowledge in order to sense changes in and cope with their environment (Barreto, 2010). The role of external knowledge has furthermore increased over time for competitive advantage (e.g. Lane et al., 2006; Lichtenthaler, 2009; Camisón & Forés, 2010), due to increased complexity of the environment and the increased pace in which it changes (Barreto, 2010; McElroy, 2008; Faber et al., 2006).

In order to cope with external knowledge, organizations should develop absorptive capacity (ACAP). ACAP is considered the dynamic capability of learning (Zahra & George, 2002; Camisón and Forés, 2010l; Noblet et al., 2011) and can be defined as the firm's ability to identify, assimilate and exploit knowledge gained from external sources (Cohen & Levinthal, 1990). In practice, ACAP explains not only how organizations can detect valuable knowledge outside of their own borders, but also how they can make sense of that knowledge, integrate it and convert it into organizational benefits. An example is external knowledge on emerging technologies that an organization senses and then integrates that knowledge in order to innovate an existing product through which the organization can answer to changing market demands. Through external knowledge inflows and the absorptive capacity to address that knowledge, ACAP can indeed lead to sustained competitive advantage (Teece et al., 1997; Zahra & George, 2002; Lichtenthaler, 2009).

Four learning processes underlie ACAP: the acquisition, assimilation, transformation and exploitation of external knowledge (Zahra & George, 2002). Hence, organizations can advance their ACAP by improving the effectiveness of these processes. In doing so, it is important to acknowledge the social dynamics perspective towards knowledge (Van den Hooff & Huysman, 2009) that underscores that knowledge is a socially constructed and shared resource (Kogut & Zander, 1992; Kianto & Waajakoski, 2010) and is shared and accessed through informal networks (Brown & Duguid, 1991) or knowledge networks (Helms & Buysrogge, 2006; Back et al., 2006; Cross & Parker, 2004) in organizations. The condition of these networks can advance or limit their performance in the sense of effective knowledge and learning processes (e.g. Teigland, 2003; Wasko & Faraj, 2005; Faraj & Johnson, 2010). Also, different learning strategies (such as the ACAP learning processes) require different network configurations for optimal performance (Nieves & Osorio, 2012).

Therefore, it is of interest to explore what specific network configurations exert a positive influence on ACAP.
The remainder of this paper is structured as follows. In the theoretical background, we elaborate key concepts of this research and place them in the context of literature. Second, we introduce a set of research questions and hypotheses to guide the research. Third, we propose a research model and account for how we formulate our measures and constructs. Fourth, in the data collection section, we elaborate the research approach and evaluate the sample. Fifth, we evaluate our model and test our hypotheses. We conclude the paper with key findings and practical suggestions that can aid organizations to improve their absorptive capacity.

8.2 Theory on networks and absorptive capacity

8.2.1 Knowledge Management

Originally, knowledge management (KM) is defined as a *"practice concerned with identifying, developing and leveraging knowledge in organizations to help them to compete"* (Alavi & Leidner, 2001). Knowledge is moreover considered the primary asset of organizations (Ibid; Grant, 1996). Grant's (Ibid) knowledge-based view of the firm (KBV) is based on the resourse-based view of the firm (RBV) (Wernerfelt, 1984; Barney, 1991) that states that organizations possess different profiles of tangible and intangible resources and capabilities, explaining differences in performance between organizations. Similarly, the availability of knowledge resources and capabilities can influence organizational performance. KM, which is widespread in organizations (Davenport & Prusak, 1998; Jashapara, 2004) aims to optimize these resources and capabilities. A distinction between resources and capabilities is reflected in KM through a differentiation of focus on the technology of KM (knowledge as a resource) and a side that underscores the human and social aspects of KM (knowledge as a capability) (Easterby-Smith & Prieto, 2008; Huysman & De Wit, 2004; McElroy, 2003). The RBV is, however, criticized for a lack of acknowledging environmental conditions (Priem and Butler, 2001; Barreto, 2010) and the KBV for assuming that knowledge is already available, neglecting the importance of its creation. Likewise, KM is criticized for mainly focusing on the internal characteristics of knowledge (Easterby-Smith & Prieto, 2008) and therefore, KM alone is deemed insufficient as an antecedent for sustainable competitive advantage.

8.2.2 Dynamic Capabilities

The dynamic capabilities view is regarded as an extension of the RBV (Easterby-Smith & Prieto, 2008) and was originally defined as the *"firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments"* (Teece et al., 1997, p. 516). In this view, turbulent environmental conditions are specifically taken into account, underscoring the importance of coping with changing market conditions. Winter (2003) differentiates between operational, dynamic and learning capabilities, explaining how learning results in dynamic capabilities, in turn resulting in operational capabilities. Dynamic capabilities are thus regarded as a first-order capability, while learning is its preceding second-order capability. Operational level capabilities are then the outcomes of dynamic capability and take shape in the form of benefits such as performance (Teece et al., 1997), economic profit (Makadok, 2001) and competitive advantage (Teece, 2007).

Barreto (2010) argues that dynamic capabilities have been approached from a wide variety of perspectives, such as their nature, role and outcomes. This has led to vagueness about the concept, resulting in a variety of definitions. In an attempt to unify the approaches, Barreto (Ibid, p. 271) postulates a unifying definition: *"A dynamic capability is the firm's potential to systematically solve problems, formed by its propensity to sense opportunities and threats, to make timely and market-oriented decisions, and to change its resource base"*. Hence, dynamic capabilities comprise four capabilities: problem-solving, environment-sensing, decision-making and changing resource bases.

Easterby-Smith & Prieto (2008) link the fields of KM and dynamic capabilities based on three underpinning topics:

- Organizational learning is the central mechanism for and antecedent of both KM and dynamic capabilities
- Dynamic capability is dependent on knowledge, through the dynamic process of the exploration and exploitation of knowledge, a distinction originally posed by March (1991)
- Both KM and dynamic capabilities are dependent on a knowledge infrastructure containing knowledge resources

Eventually, both KM and dynamic capability can be seen as first-order capabilities that reinforce each other and collectively can result in the aforementioned organizational benefits.

Although authors agree on the importance of dynamic capability for organizations, the concept is noted to also be abstract and intangible (Danneels, 2008), confusing (Winter, 2003) and not yet a theory (Barreto, 2010).

8.2.3 Absorptive Capacity

A specific embodiment of dynamic capability that received much attention is absorptive capacity (ACAP). ACAP is defined as the *"ability to identify, assimilate and exploit knowledge gained from the environment"* (Cohen & Levinthal, 1989, p. 589) and is regarded as the dynamic capability related to learning (Zahra & George, 2002; Camisón and Forés, 2010l; Noblet et al., 2011). The importance of ACAP for organizations is multifold. Foremost, we argue that ACAP, given its strong relation to learning, encompasses both a KM and dynamic capability aspect and is therefore an important capacity for organizations to develop. Previous research indeed demonstrates benefits of ACAP such as Innovation (Tsai, 2001), business performance (Gupta & Govindarajan, 2000), competitive advantage (Lichtenthaler, 2009), innovation and strategic flexibility (Zahra & George, 2002) and the ability to innovate, adapt to changes and be competitive (Daghfous, 2004; Escribano et al., 2009; Jiménez-Barrionuevo et al., 2011). Conversely, Audia et al. (2000) show that failure to cope with environmental changes can have negative consequences for organizations. Developing ACAP is increasingly important, since environments are increasingly complex (Bourgeois & Eisenhardt, 1988; Faber et al., 2005; Baretto, 2010) and since the decreasing lifespan of competitive advantages (Wiggins & Ruefli, 2005). Another reason to develop ACAP is its focus on external knowledge. Organizations increasingly depend on external knowledge in order to retain performance and competitive advantage (Camisón & Forés, 2010; Lane et al., 2006; Lichtenthaler, 2009). Moreover, external knowledge is identified as a requirement for innovation and performance (Cassiman and Veugelers, 2002; Morgan and Berthon, 2008) and an antecedent of ACAP (Kostopoulos et al., 2011). ACAP too is regarded as a first-order capability, like KM and dynamic capability (Winter, 2003; Easterby-Smith & Prieto, 2008).

Zahra & George (2002), formulated four dimensions that underpin ACAP: acquisition, assimilation, transformation and exploitation. Noblet et al. (2011) provide clear definitions of these dimensions and show that they in fact resemble knowledge processes:

- "Acquisition" is the capacity to recognize, understand the importance of, and acquire the external knowledge needed for the operations of an organization (Lane & Lubatkin, 1998; Zahra & George, 2002);
- "Assimilation" concerns the capacity to integrate external knowledge using routines and processes that allow it to understand, analyze, process and interpret information obtained from external sources (Zahra & George, 2002);

- "Transformation" is the capability to develop and refine the routines that facilitate combining existing knowledge and the newly acquired and assimilated knowledge (Noblet et al., 2011); and
- "Exploitation" is a firm's capacity to competitively use new external knowledge to achieve its organizational goals (Lane & Lubatkin, 1998).

Acquisition and assimilation together are referred to as "potential" ACAP, while transformation and exploitation are referred to as "realized" or "achieved" ACAP (Jansen et al., 2005; Noblet et al., 2011).

The link between ACAP and learning becomes apparent in these four dimensions because they align to the learning processes of "exploratory", "assimilative", "transformative" and "exploitative" learning (Gebauer et al., 2012; Lane et al., 2006). Jiménez-Barrionuevo et al. (2011) stress that organizations should always focus on both potential and realized ACAP, thus developing a sense of organizational ambidexterity (Raisch & Birkinshaw, 2008).

Recently, ample operationalization initiatives for ACAP were published. In earlier years, a clear operationalization was lacking (Wang & Ahmed, 2007). Early attempts often deficiently expressed ACAP in terms of R&D spending or intensity (Tasi, 2001; Stock et al., 2001). Moreover, Flatten et al. (2011) note that previous attempts to measure ACAP have their shortcomings, mainly in terms of scale development requirements (e.g. Jansen et al., 2005; Thérin, 2007). The variety of approaches has led to a lack of consensus for the operationalization of ACAP (Kostopoulos et al., 2011). Among the more recent attempts to operationalize ACAP are Noblet et al. (2011), Flatten et al. (2011), Jiménez-Barrionuevo et al. (2011) and Camisón & Forés (2010). All operationalizations have in common that they apply the four ACAP dimensions as proposed by Zahra & George (2002).

8.2.4 Knowledge Networks

Ever since Polanyi's (1967) distinction between tacit and explicit knowledge, it is recognized that some knowledge is hard to formalize and is embodied in persons. Therefore, the individual knowledge worker is considered the focal point for knowledge processes (Grant, 1996; Nonaka, 1994). However, it is not the sum of individual cognitions but through a social process that knowledge is sustained (c.f. Cook and Yanow, 1993; Nicolini and Meznar, 1995; Nicolini et al. 2003; Laursen & Salter, 2006). Likewise, Lave & Wenger (1991) note that knowledge is mostly a practice instead of the possession of individuals, underscoring that exchange is key. Knowledge is thus understood as "a socially constructed and shared resource" (Kianto & Waajakoski, 2010, p. 4-5) and is emergent in nature (van den Hooff & Huysman, 2009). The practice-based view of knowledge (e.g.

Brown & Duguid, 1991, 2001; Orlikowski, 2002) promotes organizational networks as appropriate coordination mechanisms for integrating dispersed knowledge. Social exchange of knowledge takes place in such social networks, which are characterized as *"a finite set or sets of actors and the relation or relations defined on them"* (Wasserman & Faust, 1994, p. 20). Specialized forms of social networks in organizations are for example communities of practice (CoP's) (Wenger & Snyder, 2000; Lave & Wenger, 1991), networks of practice (Brown & Duguid, 2000; Teigland, 2003) and knowledge networks (Helms & Buysrogge, 2006; Back et al., 2006). In this research, we adopt the viewpoint of the knowledge network since it most generically relates to knowledge exchange between individuals, without requirements such as shared practice or geographical spread. Similarities between these forms of social network types are that they describe networks that are emergent in nature (van den Hooff & Huysman, 2009) and have a collective of knowledge workers that exchange knowledge for a common purpose.

Exchange in a network can be regarded in multiple ways because interaction in a network can be based on varying motivations. Examples are friendship, communication, advice (Johnson et al., 2012) and learning (Škerlavaj et al., 2010). One network can be regarded from multiple of these viewpoints and they can coexist in a single network (Faraj & Johnson, 2010). In our research, we focus on advice-seeking (Rhee, 2004) and learning exchange in networks since the flows between actors in these network types concern knowledge instead of other forms of information. A similarity between both network types is that exchange takes place because actors have varying levels of knowledge resources and the opportunity and motivation to exchange those (Monge & Contractor, 2003). However, differences also exist. A functional difference is the way in which knowledge is exchanged. In advice networks, knowledge exchange can have an ad hoc character, since knowledge workers quickly need advice for their current activity or project, while in a learning network, focus is on developing the professional skills of its members (Helms & Buysrogge, 2006) so that knowledge can have a long-term character. Additionally, advice is more likely obtained from direct colleagues, whereas learning knowledge is more likely obtained from more senior actors than the focal actor (Škerlavaj et al., 2010). While the expectation of reciprocity is a stimulus for knowledge transfer (Kachra & White, 2008), this is mainly expected in advice networks (Cross & Sproull 2004) and less in learning networks (Škerlavaj et al., 2010). In advice networks actors tend to mutually help each other, while in a learning network exchange can resemble a master-apprentice relationship (Helms, 2007).

Structural properties of knowledge networks, that is properties that express the composition of the network, vary among networks in organizations, advancing or

constraining them to perform a common task or achieve a common goal (e.g. Teigland, 2003; Wasko & Faraj, 2005; Helms & van Reijsen, 2008; Faraj & Johnson, 2010). Therefore, knowledge networks have been studied extensively to uncover how structural properties are supporting or limiting efficient knowledge processes and outcomes with the aim of finding preferential network configurations for specific goals. Here, social network analysis is applied since it allows the expression of various properties that condition these networks. Examples are "density" (Hanneman & Riddle, 2005), that expresses the degree to which all members in a network are linked to one another, "reciprocity" (Ibid) that expresses the extent to which a relation between two members is reciprocated, "connectedness" (Krackhardt, 1994), which is the extent to which a network comprises a single component and "efficiency" (Ibid), expressing the extent to which actors have only 1 incoming link.

8.2.5 Linking network structure to benefits

Ample scholars studied structural properties of knowledge networks to uncover how they function as antecedents for organizational benefits such as (team) performance. Several network properties are for their positive impact on performance, such as density (Koka & Prescott, 2008), brokerage roles (Lee, 2010), centrality (Rhee & Ji, 2011; Chiu, 2009) and efficiency (Helms & van Reijsen, 2008). Another organizational benefit that gained attention is innovation, which is found to be influenced by for example density (Obstfeld, 2005), direct and indirect ties (Ahuja, 2000), centrality and coreness (Chiu, 2009), weak ties (Pirolo & Presutti, 2010), structural holes (Tsai and Ghoshal, 1998) and a dual network structure comprising a core of strong ties and periphery of weak ties (Capaldo, 2007). Nieves & Osorio (2012) provide an elaborate overview of research that associates network structure with knowledge creation. These authors furthermore find that researchers have claimed seemingly contradicting results studying the effects of network properties, and argue that this might be caused by the various levels of scope on which networks are studied, such as individual actors, ties (2 actors), teams, intra- and inter-organizational networks. Moreover, network properties can yield different benefits for an individual actor than for a group, for example because individual actors can use knowledge opportunistically (Moran, 2005), potentially conflicting with interests on team level. But even on the same level of scope, an optimal network configuration can vary based on the required learning strategy (Mors, 2010; Nieves & Osorio, 2012). Two main views that are distinguished in social network literature are the benefits of weak versus strong ties. Granovetter (1973) and Burt (1992) emphasize the value of weak and non-redundant ties, since these can help

individuals to access new knowledge. Coleman (1988), however, argues in favor of high density, since it allows individuals to better coordinate their efforts and can lead to trust, which is invaluable for knowledge exchange and creation (c.f. Coleman, 1988; Ahuja, 2000; Capaldo, 2007). Various authors (e.g. Capaldo, Ibid) suggest that networks ideally have both a core of strong ties and a periphery of weak ties.

Recently, authors have shed new light on how both network configurations (i.e. strong ties and high-density versus weak ties and low-density networks) are beneficial for varying purposes. Key is that they are not per se substitutes but complement each other for distinct innovation strategies. Mors (2010) identifies that while low-density networks are beneficial for accessing knowledge, high-density networks are required to integrate external knowledge. This author argues that density enables networks to collaboratively make sense of knowledge that resides beyond the organizational and geographical boundaries. Internal versus external knowledge are referred to here as homogeneous versus heterogeneous respectively, although we argue that the former distinction better expresses the nature of the knowledge investigated here. Similarly, Rost (2011) concludes that while weak ties allow access to knowledge, strong ties are required to gain network solidarity (i.e. trust), which is invaluable for knowledge recognition and realization. This author therefore concludes that open innovation only works in concert with closed innovation principles. Nieves & Osorio (2012) link these findings to learning strategies. They reason that networks are benefitted by high density and strong ties for explorative learning in order to recognize and integrate external knowledge. For exploitative learning, networks are then benefitted by low density and weak ties in order to refine and use the internal or internalized (i.e. after it was explored and integrated) knowledge in the focal network.

8.3 Research questions and hypotheses for impact

A link between knowledge networks and ACAP now becomes apparent. The common ground is found in the exploratory, assimilative, transformative and exploitative learning processes (Lichtenthaler, 2009; Gebauer et al., 2012) that underlie ACAP. These processes take place in knowledge networks and are advanced or limited by the layout of these networks, under the condition of contexts such as scope of network level, focal learning strategy and internal versus external knowledge. This implies that different ACAP dimensions can be advanced or limited by different network configurations. The influence that network structure can exert on learning processes inspires us to explore to what extent structural properties of knowledge networks influence the various ACAP dimensions. Finding structural properties that are preferential for specific

dimensions of ACAP advances insight in optimal conditions of knowledge networks to facilitate ACAP processes. Hence, our main research question is:

RQ: *To what extent do structural properties of knowledge networks advance or limit their absorptive capacity?*

This research question is exploratory in nature and intends to add new knowledge about the impact of knowledge network structure on ACAP. Given the theoretical discussion above, however, we study the distinct dimensions of ACAP individually and therefore formulate a sub-question:

SQ1: *To what extent do structural properties of knowledge networks advance or limit the individual dimensions acquisition, assimilation, transformation and exploitation of their absorptive capacity?*

Secondly, since we study knowledge networks from both a learning and advice-seeking perspective, we can additionally regard to what extent the influence of network structure on ACAP varies between both network types. We argue that both network types are relevant to study with regard to learning processes. Despite its name, in advice-seeking networks too, individuals learn, because they access new knowledge through seeking advice (Rhee, 2004; Škerlavaj et al., 2010):

SQ2: *To what extent do structural properties of learning networks versus advice networks vary in advancing or limiting the individual dimensions of their absorptive capacity?*

Based on the discussed literature, we set forth a set of hypotheses that link network properties as conditions to distinct ACAP dimensions. In doing so, we follow the recent insights that propose high density and strong ties as optimal conditions to recognize and integrate (i.e. explore and assimilate) external knowledge and low density and weak ties to refine and use (i.e. transform and exploit) internalized knowledge for a focal network (Mors, 2010; Rost, 2011; Nieves & Osorio, 2012).

In our research, focal networks are intra-organizational knowledge networks that operate as work groups within organizational boundaries. Practical reasons allowed us to study only knowledge exchange in and between these networks. Network structure between these networks and extra-organizational actors was not studied. Notwithstanding the intra-organizational group-level scope in terms of network structure, the performance of the ACAP processes of these

knowledge networks was measured separately. Our research approach thus allows us to study the effect of network structure in intra-organizational knowledge networks on their ACAP and is essentially concerned with how these networks as distinct entities are capable of dealing with the various learning processes that underlie ACAP.
Acknowledging this choice of scope, we note that that ACAP is deemed applicable to any unit that learns, that is not just organizations as a whole (Jiménez-Barrionuevo et al., 2011). In fact, ACAP also exists on the level of organizational units (Tsai, 2001). This level of scope furthermore prevents recall bias (Freeman et al., 1987) that can occur in large networks and it can yield a larger sample than when studying ACAP on an organizational level. Figure 8.1 below visually represents the scope in terms of network structure in this research. Knowledge exchange was studied in a directed way, where an exchange from actor A to B means that actor A provided knowledge (i.e. learning or advice) to actor B.

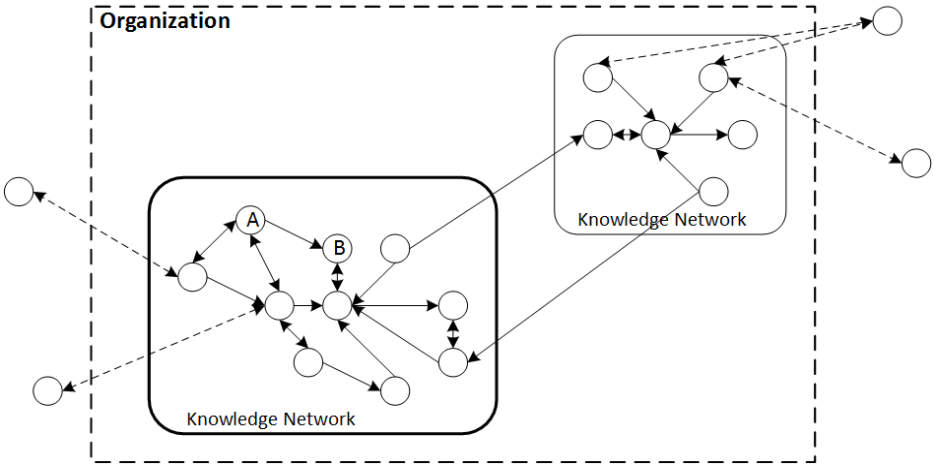

Figure 8.1. Research scope: intra-organizational networks within the organizational boundary

Having clarified the scope of our study in terms of network structure, we turn to our hypotheses. First, we assume that in order for a network to be able to perform learning processes, the network must be well-connected (Teigland, 2003; Helms, 2007). Therefore, it is relevant to study structural embeddedness of actors in the network. Connectedness expresses the extent to which all actors in a network are embedded in the same structure (Krackhardt, 1994). This allows actors to reach each other and allow knowledge exchange and learning without

separating or excluding some actors from these activities. Hence, we consider that a higher degree of connectedness improves the performance of all ACAP learning processes.

H1: Connectedness advances all ACAP dimensions

A different way of regarding structural embeddedness is the density of a network. Density is expressed as the percentage of possible connections between actors that are present in the network (Hanneman & Riddle, 2005). Following the recent literature as discussed, a high level of density is theorized to be beneficial for explorative learning (represented in the potential ACAP dimension), especially given the external nature of knowledge that is involved in potential ACAP processes. Conversely, exploitative learning (represented in the realized ACAP dimension) is put forward to benefit from low levels of density instead. These claims can be tested by hypothesizing:

H2a: Density advances the acquisition and assimilation (potential) ACAP dimensions
H2b: Density limits the transformation and exploitation (realized) ACAP dimensions

Furthermore, trust between actors is important since it assures solidarity (Rost, 2011) and motivation (Agterberg et al., 2010) among actors focusing on a common purpose and avoids opportunistic behavior of individual actors (Koka & Prescott, 2008). Trust is recognized as beneficial for acquisition ACAP (Lane et al., 2001) and combining (Coleman, 1988) recognizing and materializing knowledge (Rost, 2011). Trust is developed between individuals through strong ties (Carey et al., 2011; Rost, 2011; Capaldo, 2007). An expression of strong ties between actors is the reciprocity of their connections (Capaldo, Ibid). Reciprocity is a form of relational embeddedness of actors in the network. Since reciprocity is more important in advice networks than in learning networks (Škerlavaj et al., 2010), efficient knowledge processes might be more dependent on reciprocity in advice networks.

H3a: Reciprocity advances the acquisition and assimilation (potential) ACAP dimensions
H3b: Reciprocity is more important for ACAP in advice than in learning networks

A situation in which learning processes and knowledge exchange can be impeded is when a network is characterized by high levels of hierarchy. Hierarchy can reduce the free flow of knowledge because status becomes a more important driver for knowledge exchange than the knowledge itself. A means to express hierarchy is through efficiency. Efficiency expresses the extent to which all actors have only one incoming link or "a single boss" (Hanneman & Riddle, 2005, p. 129) and hence, higher efficiency can build up hierarchical structures in the network, impeding learning processes. However, an extent of efficiency can also be beneficial for ACAP because efficiency prevents tie redundancy. This means that actors do not receive the same knowledge through many different people. Non-redundancy of ties can be specifically beneficial for realized ACAP, since Nieves & Osorio (2012) stress the importance of non-redundant networks in exploitation learning strategies. We therefore anticipate that:

H4a: *Efficiency limits the acquisition and assimilation (potential) ACAP dimensions*
H4b: *Efficiency advances the transformation and exploitation (realized) ACAP dimensions*

Continuing, we acknowledge that the process of exchanging knowledge among actors will generate positional differences between actors in the network. Since actors possess varying levels of resources (experience) (Monge & Contractor, 2003), some actors either send or receive more knowledge than others, causing network centralization. Network centralization is indicative of exchange among actors with different levels of expertise and can therefore be beneficial to learning in general (Škerlavaj et al., 2010) and thus positively affect the ACAP learning processes. The network centralization index expresses the variation in centrality between actors in a network (Freeman, 1979) and can be based on incoming (receiving) and outgoing (sending) exchange flows. We hypothesize:

H5a: *In-degree centralization advances all ACAP dimensions*
H5b: *Out-degree centralization advances all ACAP dimensions*

The principle of organizational ambidexterity (Raisch and Birkinshaw, 2008) prescribes that organizations should simultaneously strive for both explorative and exploitative learning strategies in order to be successful. Jiménez-Barrionuevo et al. (2011) add that focusing on only potential or realized ACAP induces the risk of failing at either responding to environmental challenges or applying new knowledge in practice. Following the discussed literature, this requires a network to comprise both a dense component to cope with explorative learning processes

and a low-density component to cope with exploitative learning processes. A measure to express the existence of this "dual network architecture" (Capaldo, 2007, p. 586) is the core-periphery structure (Borgatti & Everett, 1999). A higher core-periphery fit indicates a more evident existence of both a high-density core and low-density periphery. We therefore anticipate that:

H6: Core-periphery fit positively impacts ACAP in general

Finally, if networks indeed require high density and strong ties to coordinate the recognition and integration of new external knowledge, a network requires to work together in close cooperation. Networks that operate in this way would have higher levels of potential ACAP. A means to observe this fact is provided by the External Internal (E-I) Index property that expresses the extent to which a network is focused on exchange within the group (negative E-I Index) or towards other groups (positive E-I Index) (Krackhardt & Stern, 1988, Helms, 2007, Müller-Prothmann, 2007). We argue that an inward focus of actors strengthens coordination and thus potential ACAP. In our research, this inward or outward trend is measurable since we observed the interaction between knowledge networks that coexist in organizations. An E-I Index based on interaction between intra-organizational knowledge networks is therefore possible to formulate. We thus anticipate that:

H7: A negative E-I Index advances the acquisition and assimilation (potential) ACAP dimensions

An overview of all network properties discussed in this section, including their definition and key reference is provided in Appendix C. Guided by these seven hypotheses, we propose our research model through which we explore the hypothesized relations between the structural properties of knowledge networks and ACAP.

8.4 Research model and measurement formulation

Figure 8.2 below displays the research model that we apply in order to test our hypotheses and answer the respective research questions.

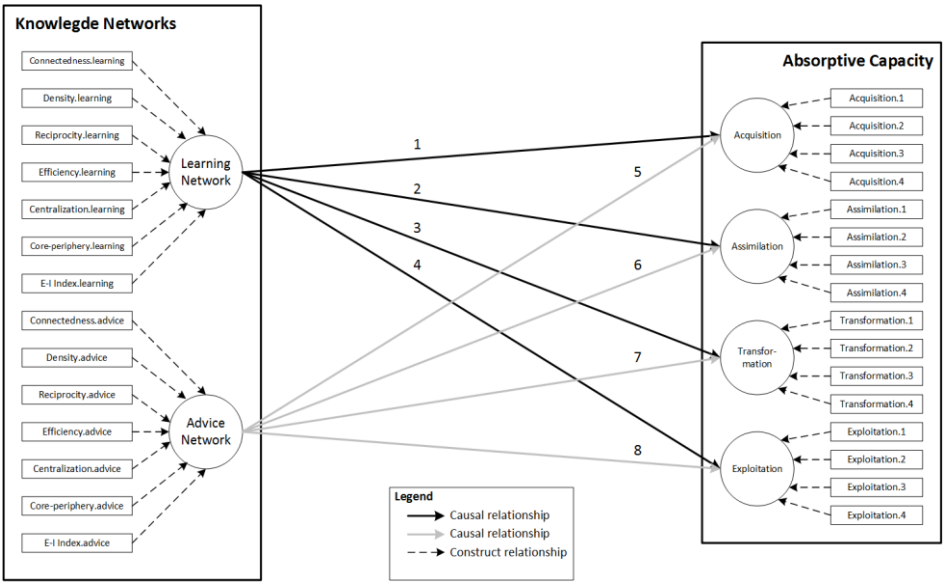

Figure 8.2. Research model

8.4.1 Measurement formulation

To conduct the proposed research, we formulate a set of constructs and measures that allow to observe network structures and ACAP in practice. Measurement of knowledge network properties is straight-forward. Based on data of observed knowledge networks (discussed below), all knowledge network structural properties are directly measured using specialized social network analysis software such as Netminer and Ucinet. Our sociometric survey is included in Appendix C.

Concerning the measurement of absorptive capacity, we considered various recent contributions to its operationalization (Flatten et al., 2011; Noblet et al., 2011; Jiménez-Barrionuevo et al., 2011; Camisón & Forés, 2010). Eventually, we decided to adopt the measurement model put forward by Noblet et al. (2011). The multidimensionality of ACAP is underscored by various authors (e.g. Cohen & Levinthal, 1990; Lane & Lubatkin, 1998; Todorova & Durison, 2007) and development of a multi-dimensional construct for ACAP is suggested (Lane et al., 2006). Consequently, it makes most sense to assume that changes in ACAP indicators change ACAP (formative) instead of the other way around (reflective), thus avoiding a Type I error (Diamantopoulos & Siguaw, 2006). Constructing a formative ACAP index instead of a reflective scale additionally prevents not using relevant indicators, since during item purification in scale development, reflective

items that could in fact be representative for the construct could be removed if they do not correlate with other items that are intended to measure the same concept (Bollen, 1984). Alternatively, index construction allows item multidimensionality by allowing variance, both between the four ACAP dimensions and in each ACAP dimension. Since all but Noblet et al.'s (2011) operationalizations are based on reflective scales, we adopt their measurement model to maximally allow coverage of the ACAP concept space. Based hereon, we formulated a survey comprising 16 Likert-scale questions, where groups of four questions are tied as formative measures to each ACAP dimension construct. The survey was expert-reviewed by Noblet et al. and is included in Appendix C. In supplement, we note that an inspection of the mentioned reflective ACAP scales revealed that most of our measures are also found in these scales but that no individual scale covers the concept variety of the ACAP index put forward by Noblet et al.

8.5 Data collection of impact

8.5.1 Approach

We defined a data collection approach to quantitatively test our model. We define our population in terms of knowledge-intensive organizations, that is organizations that are highly dependent on (working with) knowledge. C-level managers (i.e. CEO, COO or CIO) of knowledge-intensive organizations in our own social networks were approached. In these organizations, several intra-organizational knowledge networks were identified and selected. These networks are all knowledge networks in the sense that they comprise knowledge workers that are dependent on knowledge from their network members in order to perform their activities. Moreover, the members in each network possess similar knowledge, making the network a suitable vehicle for knowledge exchange among its members.

First, two sociometric surveys were presented to all members per network, aiming at collecting data to depict their learning and advice-seeking knowledge exchanges. Through a list of colleagues, network members could indicate from whom they had learned and received advice respectively. Regarding the learning network survey, tie strength was measured on a 5-point Likert scale ranging from passive to active learning. This scale measures the viscosity (richness) of knowledge transfer (Davenport & Prusak, 1998; Helms, 2006), based on Leonard & Swap's (2005) concept of viscosity. Tie strength in the advice network survey was measured by means of a frequency scale (sporadically to frequently), which is traditional as a means to measure tie strength in advice-seeking

networks (Rhee, 2004). Second, our ACAP survey was presented to two senior representatives per network, selected by management when deemed senior enough to have a helicopter overview over the network, being able to qualify the performance of ACAP learning processes in the networks. Mostly, one member had a managerial responsibility over the network, while the other member was a senior expert regarding the content of the network. All surveys were conducted between December 2012 and June 2013 with the use of LimeSurvey 2.0. Full anonymity was guaranteed to stimulate high response rates.

8.5.2 Sample

In total, 24 networks divided over five organizations participated in both the sociometric and the ACAP surveys. The average numbers of actors per network is 23. In total, 542 employees fully completed our sociometric survey, which is 89 percent of the 607 invitees. This average response rate is deemed high and adequate to construct social networks based on its data. We acknowledge, however, that the response rate in individual networks varied and while the majority of networks scores 85 percent participation and up, a few networks scored lower. Although a minimum response rate of 80 percent is suggested (e.g. Teigland, 2003), successful network research is conducted based on lower response rates (e.g. Johnson et al., 2012, p. 2; 67 percent response rate). Balancing between quality of the network data and the sample size in terms of networks, we decided to drop only networks with a response rate clearly lower than 70 percent (one case dropped). Furthermore, after several interviews with the participating organizations, we decided to drop one case because we doubted the knowledge-intensive nature of the network and we dropped one case due to an incomplete ACAP survey response. By collecting two ACAP responses per network, our eventual sample comprises 42 (21*2) learning network cases and 42 advice network cases.

When all network data was collected, we refined the LimeSurvey tables into adjacency matrices that allow formulation of the knowledge networks. Additionally, we transposed the matrices, inversing tie direction. In our survey, we deliberately asked “from whom” respondents received knowledge to minimize a possible social desirability bias when asking “to whom” respondents provide knowledge. Transposing the matrices restores tie direction, resulting in networks where tie direction represents knowledge flows from one actor to another. We applied Netminer 4.1 to compute the network properties applied in our research model for all network matrices, except for the core-periphery property, which we computed using Ucinet 6.4. We then combined all network properties with the results from the ACAP survey, resulting in our definitive dataset.

8.6 Data analysis and results of impact

8.6.1 A PLS-SEM Approach

To test our model, we applied a PLS-SEM approach due to its suitability for the exploratory nature of our research. Additionally, it allows us to work with formative constructs (Becker et al., 2012; Hair et al., 2013) and both single-item and multiple-item constructs (Hair et al., 2010). Moreover, PLS-SEM is suited for small sample sizes (Marcoulides & Saunders, 2006; Sosik et al., 2009; Hair et al., 2013) and capable of handling ordinal measures (Hair et al., 2010; Haenlein & Kaplan, 2004; Chin, 2010). We apply WarpPLS 3.0, since it is a suitable tool for formative constructs, is known to yield more stable weights and lower levels of collinearity than comparable tools and is capable of providing p-values for weights, loadings, path coefficients and correlations (Kock, 2012). Moreover, WarpPLS supports nonlinear analysis of relationships between latent variables.
After loading our dataset in WarpPLS, we standardized all values to allow comparison between our ordinally measured variables. From here, because we hypothesized that network properties can exert varying effects on distinct ACAP dimensions, we chose to model each ACAP dimension individually. Combined with the 2 network types (i.e. learning and advice) this results in eight testable models (two network types * four ACAP dimensions). After assembling the eight model configurations, we inspected the correlations between the network properties and the ACAP dimensions to get a first impression of the relations between our independent and dependent variables. A full correlation matrix is provided in Appendix C. We then performed PLS-SEM path analyses for each of the eight models individually, based on the WarpPLS 3.0 algorithm that specifically tries to identify warped (nonlinear) paths. However, we initially found no stable models. Through an inspection of the intercorrelations of the network properties (the independent variables) we noticed an extremely high correlation of density with efficiency of -.997 ($p < .0001$). From a network theory perspective, this correlation is accountable: both measures are concerned with the amount of connections that are made between actors. While a higher density means that more connections are made, a higher efficiency means that less connections are present. Both measures thus counterbalance each other. Given our interest in density from our theoretical discussion, we decided to drop efficiency from our models. This resulted in eight stable models that pass various tests of evaluation as discussed below.

8.6.2 Evaluation of the models

The formative nature of our PLS-SEM models requires us to apply formative validation techniques instead of standard tests such as convergent validity and reliability for reflective models (Rossiter, 2002). In our formative model, the ACAP constructs measures should not show redundancy since the measures are different aspects of their construct (Hair et al., 2010; Kock, 2012). Hence, we follow Hair et al.'s (2011) validation approach for formative models. Moreover, we applied the jackknifing resampling technique, because it renders more reliable p-values for smaller samples and reduces effects of outliers (Kock, 2011a). We evaluated all eight models based on the following criteria and thresholds.

A first criterion for the evaluation of formative constructs is that they represent the concept space (Petter et al., 2007). We argue that we comply with this requirement, since we adopt Noblet et al.'s (2011) scientifically constructed and validated index for ACAP. Second, on a measures level (outer model), we inspected the weights and loadings for all multi-item constructs (the ACAP dimension constructs). Kock (2012) prescribes that all measure weights (relative contribution) should have a p-value of < 0.05 and that similar findings should be found for loadings (absolute contribution). Moreover, we inspected the VIF values of the measures and applied a strict threshold of < 2.5 based on Kock (Ibid). All measures but one pass these tests. "Acquisition.4" has a slightly higher p-value but passes the VIF test. We decided to leave the measure in our model since the test violation is not high and to safeguard the concept space of the acquisition dimension of ACAP. Third, to evaluate the inner models (construct-level evaluation), we inspected the R2 values of all endogenous latent variables as a means to interpret the predictive capability of the model and apply Hair et al.'s (2011) scales as thresholds for interpretation (i.e. .75, .50 and .25 are substantial, moderate and weak respectively). Almost all of our models have R2 values of at least .25. Some models score lower. We argue that this is because some path coefficients score weak as predictors for ACAP and found that R2 values were easily increased by retaining only significant path coefficients in the models. Since we wish to test all of our hypotheses, we intentionally leave all independent variables intact in our models. Fourth, we tested the full collinearity VIF for each latent variable to test vertical and lateral collinearity and applied a threshold of < 3.3 (Kock and Lynn, 2012). Also, we inspected Block VIF's and applied a threshold of max. 3.3 (Kock, 2012). All models pass these tests. Fifth, we tested for discriminant validity by inspecting the correlations between all constructs in our models, applying a threshold of correlation coefficients of < .71 (Andreev et al., 2009). Here, we found that reciprocity-connectedness and reciprocity-density did not pass this test. This indicates that these variables are

conceptually related, which is explainable from network theory. We decided to leave these variables intact in our models to keep our hypotheses testable. Sixth and last, on the full model level we tested one model fit index: the AVIF (Average VIF) that should score < 5 (Kock, 2012). All models pass this test. We did not test other full model fit indices such as the APC (Average Path Coefficient) and the ARS (Average R-Squared) since our goal is not to compare models for a best fit but to test our hypotheses. These fit indices are thus irrelevant here (Kock, Ibid, p. 30).

After running the described evaluation tests and considering their impact, we are able to provide the results of our eight models in table 8.1 below. For each model, path coefficients are provided including their sign direction and significance level. We note that we created these eight models to visually separate the influence of the network properties for each ACAP dimension and tested that combining all ACAP dimensions in one model per network type would not have altered the below results. Each model number "#" corresponds to the numbered investigated causal relationship in Figure 8.2.

*Table 8.1. Summary of path coefficients and sign direction (****=p<0,001; ***=p <0.01; **=p<0.05; *=p<0.1)*

#	Network	ACAP Dimension	Connect.	Density	Recipr.	InDegC.	OutDegC.	CorePF.	E-I Index
1	Learning	Acquisition	0,352	**0,468****	0,041	0,127	0,200	-0,277	-0,143
2	Learning	Assimilation	-0,359	**0,37***	-0,012	-0,184	**0,500*****	**-0,272****	0,147
3	Learning	Transformation	**0,448*****	**0,345***	-0,119	-0,03	0,192	-0,03	0,013
4	Learning	Exploitation	**0,322******	0,141	0,209	-0,023	**0,211***	0,282	**0,189***
5	Advice	Acquisition	**0,417****	**0,341****	0,108	-0,068	0,162	-0,063	**-0,222***
6	Advice	Assimilation	**0,362****	**0,248***	0,16	-0,234	**0,369*****	-0,007	**-0,168***
7	Advice	Transformation	**0,452****	0,015	-0,032	0,023	**0,453*****	-0,151	-0,083
8	Advice	Exploitation	**0,234***	0,168	0,097	0,096	**0,294***	-0,02	**0,261****

8.6.3 Findings

The results show that connectedness is indeed positively impacting ACAP. However, we only find significant coefficients for all ACAP dimensions in the advice network, while in the learning network only transformation and exploitation appear to be benefitted (H1). Furthermore, we find positive links between density and ACAP dimensions. Interestingly, the strength of the relation between density and ACAP decreases in the direction from acquisition towards exploitation, best evident in the learning network. These findings are in line with hypothesis H2a only to the extent that density appears important for the potential ACAP dimensions (H2). We are not able to find a significant unique contribution of

reciprocity compared to other network properties for any of the ACAP dimensions. Judging from the correlations in Appendix C, reciprocity does have a positive effect on ACAP, which is most apparent in the acquisition dimension of ACAP in both network types and in line with our hypothesis. However, reciprocity does never appear to have a unique contribution to ACAP (H3). We furthermore find that when we switch density for efficiency in our models, a negative impact is observable of efficiency on ACAP, which is most evident in the potential dimensions of ACAP. Therefore, we are able to defend hypothesis H4a, but we were not able to find evidence for hypothesis H4b. With regard to In-Degree Centralization and Out-Degree Centralization, we find several significant positive coefficients for Out-Degree Centralization, both in the learning network (assimilation and exploitation) and in the advice network (all ACAP dimensions but acquisition) (H5b). Conversely, we observe no significant coefficients for In-Degree Centralization, signifying that this network property has no unique relevance for ACAP (H5a). In contrast to our hypothesis, we find a significant negative effect of Core-Periphery Fit on ACAP on the acquisition dimensions of ACAP in the learning network, suggesting that a high Core-Periphery Fit is in fact limiting this ACAP process (H6). Finally, we do a promising observation with regard to the effect of the E-I Index on ACAP. In the advice network, we observe that the E-I Index is negatively associated with the potential ACAP dimensions, which is in line with hypothesis H7. Additionally, we find that the E-I Index is positively associated with the exploitation ACAP dimension. Its role is, however, mostly evident in the advice networks (H7).

To test our findings more elaborately, we controlled our models for four contextual variables: size and IT focus of the organization and geographical spread and size of the networks. When applying these variables, most significant coefficients that were found earlier retain their significance. However, we find some exceptions. In the learning network, density sometimes loses significance when controlled for organizational size and IT focus in the assimilation dimension. However, in most cases these controls raise the original p-value only slightly. We furthermore checked that density does remain significant when modeled with these controls and ACAP only, cancelling out that the controls would directly negate the effect of density on ACAP. We suspect that our relatively low sample size plays a role in these findings and suggest that additional research should further investigate the role of these contextual variables. Likewise, concerning the E-I Index we find that controlling for organizational size and IT focus sometimes renders this network property insignificant. On the other hand, we find hints of relations between our contextual variables and one ACAP dimension. Although these hints are suggestive, it appears that acquisition ACAP is benefitted by a smaller organization and more IT focus.

8.7 Conclusion and discussion on the impact

Driven by the increased need for organizations to develop absorptive capacity to remain innovative and competitive, in this paper we investigate how structural properties of knowledge networks advance or limit this capacity. Recent literature guided us to formulate a set of seven hypotheses. Based on our analysis of 42 cases of learning networks and 42 cases of advice networks, we are able to promote several network configurations that can advance absorptive capacity.

8.7.1 Key Findings and implications

So, what claims can we make based on the results presented here? First, it appears that in our sample, knowledge networks benefit from high levels of connectedness, underscoring the importance of well-connected networks. Connectedness should therefore be regarded as a foundational requirement for knowledge networks with regard to ACAP. The fact that this evidence is not found for potential ACAP in the learning network could be induced by the relative importance of density, out-degree centralization and core-periphery fit, thus reducing the unique contribution of connectedness here. Second, we can confirm our hypothesis H2a that density indeed supports explorative learning strategies, which is observed in both the learning and the advice network. Moreover, we also found that density is not important for exploitative learning, although this does not allow us to conclude that low density supports exploitative learning. Third, for efficiency we observed comparable behavior over the networks and the ACAP dimensions as with density but in an inversed way and therefore conclude that efficiency limits potential ACAP. We argue that efficiency limits the coordination capabilities of knowledge networks and that it can reduce trust. Fourth, out-degree centrality appears to be especially relevant in the advice network. In practice, this means that networks benefit with regard to ACAP when variation among actors in out-going connections is high. Its benefit for ACAP exists because it could provide clearer distribution of knowledge throughout the network (relatively few actors feature as the main senders of knowledge) so that actors are better able to receive the knowledge. Fifth, logic in the negative association that we found for core-periphery fit for assimilation ACAP in the learning network can be related to the role for density here: a distribution into a high density and a low density periphery block is then limiting the buildup of high levels of density in the network. Sixth and last, our findings in the advice network relating to the E-I Index suggest that networks indeed benefit from an internal focus for potential ACAP. Additionally, they benefit from an external orientation for realized ACAP. We argue that accessing diverse knowledge outside of the focal network but

within the organizational boundaries supports the networks to refine and use the internalized knowledge as suggested by both Rost (2011) and Nieves & Osorio (2012).

When regarding our overall findings, it comes to mind that we are not able to find the tipping point between explorative and exploitative learning that recent scholars theorize in terms of density. Although we find support for the notion that explorative learning thrives on high levels of density, we do not find a negative but instead no association between density and exploitative learning. We argue that a possible explanation for these findings lies in the external nature of knowledge that we focus on in this research. Although the nature of knowledge is not studied in the networks itself, we explicitly link the structure of these networks to processes that deal specifically with external knowledge. Although density appears to be mainly relevant for acquisition ACAP and to a lower extent also to assimilation ACAP, the focus on external knowledge in this study could negate the expected benefits of low-density networks for exploitation ACAP. Although weak ties and low density are required for exploitative learning, the networks additionally need strong ties and high density to cope with the external nature of the knowledge here (Ahuja, 2000), effectively cancelling out each other's benefits in our data. A comparable vitiating effect is reported by Mors (2010). In comparison, in an earlier study we examined the impact of knowledge network structure on team performance. Here, network structure was linked to performance benefits induced by knowledge provided by internal colleagues to focal actors. In this study, we found that density hindered team performance, while efficiency advanced it. In sum, these findings make sense through the focus on internal knowledge in the former and external knowledge in the present study.

8.7.2 Practical implications

A key takeaway for organizational knowledge networks is that in order to safeguard their ACAP performance, they should strive for well-connected but not necessarily dense networks. But how to stimulate connectedness? Managerial control over networks is not recommended (Alvesson et al., 2002; Thompson, 2005) but management should shape the right conditions for them to thrive (Van den Hooff & Huysman, 2009). Agterberg et al. (2010) argue that connectedness can be stimulated by formalizing the network and provide opportunities for its members to meet face-to-face. Moreover, network density can be stimulated through explication of its members, so they know whom they can connect to. Stimulating out-degree centrality is possible through promoting certain actors as knowledge stewards that can coordinate knowledge out-flows or by introducing a KM IT system that serves as a key portal to distribute knowledge. This

intervention can greatly increase out-degree centrality since the relative out-degree of these coordinators will become higher than that of others.

8.7.3 Limitations and Future Research

One main limitation of this study is the amount of data that we were able to apply to test our models. Obtaining data in network research is difficult due to the extensive effort required by participating organizations (Teigland, 2003) and the sheer amount of responses required to formulate networks. In our survey, 542 knowledge workers participated in sociometric surveys and separately, 48 managers participated in the ACAP survey. Such obstacles are recognized as a probable reason for a lack of studies that examine knowledge networks (Škerlavaj et al., 2010). In terms of generalizability, we note that we conducted our research in only Dutch organizations, disallowing us to generalize our findings to other countries. Moreover, in some cases we found that when controlling for contextual variables, some findings turn insignificant, which might be caused by our relatively low sample size. We encourage future research to expand the data we gathered in this study. Exploration of additional knowledge networks could help to complement or contradict our findings. Especially the link with the E-I Index and core-periphery fit measures should be further studied. Also, studying the content of knowledge adds an extra dimension to the analysis opportunities regarding the knowledge networks. Next to the structure of knowledge flows, content analysis can shed more light on for example the influence of internal versus external knowledge for a preferential knowledge network configuration.

Part VI

Conclusion

Chapter 9

Conclusion and Outlook

This final chapter reviews the research questions that form the foundation of this dissertation and summarizes the main findings set forward throughout the chapters of this work. Furthermore, the main findings are elaborated in a discussion, limitations are examined, personal reflections are provided and avenues for future research are considered.

9.1 Research questions and findings

The main research question of this dissertation is:

MRQ: *How can dynamic capability in organizations be advanced from a knowledge perspective?*

Underlying this main research question are three perspectives towards knowledge that form the three main parts of this dissertation: knowledge management (KM), social capital and knowledge networks. The impact of KM on DC was studied by empirically investigating the effect of the adoption of KM policies by organizations on their DC. The impact of social capital on DC was similarly studied by empirically examining the effect of the availability of several forms of social capital in organizations on their DC. Additionally, social capital was studied in concert with KM policy adoption, in order to uncover which perspective towards knowledge, either the KM or the social capital perspective, would yield the best potential to advance DC. Finally, the knowledge network perspective was adopted to further zoom in on the social dynamics of knowledge to study the impact of knowledge network configurations on DC. In this approach, specifically the DC of learning, ACAP, was studied.
Since the main research question is a composite of the underlying research questions, these research questions are first reviewed separately, complemented by the formulation of a generic answer to the main research question. A review of the Knowledge-Based Dynamic Capability Model that we introduced in chapter 1 of this work places these findings in their proper context.

9.1.1 The Knowledge Management perspective

In order to drill down on the three perspectives towards knowledge, the main research question was divided into three research questions that each addressed one of these perspectives towards knowledge. The first research question addressed the KM perspective:

RQ1: *To what extent can dynamic capability in organizations be advanced through knowledge management?*

To answer this research question, a specific set of KM policies was studied: the Sustainability Code. This KM approach is based on the New Knowledge Management thoughts of Mark McElroy and is a second generation approach towards KM. It therefore encompasses both an IT (system) and a HR (human social) approach towards KM. Moreover, this KM approach was specifically put forward to allow organizations to develop the capability of sustainable innovation, which closely aligns with DC. To investigate the potential impact of this KM approach on DC, an assessment method was developed that enables measurement of the adoption of the Sustainability Code in organizations. Through an empirical test in 30 Dutch organizations, the assessment method was applied to examine to what extent organizations had adopted the Sustainability Code. By combining this insight with the measurement of a level of sustainable innovation in these organizations, conclusions were drawn on the effect of the KM approach on sustainable innovation. It appeared that the sustainability code is indeed a viable KM approach to advance sustainable innovation. Further tests indicated that the KM approach does not significantly influence innovation and that the extent to which an organization is externally oriented, i.e. involving external stakeholders in their processes, is another important factor that influences sustainable innovation and complements the sustainability code in doing so.

Organizational conditions

Furthermore, organizational conditions were investigated that were associated with higher levels of Sustainability Code adoption in an effort to uncover organizational antecedents for the effective adoption of this KM approach. For this purpose, several organizational conditions were examined, such as size, hierarchy and value proposition. It appeared that the surveyed organizations apply the Sustainability code for 60% on average, but that its application varied to a large extent between organizations. Organizational conditions that were associated with a higher degree of adoption were a flat (i.e. non-hierarchical) organizational structure, orientation on business-to-business operations and the availability of an IT system that supports KM.

Fortifying the findings
In a second empirical study among 55 Dutch and Belgian organizations, the assessment method was repeated, which allowed investigation of the impact of the KM approach in a separate sample. In addition, the DC construct was extended in order to apply a more elaborate proxy for DC. Moreover, a more thorough statistical approach was adopted in the form of PLS-SEM. The study again confirmed that adoption of the KM policies advanced DC in organizations. Furthermore, through modeling the distinct cornerstones of the KM approach in a multidimensional second-order model, cornerstones that specifically attributed to DC could be uncovered. Some cornerstones proved to be of particular value for DC. These policies in sum aim at the recognition of a cyclical flow of knowledge, i.e. that organizations consciously regard knowledge processes as a knowledge life-cycle. In this life-cycle, specific attention should be paid to the evaluation of knowledge, which should result in renewal of knowledge through abandoning knowledge that is no longer true or relevant. Secondly, policies that aim at an open and transparent organization and the empowerment of employees in knowledge processes (including evaluation) appeared to advance DC.

9.1.2 The Social Capital perspective

The second research question of this dissertation addressed the social capital perspective towards knowledge:

RQ2: *To what extent can dynamic capability in organizations be advanced through social capital?*

For the purpose of this second part of the dissertation, a measurement method for the examination of social capital availability was adopted from Kianto & Waajakoski (2010) that these authors successfully applied in earlier research. The measurement method was applied in chapter 4 of this dissertation in the previously mentioned sample of 55 organizations, in concert with the Sustainability Code measurement method. Through application of the measurement method, the availability of several socio-centric (i.e. group-level focus) forms of social capital could be measured in organizations. Structural, relational and cognitive social capital were examined as forms of social capital, both in the internal organization and between the organization and external partners.
Contrary to the expectations, it appeared that social capital availability in general had no effect on DC at all. However, the formulation of social capital as a second order construct allowed to investigate the role of the distinct forms of social capital on DC. At this level, observations suggested that especially *cognitive internal*

social capital may play a role in advancing DC. A deeper investigation – of the correlations between the individual social capital and DC measurement items – repeated this suggestion and additionally showed that although some significant correlations were found for *internal* social capital, almost no significant correlations were found for *external* social capital.
Furthermore, the use of WarpPLS as the application for performing the PLS-SEM analysis allowed to investigate the relation between social capital and DC from a non-linear perspective. Although modesty should be applied given the relatively low sample size, a non-linear curve was found for the relation between social capital and DC. It suggested that a certain extent of social capital is beneficial, but that this benefit stagnates and turns into an obstacle when social capital levels are high. Since the impact of social capital and KM on DC were examined in concert in this study, another conclusion of this study was that the adoption of KM policies was better able to explain DC than social capital availability could.

9.1.3 The Knowledge Network perspective

The third and fourth research questions addressed the knowledge network perspective towards knowledge. First, the third research question concerned the investigation of available tools and techniques to conduct knowledge network analysis in practice:

RQ3: *What knowledge network analysis tools and techniques are available and how to they relate?*

This research effort was undertaken to develop a picture of available methods to conduct knowledge network analysis under the notion that knowledge network analysis is a delicate, extensive and time-consuming practice for both researchers and participating organizations. An overview of available methods and techniques was therefore deemed necessary in order to know of their strengths and weaknesses and to select proper tools and techniques to further study the impact of knowledge networks on DC. Differences between various data capturing techniques definitely existed, as is elaborated in chapter 5 of this dissertation. In a case study in a Dutch IT-services firm, several knowledge network data capturing techniques were applied and compared for their ability to represent two distinct types of knowledge networks: learning and advice networks. Results showed that capturing sociometric data through email communication allows researchers and practitioners a means to formulate knowledge networks that are comparable to those networks that are constructed through sociometric surveys.

These similarities exist mainly on the network properties level. When zooming in to the actor level, however, the networks are less comparable. Although differences appeared between the similarities for the advice and the learning network, these differences were only marginal. Conversely, it appeared that telephone logs and text message logs were no viable alternatives in formulating a knowledge network, since both data capturing techniques could not generate knowledge networks that significantly resembled the knowledge networks captured through sociometric surveys.

ESNE: Email Social Network Extraction

The data capturing techniques comparison study was pillared by a tool that was specifically developed for the purpose of extracting knowledge networks from email communication logs. This tool, which is referred to as ESNE: Email Social Network Extraction, was applied in chapter 5 and furthermore discussed in chapter 6. In the latter chapter, the development of the ESNE tool was elaborated. Its development was grounded on an in-depth study of available tools that use email as a source for social network analysis and allowed to formulate specific criteria based on which tools could be compared. Examples were filtering of local groups and the inclusion of email aliases. Moreover, these criteria were taken in to account in the development of ESNE itself. Many of the criteria were incorporated in the tool. Although the tool proved useful in conducting several knowledge network analyses, a shortcoming was noticed too, since it only allowed to formulate the structure of knowledge networks. Lacking was the ability to formulate the content that is exchanged through those networks. Integration of the tool was proposed with another tool (EKE) that specifically aimed at content extraction through email. This avenue was, however, not further explored. The primary reason for this is that eventually, sociometric surveys were the best accessible means to collect sociometric data in the studies discussed in chapters 7 and 8 of this dissertation. However, the EKE tool was further developed and evaluated (Tedmori & Jackson, 2012) and insights from the proposed integration stimulated later research initiatives (Rivera-Pelayo et al., 2013).

Pre-testing the research approach

Guided by the insights of these efforts, a course was set out to study knowledge networks for their impact on DC, which was reflected in the fourth research question:

RQ4: *To what extent can dynamic capability in organizations be advanced through the structure of their knowledge networks?*

Chapters 7 and 8 explored the impact of structural properties of knowledge networks in organizations. First, in chapter 7, the impact of knowledge networks on team performance was studied. This step was undertaken to first explore the research approach applied in this dissertation that deviated from traditional approaches. The current study deviated in two ways. First, a group-level focus was adopted that examines benefits of knowledge network structure for organizational units, instead of an actor-level focus that studies benefits of network structure for individual actors. The latter approach was more commonly seen in network literature. Secondly, the study regarded multiple network properties simultaneously, where other studies mostly focused on one or a few network properties. Findings of the analysis of 18 knowledge-intensive learning networks in a Dutch software development company revealed that these networks thrived on *connectedness* of the networks and on *low-density* and *non-redundant* learning relations. These findings underscored that more learning relations are not always better, since participating in knowledge exchange is also time-intensive. In sum, this research suggested that especially non-redundancy and a variety in contacts would stimulate group performance of the knowledge workers in the networks.

Testing the impact of network structure

Tuning into DC, in chapter 8 a study was conducted that specifically examined preferential network configurations for DC. Again, a network (group-level) focus was adopted in order to study the impact of network structure on DC for knowledge networks as a whole instead of benefits for individual actors. In this case, DC was studied in the embodiment of ACAP, the DC of learning based on external knowledge. For this cause, a formative measurement index for ACAP was developed in cooperation with and based on Noblet et al. (2011). Specifically, the four dimensions of ACAP that represent *explorative, assimilative, transformative* and *exploitative* learning processes were examined, since theory suggests that these distinct learning strategies may require different network configurations for optimal performance. Findings show that this indeed is true. Explorative and assimilative ACAP mainly thrive on *connectedness* and high *density*. However, high levels of density seem to be no requirements for transformative and exploitative ACAP to flourish. Furthermore, it appeared that ACAP is to a large extent benefitted by *out-degree centralization*, which suggests that concentration of outgoing knowledge flows helps these networks to develop higher levels of ACAP. An important finding that emerged through the studies set forward in chapters 7 and 8 is that different contexts may require different preferential network configurations. The study in chapter 7 explicitly focused on how colleagues operating in teams benefit from *internal* knowledge with regard

to the performance of their group. Conversely, in chapter 8, explicit focus was put on how intra-organizational networks deal with *external* knowledge. Recent literature put forward that knowledge networks may require high density and strong ties in order to *recognize*, make sense of and *integrate* external knowledge, while they may subsequently require low density and weak ties to *refine* and *use* the internal (or internalized) knowledge. The difference in contexts between chapters 7 and 8 in terms of a focus on internal versus external knowledge respectively may explain the difference in findings between both chapters with regard to density.

9.1.4 Answering the main research question

The combination of the findings with the three perspectives on knowledge allow for an answer to the main research question. DC in organizations can be advanced through both a formal and informal approach towards knowledge. Adopting formally supported KM policies, organizations should focus on the openness of their knowledge processes to all employees in the organization. Furthermore, they should focus on the evaluation of new and existing knowledge, the deletion of invalidated knowledge and the renewal of knowledge in general. The adoption and use of a KM IT system can help organizations to streamline their knowledge processes and help to advance DC. Through the informal lens, the availability of social capital is not per definition beneficial for advancing DC. A saturation effect appears to present itself, where a certain degree of social capital availability indeed supports DC, but too much social capital negates this benefit. The zoom lens on the structural property of social capital has shed additional light on this pattern by pointing out that contextual factors may be at play. Although high levels of *density* appear to be negatively influencing performance when *internal* (existing) knowledge is exchanged, organizations in fact advance their DC through high levels of *density* when external (new) knowledge is concerned. Especially in the case of DC that heavily relies on external knowledge, organizations are benefitted by these high levels of structural social capital availability. In terms of the learning processes that provide the fundament for DC, it should be noted that especially *explorative* and *assimilative* learning strategies (i.e. the *potential* dimensions of absorptive capacity) are benefitted by high levels of *density* for organizations to advance their DC. Furthermore, learning processes in general are benefitted by high levels of *connectedness* and a strong concentration of outgoing knowledge flows in their knowledge networks. Organizations should therefore make educated decisions when stimulating the right context for knowledge networks to flourish and should take the internal or external nature of the knowledge and the pursued learning strategy into account.

Figure 9.1 below displays the Knowledge-Based Dynamic Capability Model that was introduced in chapter 1 of this work. The highlighted components in the figure mark the components of the model that were elaborated and validated in this research, being:

- The effect of knowledge management on DC
- The effect of social capital availability on DC
- The effect of knowledge network structure on DC
- The interplay between learning processes and DC

The non-highlighted parts present avenues for future research, which will be briefly discussed at the end of this chapter.

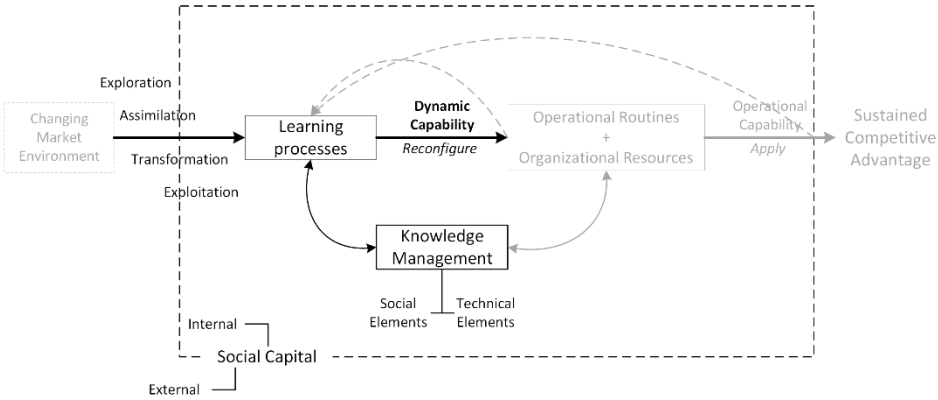

Figure 9.1. Validated components of the Knowledge-based Dynamic Capability Model

9.2 Conclusions and discussion on the findings

Throughout this dissertation, three perspectives on knowledge have been considered with regard to advancing DC in organizations. Since these perspectives have been considered individually throughout the chapters in this study, with the exception of chapter 4, a discussion of their confluence is appropriate. The section below first summarizes the similarities and differences between the three knowledge perspectives and then bridges the conclusions from each of the perspectives towards a main conclusion.

9.2.1 Confluence of the perspectives on knowledge

As set forward in the introduction of this dissertation (chapter 1), the similarity between all three perspectives towards knowledge is that they concern conditions for effective knowledge and learning processes. The confluence of the three

perspectives thus lies in the fact that all three perspectives offer a means to focus on the potential impact of knowledge on DC.
Notwithstanding their similarity, differences also exist that provide justification to study the potential effect of these knowledge perspectives on DC distinctly. A major difference between the KM and social capital perspectives on knowledge is referred to as an *engineering* versus an *emergent* approach towards knowledge respectively (Van den Hooff & Huysman, 2009). KM as an engineering approach focuses on the role of deliberate managerial interventions to create the right conditions for knowledge processes. The social capital perspective on the other hand is concerned with emerging conditions that facilitate knowledge processes. Furthermore, a difference between the social capital and the knowledge network perspective towards knowledge, both being *emergent* approaches, also exists. The knowledge network perspective can be regarded as a zoom lens on the *structural* dimension of social capital that concerns the structure of relationships in social networks (Kianto & Waajakoski, 2010). While social capital mainly focuses on the *availability* of the structure of relations among actors in networks, the knowledge network perspective zooms in on this dimension and more deeply investigates the *structural properties* of these networks structures.

The nature of KM in this research
It should be noted that a KM approach towards DC, especially the Sustainability Code policies that were studied in this dissertation, is not per se the same as exerting *managerial control*. Managerial control can in fact hamper the success of knowledge flows such as in organizational networks (Agterberg et al., 2010). Instead, the KM policies studied in this dissertation should be regarded as policies that *stimulate* knowledge processes in organizations. Although these policies are formal in nature in the sense that they are issued from or supported by management, they are not intended to control or restrict but instead to open up knowledge flows and create the right conditions for effective knowledge processes.

9.2.2 Discussion and comparison of the results

The impact of KM down the hierarchy of capabilities
It may next be relevant to further discuss and compare the various findings as set forward in this work. A first question that rises is why adoption of the Sustainability Code policies could exert a positive influence on sustainable innovation but not on innovation (chapters 2 and 3). The answer to this question can be provided by two similar views. First is McElroy's *three-tier model* (McElroy, 2008), also discussed in this dissertation as the *epistemic hierarchy* in the New Knowledge

Management thoughts. This notion underscores the indirect relation between KM and organizational outcome and places sustainable innovation as an outcome of KM and an antecedent of organizational outcome. Therefore, it can be argued that the Sustainability Code may positively influence sustainable innovation, but cannot directly influence innovation as an organizational outcome. The same differentiation is found in DC theory. The concept of the *hierarchy of capabilities* stresses DC as an antecedent of operational capabilities that in turn influence organizational outcomes, such as sustained competitive advantage (Winter, 2003; Easterby-Smith & Prieto, 2008).

The impact of KM versus social capital

A second question is why it appeared that only KM and not social capital was able to explain an advancement of DC (chapter 4). In answering this question it should first be noted that significant paths for the impact of social capital on DC were in fact found, but these would diminish as soon as adoption of the KM policies were added to the equation (the PLS-SEM model). This means that although there is a role for social capital in explaining advancements of DC, the adoption of KM policies overshadows this influence and remains as the explanation for advancing DC. Furthermore, it is relevant to note that the paths that were found between social capital availability and DC were non-linear in nature. In the full PLS-SEM model (including the KM predictors), the curve for social capital suggestively took the form of an inverted u-shape. When modeling social capital independently of KM, this inverted u-shape was even more apparent and especially so for structural and relational internal social capital. This means that a certain extent of social capital is positive for DC, but that too much social capital stagnates DC. This inverted u-shape has previously been noticed (Rost, 2011) and has been referred to as the *'dark side'* of social capital (Kianto & Waajakoski, 2010), pointing out that too much structural social capital might lead to inertia. Furthermore, Molina-Morales & Martínez-Fernández (2009) refer to this phenomenon as the *saturation effects* of social capital, stating that too much trust may have negative impacts.

Saturation effects of social capital versus network properties

Finally, a third and fourth question arise when concerning the findings that were done from a knowledge network perspective (chapters 7 and 8). The third question relates to the findings done in chapter 4 versus the findings done in chapter 8. In the former study, an inverted u-shape was suggested for the impact of social capital on DC, especially for the influence of internal structural and relational capital. In an attempt to express specifically structural (and to a lesser extent relational) social capital in terms of structural properties of knowledge

networks, it can be argued that high levels of structural social capital may be reflected in high levels of *connectedness* and *density*. However, the study in chapter 8 only found positive influences of both network properties and no negative influences. So what may cause this difference between both findings? One explanation may be that the latter study observed DC in the expression of ACAP, thus explicitly focusing on new, *external* knowledge. Conversely, in the former study (chapter 4), the applied proxies for DC did not stress the role of external knowledge as intensively as in the latter study. In line with the argumentation of recent authors (Mors, 2010; Rost, 2011; Nieves & Osorio, 2012) who point out the importance of strong ties and dense networks for exploring new, external knowledge, it can be argued that saturation effects for connectedness and density were not found in the latter study, since both properties were explicitly advantageous for advancing ACAP, i.e. dealing with external knowledge.

Preferential network structures for internal versus external knowledge
The fourth question, with regard to the knowledge network perspective that was already touched in chapter 8, is how to explain the differences in the preferential network configurations found in chapter 7 versus chapter 8. Chapter 7 concluded that higher levels of density negatively influence team performance, while chapter 8 concludes that higher levels of density positively influence specific dimensions of ACAP. This can be supported by the notion that the former study specifically focused on how actors deal with *internal* knowledge, while the latter study focuses on how teams cope with *external* knowledge. Recent studies point out that the *exploration*, i.e. detecting, sensing and integrating external knowledge thrives on networks with high density and strong ties, while the *exploitation*, i.e. the refinement and use of knowledge thrives on low-density and weak tie networks. In sum, the studies put forward in chapters 7 and 8 in conjunction confirm the anticipated differentiation between preferential knowledge network configurations for internal versus external knowledge contexts.

9.3 Implications and practical contributions

9.3.1 Implications

This work brings about various implications concerning the advancement of DC from different knowledge perspectives. First, the role of KM policies should not be undervalued. It appeared that through the adoption of policies set forward by management, organizations can advance their DC. It even appeared that in doing so, KM had a more prominent role in stimulating DC than social capital could. This, however, did not mean that there is no role for social capital in the bigger

picture. The research suggested that social capital, especially internal social capital can impact DC, but that it is hampered by two factors. One is the evident overshadowing influence of KM policy adoption. The other is the notion of the 'dark side' or 'saturation effect' of social capital as mentioned by other scholars that puts forward that social capital may be beneficial for organizational benefits, but that too much social capital can at the same time hamper these benefits. Organizations should take careful considerations when deciding to stimulate their social capital. With regard to the KM policies, it should be underscored that these policies are not meant as a means of managerial control, restricting access to knowledge and learning, but as a means to open up and stimulate these processes. With regard to knowledge networks, organizations should take into consideration that varying learning strategies may require different network configurations for optimal performance. This insight was anticipated in recent literature and confirmed through the research conducted in this dissertation. It appeared that learning processes that deal with internal knowledge contexts benefit from lower levels of density, while learning processes that deal with external knowledge contexts benefit from higher levels of density. Organizations should strive for smart and optimal combinations of network configurations in order to address varying learning contexts and multiple learning strategies. This will allow organizations to focus on both external knowledge that may be more closely involved in DC and ACAP and on internal knowledge that may be more closely associated with operational capabilities, resources and processes. Furthermore, it may allow organizations to effectively support both explorative and exploitative learning processes, thus stimulating organizational ambidexterity. Especially since participation in organizational networks is costly in the sense of time and distraction from other (operational) processes, stimulating a mixed pattern of network configurations is key.

9.3.2 Practical contributions

Besides these theoretical implications, this research delivered some concrete practical contributions that can be applied by scholars and practitioners alike.

Knowledge-Based Dynamic Capability (KDC) Model

The KDC model that was introduced in chapter 1 builds on the earlier work of Easterby-Smith and Prieto (2008) and links the knowledge perspectives studied in this work to DC. Furthermore, it underscores the role of learning and links the learning processes that underlie absorptive capacity to knowledge and DC. Scholars can build on the KDC model to further explore the link between

knowledge and DC. Practitioners can apply the KDC model to better understand their organizational processes in relation to DC.

Sustainability code measurement method
In chapters 2, 3 and 4, a measurement method is developed and applied to measure the adoption of the Sustainability Code policies in organizational settings. This method can be applied in future contexts to gauge and develop the adoption of these policies in light of advancing sustainable innovation.

ESNE: Email Social Network Extraction
As discussed in chapter 6 and applied in chapters 5 and 6, the ESNE tool allows organizations to construct social networks and conduct social (knowledge) network analysis based on logs generated from email traffic. Moreover, the ENSE tool offers a wide range of functionality in that it is capable of generating distinct time slices of social networks, allows filtering of specific domains or groups from a larger dataset and detects and respects email aliases.

Formative operationalization for absorptive capacity
Guided by the work of and in cooperation with Noblet et al. (2011) this research proposed a formative index for the measurement of ACAP in organizations in chapter 8. The measurement method is multidimensional and formative in nature on two levels. The method respects the theoretical differences between the four fundamental dimensions of absorptive as proposed by Zahra & George (2002) but also allows variation between the items that constitute each dimension of ACAP. In doing so, the measurement method presented in this work is arguably maximally capable to support the multidimensional nature of ACAP and thus to cover its concept space.

9.4 Reflections and future work

9.4.1 Limitations

Samples
As with any research initiative, this work has its limitations that should be acknowledged. One limitation concerns the sample size of the various quantitative studies that were conducted in this work. Larger samples may have yielded more stable models and deeper insight in the specifics of the various antecedents that were studied. In the study of the effect of KM on DC, a countermeasure is that this link was studied and found positive in two different samples. Concerning the effect of social capital on DC, a larger sample would have increased the veracity

of the findings. However, the current sample did yield both a stable model that was elaborately evaluated and various significant paths. In the study of the comparability of social network data capturing techniques, data was collected in only one organization. At the same time, the depth, i.e. the richness of the data that was captured here through surveys, email, telephony and text messages, could be valued over the width of the study. In the case of the knowledge network analyses performed in chapters 7 and 8, the sample in chapter 7 consisted of 18 knowledge networks, although in order to generate those networks, 79 employees participated in the corresponding sociometric survey. Likewise, although in the sample in chapter 8, 42 cases of knowledge networks were eventually studied, 542 respondents participated in sociometric surveys and an additional 48 respondents participated in the ACAP survey. Practical reasons such as the difficulties involved in conducting sociometric surveys (e.g. the time and resources demanded from participating organizations) prevented incorporating even more respondents in the network research. The choice to conduct the research not on an actor level but on a network level reduced the actual sample size considered in the statistical analysis, but this was a deliberate choice. Studying preferential knowledge network structures on an individual actor level may have yielded misleading results. Benefits from network structure for individual actors can differ from benefits for groups, since individuals could use knowledge opportunistically. Therefore, a balance was sought between the sample size and the interpretability of the results (i.e. the network structures on a group level of analysis).

Generalizability

Another limitation may be found in the generalizability of the research results. In all research initiatives, only Dutch (and in some cases Belgian) organizations were studied. On the other hand, DC was studied in varying organizational settings and varying industries. This is deemed especially important in studies on DC, since it has been noted that DC has previously mainly been studied in industries that are 'obviously dynamic' in nature, such as the semiconductor and pharmaceutical industries (Easterby-Smith et al., 2009). This called for more research on DC in more moderately dynamic markets, as is provided by this study. Finally, a limitation is formed by the measurability of the concept of DC. Various authors note that there is both a lack of consensus and practical development of a DC construct (e.g. Easterby-Smith et al., 2009; Barreto, 2010), which complicated the work in this dissertation. As suggested and carried out in other research, in this research objective proxies were applied to measure extents of DC. Furthermore, the concept of ACAP was adopted in chapter 8 to broaden the practicability to measure DC, guided by various recent ACAP operationalizations.

9.4.2 Research methods

First versus second generation analysis techniques
In this dissertation, various research methods were applied. In particular, a variation exists between first generation and second generation statistical methods that were applied. Especially relevant in chapters 2 and 7, first generation statistical techniques were applied, mainly in the form of standard convergent validity and reliability tests and correlation analysis as a means to explore findings and formulate conclusions. On the other hand, in chapters 4 and 8, structural equation modeling (SEM) was applied, which is a second generation technique (Becker et al., 2012). It is through progressive insights that a transition was made from the former to the latter means of conducting statistical analysis through the course of this dissertation. The former chapters could have benefitted from a SEM approach in the sense that it would have enabled deeper insight in the relation between the independent variables studied, especially concerning their relative and unique effect on the dependent variables.

Formative versus reflective indicators
Besides the use of SEM, another difference in the applied research methods is that when a SEM approach was applied, formative constructs and formatively linked items were applied where appropriate. The difference between a formative and a reflective approach is that in a reflective approach, items are interpreted as functions of the latent variable, while in a formative approach, items instead constitute and cause their latent variable (Diamantopoulos & Siguaw, 2006). Inadvertently applying a reflective approach where a formative approach is appropriate is referred to as a Type I error and although this error has been commonly made in literature (Podsakoff et al., 2006), it should be avoided. The impact of a Type I error can surface when validating the applied research model, including its constructs and items, since a reflective scale encourages redundancy among items in a construct, while a formative index discourages redundancy. In this dissertation, the Type I error would mainly affect the formulation of the higher order KM construct (New Knowledge Management, Sustainability Code). In chapter 2, a reflective approach was applied to validate the construct, which should be tagged as a Type I error as the various policies (items) represent different aspects of the associated construct. However, in chapter 4, the same construct is successfully evaluated through a formative approach with corresponding formative model evaluation techniques put forward in Hair et al. (2011). Concerning chapter 7, the applied network properties are single-item measures and would therefore not be sensitive to an incorrect validation approach. Furthermore, the items used to reflect team performance

can in fact be argued to be reflective in nature and since the construct was evaluated by means of reflective validation techniques, no methodological issues are expected here.

9.4.3 Personal reflections

Pursuing the presented work was both challenging and fun. The fundament for this work was a lecture on the role of knowledge management for sustainable innovation by the late Prof. René Jorna back in 2005 during his guest lecture at Utrecht University. This inspired me to empirically test if knowledge management could indeed advance sustainable innovation and led to the first two papers on which this dissertation is based. Through progressive insight, we uncovered the link between sustainable innovation and DC. Considerable time and thought were put into the relation between these topics. Although both topics closely align, they both have a rather separate body of literature attached to them and it appears that the link between the two concepts was never mentioned before. This finding did, however, pave the way to study the concept of DC in a wider context. Through an extensive literature study, I learned more about the concept of DC, its past discussions and current debates. Furthermore, I learned about the vagueness of the concept, which is striking since the concept itself has been extensively studied and discussed in scholarly work. The seemingly intangible nature of DC surfaced for us when we developed measurement instruments that capture a level of DC in organizations. We were able to overcome this issue by applying construct proxies. The benefit of this difficulty to measure DC in practice is that it extended the (literature) search for means to better capture DC in organizations. This led to the inclusion of the topic of absorptive capacity in this research which strengthened the main research model (the Knowledge-Based Dynamic Capability Model). DC and absorptive capacity too appear to be closely related concepts when contemplating how learning processes influence DC. Then, from the antecedent perspective of the main research model, it was through the extensive work that Remko Helms has performed on knowledge networks that we added the informal perspective to knowledge as a potential antecedent for DC, next to the formal antecedent of knowledge management. This led to the inclusion of the topics of social capital and knowledge networks in this work. In retrospect, it is fascinating to see the way in which the various concepts researched in this dissertation came together. Extensive literature research, numerous in-depth discussions and a pinch of serendipity were all required.

Although the part-time nature of my research influenced the duration of my efforts, I am happy that it allowed me to stay involved in science for an extended

period of time. Parallel to the main task of conducting research and writing this dissertation, the course of doing so allowed me to professionalize my scientific skills in multiple ways. Most notably is the introduction to second generation data analysis techniques such as PLS-SEM that we applied in chapters 4 and 8 of this work. I am convinced that I would not have been able to learn and apply such techniques if I had finished my work earlier, which would have affected the quality of this dissertation.

Overall, I am very grateful for all the experience that I was allowed to gain during the course of conducting scientific research. I value the effort that eventually led to this work as a fundamental aspect of my scientific and professional career development.

9.4.4 Future work

There are various avenues for future work that are more obvious in nature. For one, future research should further operationalize the concept of DC. The unifying definition of Barreto (2010) provides guidelines to build on the operationalization in the form of distinct dimensions that underlie DC, comparably to how the four dimensions of Zahra & George (2002) underlie ACAP. This would support research on DC in any scientific field, not just in the strategic marketing or KM field.

Another direction for future research is to further understanding of the relative influence of KM and social capital on DC and the interaction between both formal and informal perspectives towards knowledge. In this research, the impact of KM and social capital on DC was addressed by taking both perspectives as separate antecedents of DC. Alternatively, both perspectives may enhance or limit each other in their effect on DC. Such a conditional approach was not conducted in this work. A comparable study is the work of Van Den Hooff & Huysman (2009) who studied both perspectives on knowledge as antecedents of knowledge sharing. A similar approach could further the understanding of the interaction between the engineering and emergent perspectives on knowledge and enrich the KDC model proposed in chapter 1 of this work, based on the work of Easterby-Smith & Prieto (2008).

Finally, the vast amount of possible contexts and angles that knowledge networks can be studied from calls for a strong increase in empirical research on preferential knowledge network configurations. Additional research that considers the role of knowledge networks in both internal and external contexts and studies those contexts from actor, group and (inter-)organizational levels of scope will progress insights required to formulate and stimulate optimally mixed network configurations to advance organizational benefits, DC included.

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Appendix

Appendix A: Organizational conditions for NKM application

Table A.1. New Knowledge Management indicators and descriptives

Policy Item	Answer Categories	Response (%)
Fallibility	Knowledge is regarded as always valid	20
	Knowledge is regarded as more or less valid	57
	Knowledge is regarded as always fallible	23
Transparency	Hierarchy strongly limits knowledge accessibility	0
	Hierarchy limits knowledge accessibility to some extent	40
	Hierarchy barely limits knowledge accessibility	60
Inclusiveness	Training and learning programs are provided top-down	13
	Training and learning programs are discussed	77
	Training and learning programs are freely accessible	10
Fair Comparison	New knowledge is not evaluated before it is accepted	53
	New knowledge is evaluated before it is accepted	47
Looking for Trouble	Employees are expected to apply knowledge	40
	Employees are expected to apply and evaluate knowledge	60
Growth of Knowledge	Employees are expected to perform knowledge processes	30
	Employees are empowered to alter knowledge processes	70
Fact / Value	Knowledge is not evaluated	20

	Knowledge is evaluated on a basis of factuality	7
	Knowledge is evaluated on a basis of factuality and added value	73
Knowledge Management	The KM function is action controlled	33
	The KM function is result controlled	23
	The KM function is semi-autonomous	37
	The KM function is autonomous	7
Policy Synchronization	Policy results in behavior	20
	Policy and behavior are aligned	63
	Behavior results in policy formulation	17
Enforcement	Employees that do not abide to knowledge rules remain active	33
	Employees that do not abide to knowledge rules leave	60
	Employees that do not abide to knowledge rules are excluded	7
Embryology	Employees are not allowed to have own, personal learning agendas	17
	Employees are provided time for own personal learning agendas	27
	Employees are provided time and resources for own personal learning agendas	57
Politics of Knowledge	Knowledge creation is dedicated to the executive function	13
	Knowledge creation is influenced by employees	27
	Knowledge creation is open to all employees	60
Ethodiversity	Employees are expected to have convergent worldviews	47
	Employees are expected to have divergent worldviews	53
Connectedness	The density of social and IT based connectivity is inadequate	23
	The density of social and IT based connectivity is adequate	77

Appendix B: Impact of KM & Social Capital on Dynamic Capability

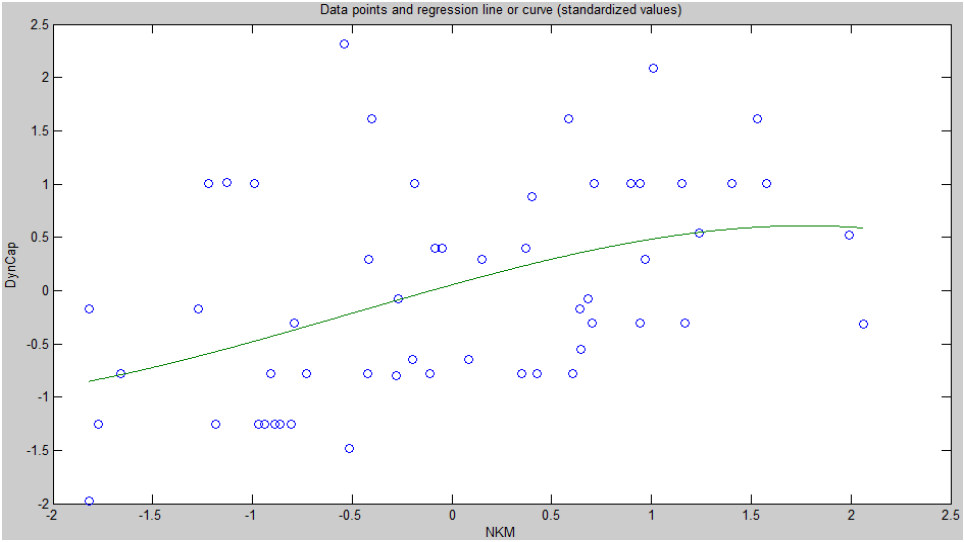

Figure B.1. Curve of NKM Adoption and Dynamic Capability

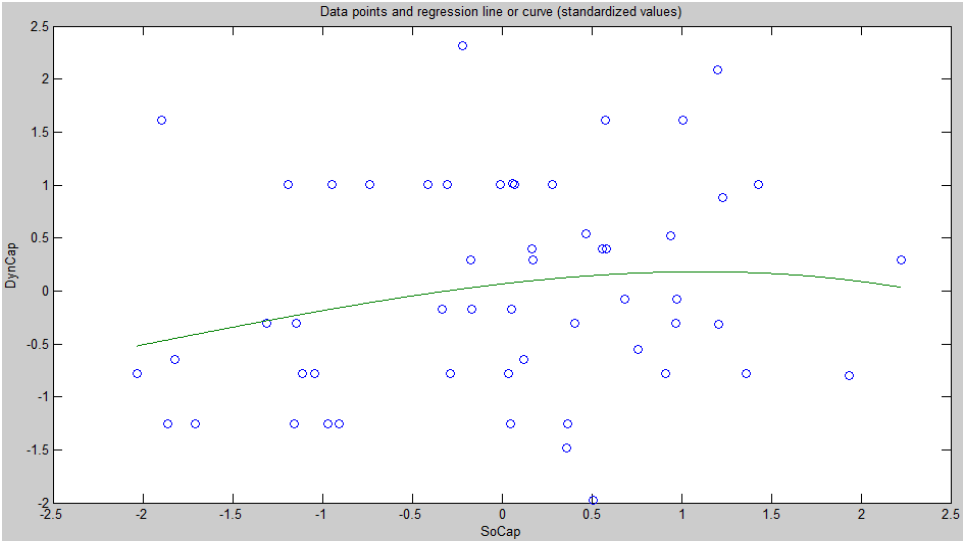

Figure B.2. Curve of Social Capital availability on Dynamic Capability

Table B.1. Correlations among the latent variables (with √AVE shown on diagonal). Highlighted values are significant at at least the < .05 level.

	DynCap	NKM KLC	NKM OE	NKM KM	NKM CAS	NKM	SoCap Str Int	SoCap Rel Int	SoCap Cog Int	SoCap Str Ext	SoCap Rel Ext	SoCap Cog Ext	SoCap
DynCap	**0,708**	0,432	0,34	0,118	-0,316	0,44	-0,05	0,217	-0,406	0,075	0,114	0,116	0,179
NKM KLC	0,432	**0,609**	0,164	0,007	-0,564	0,513	-0,162	-0,067	-0,096	-0,073	0,257	0,074	0,011
NKM OE	0,34	0,164	**0,578**	0,157	-0,324	0,866	0,192	0,296	-0,16	0,165	0,383	0,21	0,363
NKM KM	0,118	0,007	0,157	**1**	0,096	0,011	-0,195	-0,008	-0,048	-0,03	0,077	0,023	-0,041
NKM CAS	-0,316	-0,564	-0,324	0,096	**0,565**	-0,628	-0,136	-0,099	0,102	-0,088	-0,418	0,044	-0,206
NKM	0,44	0,513	0,866	0,011	-0,628	**0,45**	0,124	0,259	-0,192	0,104	0,426	0,117	0,312
SoCap Str Int	-0,05	-0,162	0,192	-0,195	-0,136	0,124	**0,807**	0,49	-0,176	0,319	0,289	0,242	0,68
SoCap Rel Int	0,217	-0,067	0,296	-0,008	-0,099	0,259	0,49	**0,758**	-0,396	0,407	0,282	0,208	0,71
SoCap Cog Int	-0,406	-0,096	-0,16	-0,048	0,102	-0,192	-0,176	-0,396	**0,666**	-0,259	-0,144	-0,286	-0,487
SoCap Str Ext	0,075	-0,073	0,165	-0,03	-0,088	0,104	0,319	0,407	-0,259	**0,749**	0,469	0,367	0,729
SoCap Rel Ext	0,114	0,257	0,383	0,077	-0,418	0,426	0,289	0,282	-0,144	0,469	**0,738**	0,479	0,687
SoCap Cog Ext	0,116	0,074	0,21	0,023	0,044	0,117	0,242	0,208	-0,286	0,367	0,479	**0,744**	0,625
SoCap	0,179	0,011	0,363	-0,041	-0,206	0,312	0,68	0,71	-0,487	0,729	0,687	0,625	**0,503**

Table B.2. p-values for correlations among the latent variables. Highlighted values are significant at at least the < .05 level.

	DynCap	NKM KLC	NKM OE	NKM KM	NKM CAS	NKM	SoCap Str Int	SoCap Rel Int	SoCap Cog Int	SoCap Str Ext	SoCap Rel Ext	SoCap Cog Ext	SoCap
DynCap		<0,001	0,011	0,389	0,019	<0,001	0,715	0,112	0,002	0,589	0,409	0,4	0,19
NKM KLC	0,001		0,23	0,957	<0,001	<0,001	0,238	0,625	0,484	0,596	0,058	0,592	0,936
NKM OE	0,011	0,23		0,253	0,016	<0,001	0,16	0,028	0,244	0,229	0,004	0,124	0,006
NKM KM	0,389	0,957	0,253		0,484	0,935	0,153	0,955	0,73	0,826	0,576	0,869	0,764
NKM CAS	0,019	<0,001	0,016	0,484		<0,001	0,32	0,474	0,457	0,523	0,001	0,748	0,132
NKM	0,001	<0,001	<0,001	0,935	<0,001		0,367	0,056	0,161	0,451	0,001	0,393	0,02
SoCap Str Int	0,715	0,238	0,16	0,153	0,32	0,367		<0,001	0,199	0,018	0,032	0,076	<0,001
SoCap Rel Int	0,112	0,625	0,028	0,955	0,474	0,056	<0,001		0,003	0,002	0,037	0,128	<0,001
SoCap Cog Int	0,002	0,484	0,244	0,73	0,457	0,161	0,199	0,003		0,056	0,294	0,034	<0,001
SoCap Str Ext	0,589	0,596	0,229	0,826	0,523	0,451	0,018	0,002	0,056		<0,001	0,006	<0,001
SoCap Rel Ext	0,409	0,058	0,004	0,576	0,001	0,001	0,032	0,037	0,294	<0,001		<0,001	<0,001
SoCap Cog Ext	0,4	0,592	0,124	0,869	0,748	0,393	0,076	0,128	0,034	0,006	<0,001		<0,001
SoCap	0,19	0,936	0,006	0,764	0,132	0,02	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	

Table B.3. Correlations among the individual measures of NKM adoption, social capital availability and dynamic capability, including their P values. Highlighted values are significant at at least the < .05 level.

	DynCap Correlations				DynCap P Values			
NKM KLC	**Proxy 1**	**Proxy 2**	**Proxy 3**	**Proxy 4**	**Proxy 1**	**Proxy 2**	**Proxy 3**	**Proxy 4**
NKM.Fallability	-0,17	-0,03	-0,08	0,07	0,222	0,805	0,543	0,623
NKM.FactValue	***0,34***	***0,40***	***0,50***	0,22	***0,011***	***0,002***	***0,001***	0,111
NKM.FairComparison	***0,28***	0,12	0,26	-0,12	***0,038***	0,405	0,054	0,38
NKM.Internalization	***0,28***	0,18	0,05	***0,28***	***0,036***	0,18	0,71	***0,042***
NKM OE								
NKM.Transparency	-0,01	0,04	0,13	0,08	0,946	0,766	0,338	0,563
NKM.Inclusiveness	0,17	***0,28***	0,10	0,26	0,213	***0,041***	0,476	0,054
NKM.LookingForTrouble	0,16	***0,27***	-0,04	***0,35***	0,231	***0,045***	0,763	***0,008***
NKM.GrowthOfKnowledge	0,22	0,25	0,13	***0,31***	0,11	0,065	0,337	***0,02***
NKM.PolicySynchronization	0,08	0,14	0,10	0,16	0,571	0,32	0,473	0,236
NKM.Enforcement	0,04	-0,04	0,06	***0,28***	0,772	0,778	0,681	***0,042***
NKM KM								
NKM.KnowledgeManagement	0,22	0,09	0,04	-0,07	0,108	0,526	0,767	0,615
NKM CAS								
CAS.PoliticsOfKnowledge	-0,19	-0,22	-0,02	-0,04	0,162	0,103	0,87	0,791
CAS.Embryology	0,15	0,19	0,12	0,12	0,288	0,161	0,386	0,4
CAS.Ethodiversity	0,13	0,23	-0,04	0,16	0,33	0,095	0,749	0,26
CAS.Connectedness	-0,11	0,22	0,20	***0,36***	0,448	0,111	0,15	***0,006***
SoCap Structural Internal								
SC.Structural.Internal.1	-0,04	-0,02	-0,19	0,19	0,795	0,908	0,163	0,157
SC.Structural.Internal.2	-0,15	0,05	-0,16	0,17	0,289	0,698	0,26	0,213
SC.Structural.Internal.3	-0,12	-0,09	-0,21	***0,32***	0,397	0,533	0,13	***0,018***
SoCap Relational Internal								
SC.Relational.Internal.1	-0,02	-0,02	0,03	0,13	0,901	0,908	0,832	0,365
SC.Relational.Internal.2	0,17	0,14	0,09	***0,43***	0,207	0,315	0,53	***0,001***
SC.Relational.Internal.3	0,01	0,15	0,04	***0,42***	0,96	0,265	0,791	***0,002***
SoCap Cognitive Internal								
SC.Cognitive.Internal.1	-0,04	0,02	-0,10	0,08	0,753	0,908	0,488	0,588
SC.Cognitive.Internal.2	***0,35***	***0,33***	0,07	***0,29***	***0,01***	***0,015***	0,638	***0,033***
SC.Cognitive.Internal.3	0,17	***0,30***	0,09	0,26	0,217	***0,024***	0,52	0,057
SoCap Structural External								
SC.Structural.External.1	-0,13	0,03	-0,02	0,16	0,343	0,859	0,911	0,237
SC.Structural.External.2	0,08	0,15	0,08	0,15	0,549	0,281	0,555	0,275
SC.Structural.External.3	-0,04	-0,05	-0,02	0,12	0,747	0,736	0,887	0,367
SoCap Relational External								
SC.Relational.External.1	-0,03	0,10	0,17	0,14	0,804	0,486	0,204	0,317
SC.Relational.External.2	-0,05	0,06	0,08	0,14	0,746	0,683	0,581	0,314
SC.Relational.External.3	-0,07	0,10	0,06	0,17	0,592	0,468	0,674	0,204
SoCap Cognitive External								
SC.Cognitive.External.1	0,10	0,04	0,02	0,09	0,466	0,802	0,902	0,499
SC.Cognitive.External.2	0,09	-0,06	0,14	-0,12	0,517	0,668	0,299	0,402
SC.Cognitive.External.3	0,10	0,06	0,08	***0,34***	0,479	0,684	0,587	***0,011***

Appendix C: Impact of network structure on Absorptive Capacity

Network Properties

Table C.1. Network properties studied in chapter 8, including their definition and key reference

Property	Reference	Description
Connectedness	Krackhardt (1994)	The extent to which the network is a single component (e.g. 35%)
Density	Hanneman & Riddle (2005)	The ratio of existing links relative to the amount of possible links (e.g. 35%)
Reciprocity (dyad method)	Hanneman & Riddle (2005)	The extent to which relations are dyadic (reciprocated) (e.g. 35%)
Efficiency	Krackhardt (1994)	The extent to which actors have only 1 incoming link (e.g. 35%)
In-Degree Centralization	Freeman (1979)	The degree of variance in in-degree centrality opposed to a perfect star network (e.g. 35%)
Out-Degree Centralization	Freeman (1979)	The degree of variance in out-degree centrality opposed to a perfect star network (e.g. 35%)
Core-Periphery Fit	Borgatti & Everett (1999)	Extent to which a network fits a model that comprises a high-density core and low-density periphery (e.g. 35%)
E-I Index	Krackhardt & Stern (1988)	Ratio of the number of links between actors of the same group and between actors of different groups (e.g. 0,7)

Sociometric Survey

Question 1: Please indicate in which way you have learned from your colleagues in the past year:

Learning: You learn from a colleague if you receive knowledge from him/her that helps you to develop yourself in your working role on the longer term. Learning is not so much about knowledge that you quickly need in your activities, but about knowledge that helps you to grow.

Per colleague, you can choose from 5 ways to learn, increasing from passive to active learning. Imagine these ways as follows:

1) You receive short suggestions or your colleague send to material (instructions, presentations)
2) Your colleague explains something to you by means of rules of thumb
3) Your colleague explains something to you in detail
4) Your colleague learns something to you by observing you and providing feedback
5) Your colleague learns something to you through active collaboration with one another

Please note that you do not have to indicate the exact value per colleague. Try to develop a sense of these 5 ways of learning and intuitively indicate per colleague which way of learning best describes how you have learned from this colleague.

Question 2: Please indicate how often you have received useful advice from your colleagues in the past year.

Advice: Advice helps you to perform your daily activities and projects. Therefore, advice is often needed at a more short-term notice.

Examples of receiving advice are:

- Your colleague offers you a solution for a problem
- Your colleague directs you to the right person or source that you need
- Your colleague helps to you regard a problem in a wider perspective
- Your colleague reviews your solution for a problem
- Your colleague assigns his/her name to your solution to support your cause

Please use the below scale:
1) Sporadically
2) Monthly
3) Weekly
4) Daily

Notes
- Your colleagues are grouped per knowledge area so they are easier to find in the list below
- Do not restrict your answers to colleagues of your own knowledge area only: provide answers for all colleagues in the list below that you have learned from
- Choose 'no answer' (default) if you did not learn from a person or if you do not know this person
- You do not have to answer this question for your own name in the list below
- You are anonymously providing your answers: no one within our organization will have access to your personal response

Absorptive Capacity Survey

Acquisition

1) To what extent do the members of your knowledge network access external knowledge?
2) To what extent are the members of your knowledge network exchanging knowledge with comparable knowledge networks in other organizations?
3) To what extent are the members of your knowledge network motivated to gather new knowledge?
4) To what extent is there a personnel turnover in your knowledge network?

Assimilation

5) To what extent has your knowledge network formulated a process or routine for the activity of the knowledge network concerning processing knowledge?
6) To what extent is your knowledge network capable of coordinating its activity?
7) To what extent is your knowledge network currently developing new ideas that are (partially) nurtured from externally sourced knowledge?
8) To what extent do you experience management support for the activity of your knowledge network concerning knowledge?

Transformation

9) To what extent does your knowledge network currently develop new products or services that are (partially) nurtured by externally sourced knowledge? This statement concerns products or services that are not yet completed but are currently in development.
10) To what extent has your knowledge network developed a process or routine for developing new knowledge?
11) To what extent is your knowledge network capable to combine/connect internal knowledge (from the internal knowledge network or organization) with/to new external knowledge?
12) To what extent has the activity of your knowledge network resulted in new ideas about existing knowledge (knowledge that already was available)?

Exploitation

13) To what extent has the activity of your knowledge network resulted in new products/services that are (partially) nurtured by externally sourced knowledge? This statement concerns products/services that are currently released by your knowledge network or organization.

14) To what extent does your knowledge network make an effort to protect the knowledge that was developed by your knowledge network?

15) To what extent is externally sourced knowledge useful for the activity of the members of your knowledge network?

16) To what extent does externally sourced knowledge support the members of your knowledge network to achieve the goals/targets of your knowledge network?

Correlation matrix

Table C.2. Correlations between the hypothesized network properties and the individual ACAP dimension constructs

Learning Correlations								
	Connect.	**Density**	**Recipr.**	**Efficiency**	**InDegC.**	**OutDegC.**	**CorePF.**	**E-I Index**
Acquisition	0,335**	0,490****	0,435***	-0,492****	-0,300*	0,072	0,172	-0,087
Assimilation	0,296*	0,299*	0,356**	-0,307**	-0,089	0,298*	0,026	-0,293*
Transformation	0,493****	0,317**	0,341**	-0,323**	-0,159	0,100	0,097	-0,062
Exploitation	0,297*	0,308**	0,315**	-0,312**	-0,082	0,260*	0,250	-0,151

Advice Correlations								
	Connect.	**Density**	**Recipr.**	**Efficiency**	**InDegC.**	**OutDegC.**	**CorePF.**	**E-I Index**
Acquisition	0,525****	0,519****	0,536****	-0,529****	-0,147	0,177	0,039	-0,110
Assimilation	0,486***	0,327**	0,480***	-0,334**	-0,033	0,324**	0,172	-0,325**
Transformation	0,576****	0,323**	0,478***	-0,323**	-0,117	0,318**	-0,011	-0,086
Exploitation	0,489***	0,346**	0,547****	-0,350**	-0,012	0,348**	0,177	-0,163

Legend	
****	P < 0,001
***	P < 0,01
**	P < 0,05
*	P < 0,1

Summary

Organizations that strive to survive need to develop sustainable competitive advantage. The challenge is that competitive advantage is not static. Instead, organizations are required to *continuously* adapt to an ever-changing market environment by changing their resources and routines. Dynamic capability, which is a concept that expresses the extent to which organizations are capable to do so, is therefore considered the Holy Grail of strategic management. At the same time, although the role of knowledge for dynamic capability is well-recognized, an explicit link to the knowledge management (KM) domain is still in its infancy.
A traditional definition for dynamic capability is *"a firm's ability to integrate, build and reconfigure internal and external competences to address rapidly changing environments"*. The potential roles of knowledge management for dynamic capability are multifold. It is best recognized in the notion that the processes through which organizations sense changes in their environment and adapt their competences (resources and routines) can be described as knowledge or learning processes. Furthermore, knowledge is an organizational resource in itself.
This PhD dissertation aims to uncover how organizations may advance dynamic capability through various perspectives on knowledge. Specifically, antecedents of dynamic capability are examined through 1) the adoption of knowledge management policies, 2) the availability of social capital and 3) the structure of knowledge networks in organizations. All three perspectives concern the effectiveness of knowledge processes and may therefore contribute to or limit the knowledge processes that facilitate dynamic capability. The justification to observe all three perspectives distinctly is found in their differences. Knowledge management is an engineering approach, while social capital and knowledge networks are emergent approaches towards knowledge. While social capital provides a broad insight in the social fabric of knowledge processes, knowledge network analysis provides an in-depth zoom lens on the structure of that fabric.
The first part of this research focuses on the effect of the adoption of a specific set of KM policies on dynamic capability. Observed through survey research, it appears that this policy model can indeed advance dynamic capability. Moreover, organizational conditions are uncovered that are preferable for the adoption of these KM interventions. Supportive organizational conditions are a flat organizational structure and the usage of a KM information system. An additional

result of this research is a validated measurement method for the adoption by organizations of the KM policies under investigation that are bundled in the 'Sustainability Code'. This set of policies is a part of the second generation KM postulation 'New Knowledge Management'. The measurement method is the first and only operationalization of this KM declaration.

Part two of this work focuses on the potential role of social capital availability for dynamic capability. Moreover, the aforementioned KM policy model is again investigated, this time in concert with social capital availability. This allows to uncover which of both approaches towards knowledge has more leverage to advance dynamic capability. Findings repeat the confirmation that adoption of the KM policy model advances dynamic capability in organizations. Policies that are especially beneficial involve stimulating an open organization where knowledge is transparent for employees and actively evaluating the factuality and usefulness of knowledge in the organization. Furthermore, it appears that social capital availability has no unique contribution to dynamic capability. An argument that can explain this latter finding is the appearance of 'saturation effects' of social capital, that point out how a certain degree of social capital can in fact stimulate dynamic capability, but that too much social capital can neutralize and even hamper these benefits.

In the next part of this research, focus is put on methods and techniques to conduct knowledge network analysis under varying organizational conditions. This effort is undertaken to verify which of the various available data sources to compose knowledge networks (i.e. survey, mail, telephone logs) is best suitable for the aims of this research. The investigation reveals that knowledge networks that are composed based on email data are significantly comparable to those networks based on sociometric surveys, but that other data sources cannot provide the same results. Furthermore, a tool is developed that allows the automatic formulation of knowledge networks based on email data. The tool is discussed in context of other tools available. The distinctiveness of this tool is that it supports email aliases, filters non-personal email and allows for the partition of data in time slices. Moreover, a differentiation between tools that focus on the structure versus the content exchanged in knowledge networks is recognized and an integrative means to tackle both challenges in one approach is proposed.

The final part of the research focuses on the role of knowledge network structure for dynamic capability. An initial research is conducted to test a unique research approach that focuses on both group-level instead of individual-level benefits of knowledge network structure and tests multiple structural properties of knowledge networks concurrently. Findings of this research that examined preferential knowledge network structures for team performance in organizations show that these teams thrive on low levels of density and high levels of efficiency.

Following, preferential network structures for dynamic capability are investigated. In this part of the research, dynamic capability is investigated in the embodiment of the closely related concept of absorptive capacity, due to a better means of operationalizing the concept. Absorptive capacity concerns the extent to which organizations are capable to explore, assimilate and transform external knowledge and exploit it for commercial ends. Several important findings are presented here. Foremost, it appears that high levels of density play a key role for exploring and assimilating external knowledge, while they have no unique role for transforming and exploiting external knowledge. Furthermore, a high concentration of outgoing knowledge flows appears to be beneficial for absorptive capacity.

As a result of this research, it appeared that contextual factors, such as whether internal or external knowledge is concerned, play a major role regarding the question what an optimal knowledge network structure is. Therefore, future research is recommended to analyze more knowledge networks, while carefully pinpointing the context of the studied networks. Furthermore, this research calls for a further operationalization of the concept of dynamic capability and a further analysis of the interplay between knowledge management and social capital concerning the advancement of dynamic capability in organizations.

Nederlandse Samenvatting

Organisaties die ernaar streven om te overleven dienen een duurzaam concurrentievoordeel te ontwikkelen. De uitdaging daarbij is dat concurrentievoordeel niet statisch is. Integendeel, organisaties moeten zich continu aanpassen aan een altijd veranderende marktomgeving door hun middelen en routines te veranderen. Dynamisch vermogen is een concept dat uitdrukking geeft aan de mate waarin organisaties hiertoe in staat zijn en wordt daarom gezien als de Heilige Graal van strategisch management. Tegelijkertijd is het zo dat hoewel de rol van kennis voor dynamisch vermogen goed wordt herkend, een expliciete link naar het domein van kennismanagement nog in haar kinderschoenen staat.

Een traditionele definitie voor dynamisch vermogen is *"de gave van een organisatie om interne en externe competenties te integreren, ontwikkelen en herconfigureren om snel veranderende omgevingen te kunnen adresseren"*. De mogelijke rol van kennismanagement voor dynamisch vermogen is meervoudig. Dit is het beste herkenbaar in het feit dat de processen waardoor organisaties veranderingen in hun omgeving waarnemen en hun competenties (middelen en routines) aanpassen, beschreven kunnen worden als kennis- of leerprocessen. Bovendien is kennis zelf ook een organisatorisch middel.

Dit promotieonderzoek heeft als doel om vast te stellen hoe organisaties hun dynamisch vermogen kunnen versterken via verschillende perspectieven op kennis. Meer specifiek worden antecedenten van dynamisch vermogen bestudeerd door 1) de adoptie van kennismanagement beleid, 2) de beschikbaarheid van sociaal kapitaal en 3) de structuur van kennisnetwerken in organisaties. Alle drie de perspectieven hebben een raakvlak met de effectiviteit van kennisprocessen en kunnen daarom de kennisprocessen die ten grondslag liggen aan dynamisch vermogen versterken of beperken. Dat alle drie de perspectieven afzonderlijk worden benaderd, wordt gerechtvaardigd door hun verschillen. Kennismanagement is een formele benadering van kennisprocessen, terwijl sociaal kapitaal en kennisnetwerken informele en emergente benaderingen van kennis zijn. Terwijl sociaal kapitaal een generiek en breed beeld geeft van het sociale weefsel van kennisprocessen, fungeert kennisnetwerk analyse als een zoomlens op de structuur van dat weefsel.

Het eerste deel van dit onderzoek concentreert zich op het effect van de adoptie van een specifiek kennismanagement beleid voor dynamisch vermogen. Via

enquêteonderzoek blijkt dat dit kennismanagement beleid inderdaad het dynamisch vermogen versterkt. Daarnaast worden organisatie-eigenschappen ontdekt die van voorkeur zijn voor het adopteren van de bestudeerde kennismanagement interventies. Organisatie-eigenschappen die hieraan bijdragen zijn een platte organisatiestructuur en het gebruik van een kennismanagement informatiesysteem. Een aanvullend resultaat van dit onderzoek is een gevalideerde meetmethode voor de adoptie door organisaties van het bestudeerde kennismanagement beleid, dat is gebundeld onder de naam 'Duurzaamheidscode'. Deze verzameling beleidspunten is onderdeel van het tweede generatie gedachtegoed 'Het Nieuwe Kennismanagement'. De meetmethode is de eerste en enige operationalisatie van deze kennismanagement uiting.

Deel twee van dit werk concentreert zich op de potentiële rol van de beschikbaarheid van sociaal kapitaal voor dynamisch vermogen. Daarnaast wordt het eerder genoemde kennismanagement beleidsmodel wederom bestudeerd, dit maal in samenspel met de beschikbaarheid van sociaal kapitaal. Deze opzet maakt het mogelijk om te ontdekken welke van beide benaderingen van kennis meer invloed heeft om dynamisch vermogen te versterken. De bevindingen bevestigen dat de adoptie van het kennismanagement beleidsmodel dynamisch vermogen in organisaties versterkt. Beleidspunten die in het bijzonder bijdragen, omvatten het stimuleren van een open organisatie waar kennis transparant is voor medewerkers en het actief evalueren van de juistheid en toepasbaarheid van kennis in de organisatie. Hiernaast blijkt dat de beschikbaarheid van sociaal kapitaal geen unieke bijdrage levert voor dynamisch vermogen. Een mogelijke reden voor het verklaren van deze bevinding is het vóórkomen van 'verzadigingseffecten' van sociaal kapitaal. Dit houdt in dat een zeker niveau van sociaal kapitaal het dynamisch vermogen wel degelijk kan stimuleren, maar dat te veel sociaal kapitaal dit effect kan neutraliseren of zelfs kan tegenwerken.

In het volgende deel van het onderzoek wordt de aandacht verlegd naar methoden en technieken om kennisnetwerk analyse uit te voeren onder variërende organisatorische omstandigheden. Deze inspanning wordt verricht om te verifiëren welke van de diverse beschikbare databronnen om kennisnetwerken samen te stellen (zoals een enquête, e-mail of telefonie logbestanden) het meest geschikt is voor het doel van dit onderzoek. De resultaten tonen aan dat kennisnetwerken die worden samengesteld op basis van e-mailcommunicatie significant vergelijkbaar zijn met netwerken gebaseerd op sociometrische enquêtes, maar dat andere databronnen niet dezelfde resultaten kunnen bieden. Daarnaast wordt een tool ontwikkeld die het mogelijk maakt om automatisch kennisnetwerken samen te stellen op basis van e-mailcommunicatie. De tool wordt besproken in de context van andere beschikbare tools. Het

onderscheidende vermogen van deze tool is dat hij ondersteuning biedt voor e-mail aliassen, het filteren van niet-persoonlijke e-mail en het partitioneren van de data in tijdseenheden. Bovendien wordt een onderscheid erkend tussen tools die focussen op de structuur van het netwerk tegenover de inhoud die wordt uitgewisseld in de kennisnetwerken en wordt een geïntegreerde manier om beide invalshoeken in één inspanning te bestuderen voorgesteld.

Het laatste onderdeel van dit onderzoek concentreert zich op de rol van kennisnetwerk structuren voor dynamisch vermogen. Een voorstudie wordt uitgevoerd om een unieke onderzoeksaanpak te testen die zich concentreert op zowel voordelen op groepsniveau in plaats van op individuniveau van kennisnetwerk structuur als dat het meerdere structurele eigenschappen van kennisnetwerken tegelijkertijd meet. Resultaten van deze voorstudie die voorkeursstructuren in netwerken onderzoekt voor teamprestaties in organisaties tonen aan dat deze teams gedijen op een lage mate van *density* en een hoge mate van *efficiency* (beiden zijn indicatoren die worden toegepast in kennisnetwerk analyse). Vervolgens worden voorkeursstructuren in kennisnetwerken voor dynamisch vermogen bestudeerd. In dit deel van het onderzoek wordt dynamisch vermogen bestudeerd in de vorm van het nauw verwante concept 'kennis absorptievermogen', vanwege een meer geschikte manier om dit concept te operationaliseren. Kennis absorptievermogen betreft de mate waarin organisaties in staat zijn om externe kennis te exploreren, assimileren, transformeren en exploiteren voor commerciële doeleinden. Meerdere belangrijke bevindingen worden gepresenteerd. In de eerste plaats blijkt dat een hoge mate van *density* een sleutelrol vertegenwoordigt voor het exploreren en assimileren van externe kennis, terwijl dit geen unieke rol blijkt te vervullen voor het transformeren en exploiteren van externe kennis. Daarnaast blijkt dat een hoge mate van de concentratie van uitgaande kennisstromen bevorderlijk is voor het kennis absorptievermogen.

Uit het onderzoek is gebleken dat contextuele factoren, zoals of het nu om interne of externe kennis gaat, een grote rol spelen bij de vraag wat een optimale kennisnetwerk configuratie is. Daarom wordt aanbevolen om in verder onderzoek meer kennisnetwerken te analyseren, waarbij de context nauwkeurig wordt geduid. Tevens wordt opgeroepen tot een verdere operationalisatie van het concept dynamisch vermogen en het nader bestuderen van de samenhang tussen kennismanagement en sociaal kapitaal als het gaat om het versterken van dynamisch vermogen.

Curriculum Vitae

Jurriaan van Reijsen was born on August 30, 1982 in Tiel, The Netherlands. From 2000 to 2004 he studied at the Academy for Digital Communication at the Utrecht University of Applied Sciences where he obtained his bachelor's degree in Communication. After graduating, he studied Business Informatics at Utrecht University from 2005 to 2006 where he obtained his master's degree in Information Science. Late 2006, he started to work part-time on his PhD research at Utrecht University.

Next to his PhD research, Jurriaan has worked as a consultant for several of the Dutch top 100 organizations as an expert in learning technology. Here, he fulfilled the roles of project manager, product specialist and trainer for (the implementation of) software products in the fields of Learning Management Systems (LMS), Learning Content Management Systems (LCMS) and team collaboration software products. Jurriaan is PRINCE2™ and ITIL® certified and has an expert status in the team collaboration software product 'Confluence' by Atlassian. Moreover, he is co-organizer of the Netherlands Atlassian User Group (NLAUG) and has been a reviewer for the book 'Atlassian Confluence 5 essentials'.

The main research areas of Jurriaan are knowledge management, social network analysis and dynamic capability. He has been a reviewer for several prominent international conferences in the Information Systems domain, including ECIS (The European Conference on Information Systems) and PACIS (The Pacific Asia Conference on Information Systems).

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